Science

Standards

Guide

Diocese of Owensboro, Kentucky
Revised 2017

DIOCESE OF OWENSBORO
McRaith Catholic Center
OFFICE OF THE BISHOP

June, 2017

My dear brothers and sisters in Christ,

It is my pleasure to present to you the Diocese of Owensboro Science Standards for grades K-12. The science standards are a result of the work of many of our science teachers across the diocese for whom we are deeply appreciative. We honor our late Bishop John Jeremiah McRaith, who connected deep faith and spirituality with the scientific knowledge of those who cultivate the land to bring forth its bounty for the good of humanity, by dedicating these science standards to him.

We are especially grateful to Dr. Emily DeMoor, of Brescia University, for writing the introduction to Catholic Identity and for her development of Catholic Identity for each of the standards. Her education, experience and research provided Catholic connections between the science standards, scripture and tradition, which includes the Magisterium and other theological writings, the saints, the sacraments, Catholic scientists, and Catholic Social Teaching.

St. Albert the Great, patron saint of scientists, pray for us.

Sincerely in Christ,

Most Reverend William F. Medley
Bishop of the Diocese of Owensboro

600 Locust Street, Owensboro, KY 42301-2130 • (270) 683-1545 • FAX (270) 683-6883 • www.owensborodiocese.org

Dedicated to:

Bishop John Jeremiah McRaith
1934-2017
Diocese of Owensboro
1982-2009
Executive Director of the Rural Life Conference
1971-1978
Leader of USCCB Food, Agriculture and Rural Concerns Sub-committee

Bishop John J. McRaith was born in Hutchinson, Minnesota on December 6, 1934. He graduated from St. Bernard Seminary in Dubuque, Iowa, and was ordained a priest of the Diocese of New Ulm, Minnesota, on February 21, 1960. In 1982, he was ordained as the third Bishop of the Diocese of Owensboro. In addition to shepherding the Catholic Church of western Kentucky, Bishop McRaith served as board member for Brescia University, the Daniel Pitino Center, McAuley Free Clinic in Owensboro, and Lourdes Hospital Foundation in Paducah.

Bishop John J. McRaith said his dedication to rural life "fueled his desire to travel around the country and address rural issues, social justice and the importance of a rural ministry. Becoming a recognized authority on Catholic rural life, he spent these years giving conferences and workshops in many dioceses across America" (Diocese of Owensboro). During a 1994 national teleconference he said "I learned about the sacredness of land. I grew to love the land to and to know that there's life there, and if you abuse it, you'll eventually pay the price."

"A Pope Francis before Pope Francis. Pope Francis' encyclical ***Laudato Si'*** is about caring for the earth, and if anybody embodied that forty years ago it was Bishop John J. McRaith." stated Bishop William Francis Medley.

Science is the study of the natural world – God's sacred creation, so it is with deep gratitude for this beloved man, his vision and service, that we dedicate the Diocese of Owensboro Science Standards to Bishop John Jeremiah McRaith.

TABLE OF CONTENTS

DIOCESE OF OWENSBORO

Most Reverend William F. Medley
Bishop of Owensboro

COMMITTEE FOR TOTAL CATHOLIC EDUCATION

Zach Ault
Paducah Deanery

Joe Bland
McRaith Catholic Center Staff

Sr. Vivian Bowles, OSU
Council of Religious Representative

Patti Brown
Hopkinsville Deanery

John Broxon
At Large Representative

Pat Cairney
At Large Representative

Emily Danchisin
Lakes Deanery Representative

Bob Davis
At Large Representative

Rev. Robert Drury
Fancy Farm Deanery Representative

Stephanie Frey
Owensboro East Deanery Representative

Rev. Larry Hostetter
Priests' Representative

Judy Jenkins
Teacher Representative

Tina Kasey
McRaith Catholic Center Staff

Angie Krampe
Central Deanery Representative

Jim Mattingly
McRaith Catholic Center Staff

Karen Meredith
Eastern Deanery Representatives

Elaine Robertson
McRaith Catholic Center Staff

Nancy Smith
Owensboro West Deanery Representative

Sr. Rosanne Spalding, OSU
Council of Religious Representative

Rev. John Vaughan
Priests' Representative

Ben Warrell
Diocesan Staff

Kelly Wiseman
Bowling Green Deanery Representative

REVISION COMMITTEE FOR SCIENCE STANDARDS

Dr. Emily DeMoor, Co-Chair
Brescia University

Ann Flaherty, Co-Chair
Diocese of Owensboro Catholic Schools

Debby Brown
Christ the King School

Jill Chappell
Owensboro Catholic High School

Ryan Cowsert
St. Mary Middle School

Amanda Farmer
St. Joseph School

Chris Hamilton
Mary Carrico Memorial School

Jane Irwin
Sts. Peter and Paul School

Lauren Johnson
Catholic Schools Office

Amanda Kauffeld
Owensboro Catholic Elementary 4-6 School

Cindy Loxley
John Paul II School

Beth May
St. Joseph School

Stephanie Millay
Owensboro Catholic Elementary K-3 School

Cheri Phillips
Holy Name School

Lynn Price
Owensboro Catholic Elementary 4-6 School

Lori Ann Redmon
Trinity High School

Amy Ridley
St. Mary High School

Morgan Rudy
Owensboro Catholic Middle School

Stephanie Thomas
John Paul II School

MISSION STATEMENT OF THE CATHOLIC SCHOOLS OF THE DIOCESE OF OWENSBORO

The curriculum in the Catholic School reflects the six tasks of catechesis:
"to promote knowledge of the faith, to further knowledge of liturgy and the sacraments, to support moral formation in Jesus Christ, to teach the Christian how to pray with Christ, to prepare the Christian to live in community and to participate actively in the life and mission of the Church."

(NDC, #20; GDC, #85-86)

The mission of the Catholic Schools of the Diocese of Owensboro is to share in the Church's mission, to proclaim the message of Jesus Christ as lived out in the Catholic Church which creates a worshipping community of believers whose service is a witness of their Christian love.

STANDARDS REVISION PLAN FOR
THE DIOCESE OF OWENSBORO

The Standards Revision Committee for Schools of the Diocese of Owensboro, Kentucky was established in April 1994 to provide direction in developing the curricula for all subject areas. In order to provide direction, there was also a need for a long term, comprehensive standards revision plan. A time line was established for assessing and developing standards that would be consistent with the teachings of the Catholic Church, would address educational reform, and would include the requirements for the Kentucky Non-Public School Commission Certification Process.

Subject Area	Standards Review and Revision	Approval by: Diocesan Standards Committee, PACESS, Committee for Total Catholic Education, Most Rev. William F. Medley	Textbook Selection	Purchase Textbooks
Group III - Science	2016 - 2017 *Complete by Spring, 2017*	Spring, 2017	*Complete by* Spring, 2018	Summer, 2018
Group IV - Social Studies	2017 - 2018 Complete by Spring, 2018	Spring, 2018	Complete by Spring, 2019	Summer, 2019
Group V - Arts & Humanities Foreign Language	2018 - 2019 Complete by Spring, 2019	Spring, 2019	Complete by Spring, 2020	Summer, 2020
Group VI – Religion Vocational Studies and Practical Living	2019 - 2020 Complete by Spring, 2020	Spring, 2020	Complete by Spring, 2021	Summer, 2021
Group I - Math	2020 - 2021 Complete by Spring, 2021	Spring, 2021	Complete by Spring, 2022	Summer, 2022
Group II - English/Language Arts	2022-2023 Complete by Spring, 2022	Spring, 2022	Complete by Spring, 2023	Summer, 2023

Standards Revision Committee efforts will focus on student learning. It is recommended to teachers that planning, written curriculum guides, textbooks, assessments, etc., be seen as means for student learning. All processes should be developed to ensure continuous improvement of the curriculum.

The Diocesan Standards Revision Committee consensually agreed that the standards for each subject area would be developed and completed according to the standards revision plan. Textbooks and/or materials would be chosen to support the Standards Guide.

It was also agreed that a Standards Revision Committee would be established for each subject. Each committee needs to explore the present status, refer to all available resources, and develop content standards for grades K-12.

***High Schools Religion Texts can be purchased as they become available and approved by the United States Conference of Catholic Bishops (USCCB).**

NATIONAL STANDARDS AND BENCHMARKS FOR EFFECTIVE CATHOLIC SCHOOLS

"A school's Catholic Identity should not be confined to the religion curriculum and campus ministry activities. Every subject taught should be connected in some way to the school's Catholic Identity. The effective way of aligning academics with Catholic Identity is by integrating the seven principals of Catholic Social Teaching into the overall school curriculum."

(Momentum, Sept/Oct 2008)

Standard 2:

An excellent Catholic school adhering to mission provides a rigorous academic program for religious studies and catechesis in the Catholic faith, set within a total academic curriculum that integrates faith, culture and life.

2.4 The school's Catholic Identity requires excellence in academic and intellectual formation in **all** subjects including religious education.

2.5 Faculty uses the lenses of Scripture and the Catholic intellectual tradition in **all** subjects to help students think critically and ethically about the world around them.

2.7 The theory and practice of the Church's social teachings are essential elements of the curriculum.

The United States Conference of Catholic Bishops affirms the message of the Congregation on Catholic Education that intellectual development of the person and growth as a Christian go forward hand in hand. Rooted in the mission of the Church, the Catholic school brings faith, culture and life together in harmony. In 2005, the bishops noted that "young people of the third millennium must be a source of energy and leadership in our Church and our nation. And, therefore, we must provide young people with an academically rigorous and doctrinally sound program of education" (Renewing Our Commitment to Catholic Elementary and Secondary School in the Third Millennium, 2005).

The essential elements of "an academically rigorous and doctrinally sound program" mandate curricular experiences—including co-curricular and extra-curricular activities—which are rigorous, relevant, research-based, and infused with Catholic faith and traditions. The following essential elements provide a framework for the design, implementation, and assessment of authentic academic excellence in Catholic school education from prekindergarten through secondary school.

Standard 7:

An excellent Catholic school has a clearly articulated rigorous curriculum aligned with relevant standards, 21st century skills, and Gospel values, implemented through effective instruction.

7.1 The curriculum adheres to appropriate, delineated standards, and is vertically aligned to ensure that every student successfully completes a rigorous and coherent sequence of academic courses based on the standards and rooted in Catholic values.

7.2 Standards are adopted across the curriculum, and include integration of the religious, spiritual, moral, and ethical dimensions of learning in **all** subjects.

7.3 Curriculum and instruction for 21st century learning provide students with the knowledge, understanding, and skills to become creative, reflective, literate, critical, and moral evaluators, problem solvers, decision makers, and socially responsible global citizens.

7.4 Curriculum and instruction for 21st century learning prepares students to become expert users of technology, able to create, publish, and critique digital products that reflect their understanding of the content and their technological skills.

7.5 Classroom instruction is designed to intentionally address the affective dimensions of learning, such as intellectual and social dispositions, relationship building, and habits of mind.

7.6 Classroom instruction is designed to engage and motivate all students, addressing the diverse needs and capabilities of each student, and accommodating students with special needs as fully as possible.

7.7 Faculty collaborate in professional learning communities to develop, implement, and continuously improve the effectiveness of the curriculum and instruction to result in high levels of student achievement.

7.8 The faculty and professional support staff meet (arch) diocesan, state, and/or national requirements for academic preparation and licensing to ensure their capacity to provide effective curriculum and instruction.

7.9 Faculty and professional support staff demonstrate and continuously improve knowledge and skills necessary for effective instruction, cultural sensitivity, and modeling of Gospel values.

7.10 Faculty and staff engage in high quality professional development, including religious formation, and are accountable for implementation that supports student learning.

Standard 8:

An excellent Catholic school uses school-wide assessment methods and practices to document student learning and program effectiveness, to make student performances transparent, and to inform the continuous review of curriculum and the improvement of instructional practices.

8.1 School-wide and student data generated by a variety of tools are used to monitor, review, and evaluate the curriculum and co-curricular programs; to plan for continued and sustained student growth; and to monitor and assess faculty performance.

8.2 School-wide and aggregated student data are normed to appropriate populations and are shared with all stakeholders.

8.3 Faculty use a variety of curriculum-based assessments aligned with learning outcomes and instructional practices to assess student learning, including formative, summative, authentic performance, and student self-assessment.

8.4 Criteria used to evaluate student work and the reporting mechanisms are valid, consistent, transparent, and justly administered.

8.5 Faculty collaborate in professional learning communities to monitor individual and class-wide student learning through methods such as common assessments and rubrics.

From: *National Standards and Benchmarks for Effective Catholic Elementary and Secondary Schools*, http://www.catholicschoolstandards.org/the-standards/2014-07-13-13-36-30/download-the-standards

EUCHARISTIC PRAYER 3

(excerpt)

Father, You are holy indeed, and all creation rightly gives You praise. All life, all holiness comes from You through Your Son, Jesus Christ our Lord, by the working of the Holy Spirit.

PSALM 148

Hallelujah!

Praise the LORD from the heavens; praise Him in the heights.

Praise Him, all you His angels; give praise, all you His hosts.

Praise Him, sun and moon; praise Him, all shining stars.

Praise Him, highest heavens, you waters above the heavens.

Let them all praise the LORD's name; for He commanded and they were created,

Assigned them their station forever, set an order that will never change.

Praise the LORD from the earth, you sea monsters and all the deeps of the sea;

Lightning and hail, snow and thick clouds, storm wind that fulfills His command;

Mountains and all hills, fruit trees and all cedars;

Animals wild and tame, creatures that crawl and birds that fly;

Kings of the earth and all peoples, princes and all who govern on earth;

Young men and women too, old and young alike.

Let them all praise the LORD's name, for His name alone is exalted, His majesty above earth and heaven.

He has lifted high the horn of His people;

to the praise of all His faithful, the Israelites, the people near to Him.

Hallelujah!

CATHOLIC IDENTITY

Reflecting on the legacy of Cardinal Newman, Bishop Gerald Kicanas explained that "Catholic is not just an adjective accidental to who you are. Catholic is core to your identity, the center of what you are about" (Barnes, et al. 2011, p. 1). He reminded us of the Holy Father's directive to not just teach the faith to students, but to provide opportunities for them to live the faith.

Our Catholic Identity includes scripture [S], tradition -- including the Magisterium (papal writings) [M] and other theological writings [TH], the sacraments [SC], Catholic Social Teaching [CST], and the lives and inspiration of the saints and holy people of God [SA]. These aspects of Catholic identity will be interwoven throughout the Diocese of Owensboro Academic Standards for Science and coded using the abbreviations provided here. And, in accordance with The Cardinal Newman Society's "Best Practice Suggestions for Science in Catholic Schools," the names of Catholic scientists will be featured in the document as well. Teachers are encouraged to supplement science textbooks with biographies of these scientists.

The academic standards will also be aligned with the "Catholic Curricular Standards and Dispositions Related to Scientific Topics" [CS] authored by The Cardinal Newman Society. These standards underscore the evangelical mission of Catholic education as they "foster in students an awareness of the God-given gift of faith to nurture their development into mature adults who will bear witness to the Mystical Body of Christ; respect the dignity of the human person; lead virtuous prayerful, apostolic lives; serve the common good; and build the Kingdom of God" ("Introduction" to Catholic School Curriculum Standards). For all knowledge becomes "living, conscious, and active" when seen in the light of faith. Learning and formation are joined as students are prepared to serve the Church and society. The Cardinal Newman Society maintains that Catholic education:

1. Involves the integral formation of the whole person, body, mind, and spirit, in light of his or her ultimate end and the good of society.
2. Seeks to know and understand objective reality, including transcendent Truth, which is knowable by reason and faith and finds its origin, unity, and end in God.
3. Promotes human virtues and the dignity of the human person, as created in the image and likeness of God and modeled on the person of Jesus Christ.
4. Encourages a synthesis of faith, life, and culture.
5. Develops a Catholic worldview and enables a deeper incorporation of the student into the heart of the Catholic Church. (Cardinal Newman Society).

The Cardinal Newman Society proposes that Catholic intellectual inquiry might use the lenses of truth, beauty and goodness as evaluative criteria for subjects under consideration (Appendix A: Educating to Truth, Beauty, and Goodness). These lenses are implicit in the Catholic Curricular Standards and Dispositions and explicitly expressed in the following document (see high school standards).

Science and Religion

Both science and religion are important and legitimate ways of knowing. They are not intrinsically at odds, but rather, in their mutual search for truth, support each other in fruitful and promising ways. According to the Cardinal Newman Society's Catholic Curricular Standards and Dispositions Related to Scientific Topics K-6, there is a unity of faith and reason in which there is "no contradiction between the God of nature and the God of faith" (CS S.K6 GS2). In ***Laudato Si'*** Pope Francis explains that *"…science and religion, with their distinctive approaches to understanding reality, can enter into an intense dialogue fruitful for both"* (2015, para. 62). His statement builds upon the words of his predecessor, Pope John Paul II, who wrote, "Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes. Each can draw the other into a wider world, a world in which both can flourish. (1988)" While still preserving their autonomy and distinctiveness, science and religion are open to the discoveries and insights of one another.

In writing about the dialog between science and religion Pope John Paul II shared a unifying vision of "all things and all peoples in Christ, who is active and present with us in our daily lives – in our struggles, our sufferings, our joys and in our searchings – and who is the focus of the Church's life and witness." This unity involves both head and heart – the desire to understand and the desire for love. As we seek to understand and make sense of our world and our experiences, we do so by creating a common vision from many factors. "The one illuminates the many: it makes sense of the whole. … We move towards unity as we move towards meaning in our lives" (Letter to Father George V. Coyne, Director of the Vatican Observatory, 1988). Pope John Paul II concluded that "only a dynamic relationship between theology and science can reveal those limits which support the integrity of either discipline, so that theology does not profess a pseudo-science and science does not become an unconscious theology. …The uses of science have on more than one occasion proved massively destructive, and the reflections on religion have too often been sterile. We need each other to be what we must be, what we are called to be" (1988).

Speaking from the perspective of science, Charles Townes, Nobel Laureate in Physics writes, "Science and religion are often viewed as separate aspects of our beliefs and understanding. But religion is an attempt to understand the purpose of our universe and science an attempt to understand its nature and characteristics, so the two are necessarily related" (The Center for Theology and the Natural Sciences). The Catholic Curricular Standards and Dispositions Related to Scientific Topics K-6 reiterate this from a religious perspective when they state that "science properly limits its focus to 'how' things physically exist and is not designed to answer issues of meaning, the value of things, or the mysteries of the human person" (CS S.K6 IS9). The scientific method thus complements the theological and philosophical questions that our students ask in order to understand God and His Works (CS S.K6 IS9). Therefore, the assumption that science can replace faith is mistaken (CS S.K6 IS10).

The Catechism of the Catholic Church further supports the reciprocal relationship between religion and science, or faith and reason, as follows:

> Consequently, methodical research in all branches of knowledge, provided it is carried out in a truly scientific manner and does not override moral laws, can never conflict with faith, because the things of the world and the things of faith derive from the same God. The humble and persevering investigator of the secrets of nature is being led, as it were, by the hand of God in spite of himself, for it is God, the conserver of all things, who made them what they are. …Though faith is above reason, there can never be any real discrepancy between faith and reason. Since the same God who reveals mysteries and infuses faith has bestowed the light of reason on the human mind, God cannot deny Himself, nor can truth ever contradict truth. (2016, Part I, p. 159).

Fr. Robert J. Spitzer, S.J. is the retired President of Gonzaga University and current President of the Magis Center (magiscenter.org), which produces educational materials, including books, articles, documentaries, videos and other media resources that explore the reciprocal relationship between science, philosophy and faith. Spitzer dismantles the myth that "faith and science are in conflict; science is truth; therefore, faith must be a fantasy," arguing instead that science does not, and cannot, disprove God. He concludes, "This secular myth does not stand up to the evidence for creation and transcendence from contemporary science. The evidence we present is quite compelling, and can maintain, defend, and even advance the faith of people who may be influenced by this myth" (https://www.magiscenter.org/science-reason-faith/). Teachers may wish to draw from the rich resources of the Magis Center as they work to counter this myth in their own settings.

Historical Overview

The Catholic Church has a long relationship with science. Founded in Rome in 1603 and international in scope, the Pontifical Academy of Sciences (originally called the Academy of the Lincei) seeks to honor pure science, assure its freedom and promote its research. Located in the Casina of Pius IV in the Vatican Gardens, the Academy is comprised of 80 esteemed Academicians from around the world who are appointed by the Pope. The Academy focuses on the areas of Fundamental Science, Science and Technology of Global Problems, Science for the Problems of the Developing World, Scientific Policy, Bioethics and Epistemology.

The Vatican's interest in astronomy dates back to Pope Gregory XIII, who engaged Jesuit astronomers and mathematicians to contribute to the reform of the calendar in the late sixteenth century. The Vatican has supported astronomical research ever since. When Pope Leo XIII established the Vatican Observatory in 1891, his intent was to show that "the Church and her Pastors are not opposed to true and solid science, whether human or divine, but that they embrace it, encourage it, and promote it with the fullest possible dedication." The present day mission of the Vatican Observatory is "to be on the frontier between the world of science and the world of faith, to give testimony that it is possible to believe in God and to be good scientists" (FAQ Science Religion). Many religious orders have contributed to the work of the Observatory, which was eventually relocated to a site 35 kilometers southeast of Rome. Due to light pollution in Rome, a second Vatican Observatory was built in Tuscon, Arizona in 1981.

By aligning the Diocese of Owensboro Academic Standards with Catholic Identity, we can further the essential dialog between science and religion and foster holistic approaches to education that nurture the spirit of the students while also cultivating their intellectual and emotional growth. This promises to bring about a fullness of knowledge, wisdom and grace.

A Sacramental Universe

Sacramental theology is a vitally important aspect of our Catholic Identity, for "…nature as a whole not only manifests God but is also a locus of his presence" (Pope Francis, 2015, para. 88). The intellectual standards of Catholic Curricular Standards and Dispositions Related to Scientific Topics K-6 state that "creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature" (CS S.K6 IS3). The Psalms and other scriptures proclaim the beauty that is evident in God's creation (CS S.K6 IS 4); beauty that opens our minds and hearts to wonder, awe, delight and reverence (CS S.K6 DS1).

In "Renewing the Earth" (1991) the United States Conference of Catholic Bishops (USCCB) write of a sacramental universe; "the whole universe is God's dwelling." They continue:

> Earth, a very small, uniquely blessed corner of that universe, gifted with unique natural blessings, is humanity's home, and humans are never so much at home as when God dwells with them. In the beginning, the first man and woman walked with God in the cool of the day. Throughout history, people have continued to meet the Creator on mountaintops, in vast deserts, and alongside waterfalls and gently flowing springs. In storms and earthquakes, they found expressions of divine power. In the cycle of the seasons and the courses of the stars, they have discerned signs of God's fidelity and wisdom. We still share, though dimly, in that sense of God's presence in nature. (United States Conference of Catholic Bishops, 1991).

Science helps to illuminate our sacramental universe, which is the context in which the seven sacraments of the Catholic Church are brought to life. The Catechism of the Catholic Church teaches that sacraments "touch all the stages and all the important moments of Christian life. … There is thus a certain resemblance between the stages of natural life and the stages of the spiritual life" (1994). Our Catholic prayers and liturgies "connect human praise with the numinous moments of the dawn and sunset and with the transitions of the seasons" (Berry, 1999, p. 25). By aligning the standards with the sacraments and with sacramentals such as holy water, which sanctify different circumstances of life, we can help young people to more deeply understand both science and religion in ways that support and enrich their intellectual and spiritual journeys. Relationships are at the heart of a sacramental universe. A sacramental view of nature extends outward toward the vast universe and inward to our homes, our families, the sanctity of the family meal and the many blessings that flow from the domestic church, as creation both inspires and nourishes us.

Systems/Relational Thinking and the Trinity

Relational or systems thinking lies at the core of both science and religion in our sacramental universe. It begins with the Trinity. In ***Laudato Si'*** Pope Francis writes,

> *The Father is the ultimate source of everything, the loving and self-communicating foundation of all that exists. The Son, His reflection, through whom all things were created, united Himself to this earth when He was formed in the womb of Mary. The Spirit, infinite bond of love, is intimately present at the very heart of the universe, inspiring and bringing new pathways*. (2015, para. 238)

Pope Francis explains that God is in intimate relationship with creation, for “the Trinity has left its mark on all creation” (para. 239). He continues, “Everything is interconnected, and this invites us to develop a spirituality of that global solidarity which flows from the mystery of the Trinity” (2015, para. 240). “…The world, created according to the divine model, is a web of relationships. Creatures tend towards God, and in turn it is proper to every living being to tend towards other things, so that through the universe we can find any number of constant and secretly interwoven relationships” (para. 240).

According to Fr. Richard Rohr, the Trinity reveals the heart of the nature of God; relationship and communion are part of the character of our loving God. We find these dynamics throughout God’s creation. Rohr writes, “Trinity is rather perfectly mirrored in the three particles of every atom orbiting and cycling around one another—the basic physical building block of the universe. What happens if these atoms are intentionally destabilized? We have a bomb of death and destruction” (Rohr, 2017).

Saints and Holy People of God

These interwoven relationships exist not only between all of creation, but also between the living and the dead through the communion of saints. The lives, works, and writings of Catholic saints and holy people of God further illuminate our understanding of the Trinity, sacramentality, relationships and communion, which may be joined to scientific understanding in the Christian pursuit of holiness. This document makes connections between the Diocese of Owensboro Academic Standards and holy people of God such as St. Albert the Great, patron saint of Science, St. Francis of Assisi, patron saint of ecology and animals, Saints Isadore and Maria, patron saints of farmers, St. Patrick, the patron saint of engineers, and others. As with Catholic scientists, teachers are encouraged to supplement the teaching of science with inspiring biographies.

Catholic Social Teaching

Whether we are exploring systems of specialized cells within organisms, feedback mechanisms, cycling and energy, ecosystems, or the movement of planetary bodies in orbit, relational thinking provides news ways to envision the Body of Christ in the world. “A Place at the Table,” A Pastoral Reflection of the U.S. Catholic Bishops, uses the metaphor of a table to cultivate a relational or systemic worldview as we seek to serve and stand in solidarity with the poor. The first leg of the table is what families and individuals are able to do. The second leg is the role and responsibility of community organizations and faith-based institutions. The third leg is the marketplace and institutions of business, commerce and labor. The fourth leg is the role and responsibility of government. The common good is served when all human endeavors are united toward the shared goal of a place at the table. We see these come together in Catholic Social Teaching (http://www.usccb.org/).

"The Church's social teaching is a rich treasure of wisdom about building a just society and living lives of holiness amidst the challenges of modern society" (http://www.usccb.org/beliefs-and-teachings/what-we-believe/catholic-social-teaching/seven-themes-of-catholic-social-teaching.cfm). The seven themes of Catholic Social Teaching are as follows:

1. Life and the Dignity of the Human Person
2. Call to Family, Community, and Participation
3. Rights and Responsibilities
4. Option for the Poor and Vulnerable
5. The Dignity of Work and the Rights of Workers
6. Solidarity
7. Care for God's Creation

The USCCB explains that these teachings are based on and inseparable from the first theme – Life and Dignity of the human person:

> Every human being is created in the image of God and redeemed by Jesus Christ, and therefore is invaluable and worthy of respect as a member of the human family. Every person, from the moment of conception to natural death, has inherent dignity and a right to life consistent with that dignity." (http://www.usccb.org/)

By aligning the Diocese of Owensboro Academic Standards for Science with Catholic Social Teaching, we can better assist our students in reflecting deeply and critically about scientific information related to everyday life and develop an informed conscience regarding abortion, euthanasia, cloning, embryonic stem cell research, agriculture, creation, ecology, energy, genetic engineering, natural resources, scientific experimentation and more.

Religion and the Environment

Life and the dignity of the human person are directly connected to care of God's creation. On September 1, 2016, Pope Francis added care for creation, our common home, to the Corporal and Spiritual Works of Mercy. Over the past few decades the last three Popes, the USCCB, and Catholic theologians have issued strong statements regarding environmentalism as a moral issue.

In his World Day of Peace address in 1990 Pope John Paul II acknowledged the ecological crisis and identified care of creation as an overarching concern for the 21st century. The Pope saw human dignity as directly linked with a healthy environment.

He proclaimed:

> The ecological crisis reveals the urgent moral need for a new solidarity, especially in relations between the developing nations and those that are highly industrialized. …When the ecological crisis is set within the broader context of the search for peace within society, we can understand better the importance of giving attention to what the earth and its atmosphere are telling us: namely, that there is an order in the universe which must be respected, and that the human person, endowed with the capability of choosing freely, has a grave responsibility to preserve this order for the well-being of future generations. I wish to repeat that the ecological crisis is a moral issue. … (1990, para. 10).

Pope John Paul II's address was followed one year later with a pastoral statement of the USCCB entitled "Renewing the Earth, An Invitation to Reflection and Action on Environment in Light of Catholic Social Teaching," which built upon the Pope's address and related Catholic Social Teaching to the environment, extending our understanding of what it means to be pro-life and highlighting the plight of the poor, who suffer the most from environmental degradation.

In his Papal Encyclical, "Caritas in Veritate" (2009), Pope Benedict XVI reiterated the call to care for creation as "God's gift to everyone." His address at the Summit on Climate Change in 2009 points to the value of scientific literary: "The Earth is indeed a precious gift of the Creator who, in designing its intrinsic order, has given us guidelines that assist us as stewards of his creation" (2009). In 2010 Benedict delivered a World Day of Peace message entitled, "If you Want to Cultivate Peace, Protect Creation," in which he spoke of a plethora of environmental issues and the growing phenomenon of environmental refugees. He expressed the desire to save humanity from self-destruction.

Pope Francis drew upon the theological foundation of his predecessors when in 2015 he wrote the encyclical letter "***Laudato Si'***, *On Care for our Common Home*," which is the most thorough and extensive papal writing on the environment. The Pope affirms that "our relationship with the environment can never be isolated from our relationship with others and with God" (para. 119). Following the introduction, the encyclical is divided into six chapters that examine "different aspects of the rupture between humans and creation and the prospects for healing this relationship" (Nguyen, 2015). (For a full list of recent papal statements on the environment see (https://catholicclimatemovement.global/statements-on-climate-change-from-the-popes/).

Care for God's Creation has become a growing concern for the Catholic Church, as it is connected to all aspects of Catholic Social Teaching, with a respect for life at the forefront.

A Framework for K-12 Science Education

The Diocese of Owensboro Academic Standards for Science are an outgrowth of a foundational document entitled "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas" (2012), written by the Committee on Conceptual Framework for the New K-12 Science Education Standards and the National Research Council, and edited by Helen Quinn and Heidi Schweingruber. The following is an overview of some of the primary ideas presented in the framework as they relate to Catholic identity. The authors of the framework write:

> The overarching goal of our framework for K-12 science education is to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology (Committee on Conceptual Framework for the New K-12 Science Education Standards, et al., 2012, p. 1)

Psalm 24 tells us that the Earth belongs to God. Psalm 148 and other wisdom writings tell us that all of creation, as well as humans, praise the Creator. The wonder and awe evoked by science can lead us to a deeper knowledge of and love for the Creator and greater reverence for creation. This is reflected in the Cardinal Newman Society Catholic Curricular Standards: Give examples of the beauty evident in God's creation (CS S.K6 IS4); Display a sense of wonder and delight about the natural universe and its beauty (CS S.K6 DS1); Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences (CS S.712 GS4); Display a deep sense of wonder and delight about the natural universe (CS S.712 DS1). Beauty, wonder and appreciation of the natural world as God's creation may lead students to greater scientific and technological literacy, lifelong learning and related career paths as well as the cultivation of a well-formed conscience.

The Framework also expresses the intention to "help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change" (p. 9). Pope Francis addresses these issues in ***Laudato Si'***. In chapter 1, "*What is Happening to our Common Home*," the Pope writes about pollution and climate change, the climate as a common good, the issue of water, the loss of biodiversity, the decline in the quality of human life, the breakdown of society and global inequality. He writes, "…*a true ecological approach always becomes a social approach; it must integrate questions of justice in debates on the environment, so as to hear both the cry of the Earth and the cry of the poor*" (2015, para. 49).

The Pope's statement underscores Catholic Social Teaching, with its preferential option for the poor, who suffer disproportionately from these major challenges. The U.S. Conference of Catholic Bishops write, "A basic moral test is how our most vulnerable members are faring" (http://www.usccb.org/). A solid understanding of science helps us to understand the forces of nature that contribute to poverty and the plight of the poor and provides insight into solutions.

Structure of the Framework

The framework is comprised of three dimensions, each of which align with Catholic Identity.

Dimension 1 describes scientific and engineering practices for the K-12 science classrooms.

1. Asking questions (for science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

In elaborating these practices, the Framework again makes connections to global issues:

> Students may then recognize that science and engineering can contribute to meeting many of the major challenges that confront society today, such as generating sufficient energy, preventing and treating disease, maintaining supplies of fresh water and food, and addressing climate change. (p. 43).

Understanding processes and practices is essential to cultivating the minds and hearts of scientists as well as theologians. In their search for truth, science and theology use different methods. Unlike science, theology includes revealed knowledge. Both science and theology, however, leave us with unanswered questions that point to a Mystery beyond human limits of knowing in this life.

Dimension 2 describes crosscutting concepts that have applicability across science disciplines:

1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter
6. Structure and function
7. Stability and change

The authors of the Framework explain:

> One assumption of all science and engineering is that there is a limited and universal set of fundamental physical interactions that underlie all known forces and hence are a root part of any causal chain, whether in natural or designed systems. Such "universality" means that the physical laws underlying all processes are the same everywhere and at all times; they depend on gravity, electromagnetism, or weak and strong nuclear interactions. Underlying all biological processes—the inner workings of a cell or even of a brain—are particular physical and chemical processes. At the larger scale of biological systems, the universality of life manifests itself in a common genetic code (p. 88).

Universality is also a cornerstone of Catholicism. In ***Laudato Si'*** Pope Francis writes that "*creation is of the order of love. God's love is the fundamental moving force in all created things…*" (2015, para. 77). The Pope speaks of "*a universal communion*." He explains that, "*as part of the universe, called into being by one Father, all of us are linked by unseen bonds and together form a kind of universal family, a sublime communion which fills us with a sacred, affectionate and humble respect*" (para. 89). He continues, "*when our hearts are authentically open to universal communion, this sense of fraternity excludes nothing and no one*" (para. 92). In this sacramental view, the Earth is a communion of subjects, not a collection of objects (Berry, 1999).

Both science and religion, then, lead us to a universal unity, or to what St. Bonaventure in the thirteenth century referred to as the Great Chain of Being. There were seven essential and unbreakable links in this sacred and coherent worldview: the Divine Creator, the angelic/heavenly, the human, the animal, the world of plants and vegetation, the waters upon the earth, and the Earth itself with its minerals. All of the links, individually and together, proclaimed the glory of God and the inherent dignity of creation. Eliminating a link would cause the chain to fall apart. Fr. Richard Rohr suggests that perhaps many of the global challenges we are experiencing today are a result of these broken chains. Scientific literacy promises to restore an understanding of the interconnectedness of all creation.

Dimension 3 describes core ideas in the science disciplines and of the relationships among science, engineering, and technology. The domains of this dimension are:

- the physical sciences
- the life sciences
- the earth and space sciences
- engineering, technology, and applications of science.

Disciplinary Core Ideas— Physical Sciences

Core Idea PS1: Matter and Its Interactions
Core Idea PS2: Motion and Stability: Forces and Interactions
Core Idea PS3: Energy
Core Idea PS4: Waves and Their Applications in Technologies for Information Transfer

The Framework states:

> Most systems or processes depend at some level on physical and chemical sub-processes that occur within it, whether the system in question is a star, Earth's atmosphere, a river, a bicycle, the human brain, or a living cell. Large-scale systems often have emergent properties that cannot be explained on the basis of atomic-scale processes; nevertheless, to understand the physical and chemical basis of a system, one must ultimately consider the structure of matter at the atomic and subatomic scales to discover how it influences the system's larger scale structures, properties, and functions. … An overarching goal for learning in the physical sciences, therefore, is to help students see that there are mechanisms of cause and effect in all systems and processes that can be understood through a common set of physical and chemical principles (p. 103).

Like Pope Francis, Pope John Paul II saw that science is "endowing us with an understanding and appreciation of our universe as a whole and of the incredibly rich variety of intricately related processes and structures which constitute its animate and inanimate components." He wrote that "the quest for the unification of all four fundamental physical forces – gravitation, electromagnetism, the strong and weak nuclear interactions – has met with increasing success." The Pope followed this statement with a question: "Is it not important for us to note that in a world of such detailed specialization as contemporary physics there exists this drive towards convergence?" (Letter to Father George V. Coyne, 1988).

Disciplinary Core Ideas —Life Sciences

Core Idea LS1: From Molecules to Organisms: Structures and Processes
Core Idea LS2: Ecosystems: Interactions, Energy, and Dynamics
Core Idea LS3: Heredity: Inheritance and Variation of Traits
Core Idea LS4: Biological Evolution: Unity and Diversity

The Framework states:

> The life sciences focus on patterns, processes, and relationships of living organisms. … Life scientists use observations, experiments, hypotheses, tests, models, theory, and technology to explore how life works. The study of life ranges over scales from single molecules, through organisms and ecosystems, to the entire biosphere, that is all life on Earth. …Living systems are interconnected and interacting. … Rapid advances in life sciences are helping to provide biological solutions to societal problems related to food, energy, health, and environment. From viruses and bacteria to plants to fungi to animals, the diversity of the millions of life forms on Earth is astonishing.
>
> Without unifying principles, it would be difficult to make sense of the living world and apply those understandings to solving problems (p. 139-140).

We can see that, again, the Framework is concerned with applications of science toward the common good. It further elaborates upon concepts related to biodiversity and the environment:

> Human beings are part of and depend on the natural world. Biodiversity—the multiplicity of genes, species, and ecosystems—provides humans with renewable resources, such as food, medicines, and clean water.
>
> The resources of biological communities can be used within sustainable limits, but in many cases humans affect these ecosystems in ways—including habitat destruction, pollution of air and water, overexploitation of resources, introduction of invasive species, and climate change—that prevent the sustainable use of resources and lead to ecosystem degradation, species extinction, and the loss of valuable ecosystem services (p. 166).

The unifying principles of science converge with those of Catholicism in articulating a sacred universe in which all is one in Christ. Pope John Paul II focused on this unity when he wrote, "In the *life sciences*, too, something similar has happened. Molecular biologists have probed the structure of living material, its functions and its processes of replication. They have discovered that the same underlying constituents serve in the make-up of all living organisms on earth and constitute both the genes and the proteins which these genes code. This is another impressive manifestation of the unity of nature" (Letter to Father George V. Coyne, 1988).

The science standards pertaining to heredity may be connected to the first theme of Catholic Social Teaching – Life and Dignity of the Human Person – and the related moral issues involving in vitro fertilization, abortion, human cloning, embryonic stem cell research and human genetic manipulation. The Cardinal Newman Standards likewise address the primary care and concern for each person as an image and likeness of God at all stages of life (CS S.712 GS1), for the human body is a temple of the Holy Spirit (CS S.712 GS3).

The Catholic Church also addresses the issue of biodiversity. St. Thomas Aquinas wrote:

> For He brought things into being in order that His goodness might be communicated to creatures, and be represented by them; and because His goodness could not be adequately represented by one creature alone, He produced many and diverse creatures, that what was wanting to one in the representation of the divine goodness might be supplied by another. For goodness, which in God is simple and uniform, in creatures is manifold and divided and hence the whole universe together participates in the divine goodness more perfectly, and represents it better than any single creature whatever. (Summa Theologiae, First Part, Question 47)

Pope Francis picks up where Aquinas left off when he writes, "When we can see God reflected in all that exists, our hearts are moved to praise the Lord for all His creatures and to worship Him in union with them" (2015, para. 87). This theology also pertains to the human community, including the poor, refugees and immigrants.

As discussed earlier, Care for God's Creation is a concern of Catholics as well as science. The United States Conference of Catholic Bishops states: "We show our respect for the Creator by our stewardship of creation. Care for the earth is not just an Earth Day slogan, it is a requirement of our faith. We are called to protect people and the planet, living our faith in relationship with all of God's creation. This environmental challenge has fundamental moral and ethical dimensions that cannot be ignored" (http://www.usccb.org/). (For more on this theme see: http://www.usccb.org/issues-and-action/human-life-and-dignity/environment/index.cfm.)

Disciplinary Core Ideas—Earth and Space Sciences

Core Idea ESS1: Earth's Place in the Universe
Core Idea ESS2: Earth's Systems
Core Idea ESS3: Earth and Human Activity

The Framework states:

> Earth and space sciences (ESS) investigate processes that operate on Earth and also address its place in the solar system and the galaxy. Thus ESS involve phenomena that range in scale from the unimaginably large to the invisibly small.
>
> Earth consists of a set of systems—atmosphere, hydrosphere, geosphere, and biosphere—that are intricately interconnected. These systems have differing sources of energy, and matter cycles within and among them in multiple ways and on various time scales. Small changes in one part of one system can have large and sudden consequences in parts of other systems, or they can have no effect at all. Understanding the different processes that cause Earth to change over time (in a sense, how it "works") therefore requires knowledge of the multiple systems' interconnections and feedbacks. In addition, Earth is part of a broader system—the solar system—which is itself a small part of one of the

> many galaxies in the universe (p. 169 -170). Astronomy and space exploration have prompted new ideas about how the universe works and of humans' place in it (p. 172).

Again, relational or systems thinking lies at the core of both science and religion. It begins and ends with the theology of the Trinity. Everything in God's creation is related to everything else. We are bonded to God, each other, and creation in love, through Jesus Christ, who unites spirit and matter, heaven and Earth, in union with the Holy Spirit. In the end, our Trinitarian God will reconcile all to Himself. Understanding our place in the universe engenders humility and stewardship.

Disciplinary Core Ideas— Engineering, Technology, and Applications of Science

Core Idea ETS1: Engineering Design
Core Idea ETS2: Links Among Engineering, Technology, Science, and Society

The Framework states:

> Students should learn how scientific knowledge is acquired and how scientific explanations are developed. They should learn how science is utilized, in particular through the engineering design process, and they should come to appreciate the distinctions and relationships between engineering, technology, and applications of science (ETS).
>
> The second ETS core idea calls for students to explore, as its name implies, the "Links Among Engineering, Technology, Science, and Society" (ETS2). The applications of science knowledge and practices to engineering, as well as to such areas as medicine and agriculture, have contributed to the technologies and the systems that support them that serve people today. Insights gained from scientific discovery have altered the ways in which buildings, bridges, and cities are constructed; changed the operations of factories; led to new methods of generating and distributing energy; and created new modes of travel and communication. Scientific insights have informed methods of food production, waste disposal, and the diagnosis and treatment of disease (p. 202). [Students'] appreciation of the interface of science, engineering, and society should give them deeper insights into local, national, and global issues (p. 203).

Links among engineering, technology, science, and society further demonstrate the connectedness of all things as the impetus to use our knowledge, skills and methods toward the common good. As Catholics, we believe that they should always be viewed in light of Catholic Social Teaching, which holds life and dignity of the human as its overarching value, and thus they should be used "at the service of humanity and, ultimately, to God, in harmony with His purposes" (CS S.K6IS7).

Conclusion

Pope John Paul II proposed that “the unity we perceive in creation on the basis of our faith in Jesus Christ as Lord of the universe, and the correlative unity for which we strive in our human communities, seems to be reflected and even reinforced in what contemporary science is revealing to us” (Letter to Father George V. Coyne, 1988). Both science and religion, then, take us to a shared vision of a diverse, yet unified and relational universe. As Catholics, we believe that all is one in and through the Trinity. As teachers, may we lead our students to the universal communion articulated by science and religion so that they may find wholeness and holiness within themselves and creation. And may we lead them ever outward toward an understanding of themselves as members of the Body of Christ in the world.

Scripture, tradition, Catholic Social Teaching, the Cardinal Newman Society Catholic Curricular Standards and Dispositions Related to Scientific Topics, and the Framework for K-12 Science Education offer us a sure guide for using science, engineering and technology toward the common good, while the Church and the sacraments nourish our souls, giving us food for the journey. The Eucharist is the center of our lives as Catholics. Science can provide a deeper understanding of “fruit of the vine and work of human hands,” while religion takes us into the heart of transubstantiation. Science and religion are essential partners in the holistic education of our Catholic youth so that they might fully “share in the Church's mission, to proclaim the message of Jesus Christ as lived out in the Catholic Church which creates a worshipping community of believers whose service is a witness of their Christian love” (The mission of the Catholic Schools of the Diocese of Owensboro).

References

Barnes, N., Dinges, B., Ph.D., Gilleo, M., Howes, D., James, M., Ph.D., Kalkbrenner, L. C., . . . Weldon, L. (2011). Sustainability and Catholic Higher Education: A Toolkit for Mission Integration. Retrieved April 2, 2017, from http://www.usccb.org/issues-and-action/human-life-and-dignity/environment/upload/sustainability-catholic-higher-ed-toolkit.pdf

Berry, T. (1999). *The Great Work, Our Way into the Future.* New York: Bell Tower

Cardinal Newman Society. (n.d.). Catholic Curricular Standards and Dispositions Related to Scientific Topics K-6. Retrieved April 2, 2017, from https://cardinalnewmansociety.org/catholic-curriculum-standards/scientific-topics-k-6/

Cardinal Newman Society. (n.d.). Catholic Curricular Standards and Dispositions Related to Scientific Topics 7-12. Retrieved April 02, 2017, from https://cardinalnewmansociety.org/catholic-curriculum-standards/scientific-topics-7-12/

Catechism of the Catholic Church, 2nd Ed. (2016). Retrieved April 02, 2017, from http://ccc.usccb.org/flipbooks/catechism/files/assets/basic-html/page-1.html#

Catechism of the Catholic Church - The seven sacraments of the Church. (n.d.). Retrieved April 02, 2017, from http://www.vatican.va/archive/ccc_css/archive/catechism/p2s2.htm

Committee on Conceptual Framework for the New K-12 Science Education Standards, Education, B. O., Division of Behavioral and Social Sciences and Education, Council, N. R., Quinn, H., Schweingruber, H., & Keller, T. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Academies Press.

Explanation of the Catholic Curriculum Standards. (n.d.). Retrieved April 02, 2017, from https://cardinalnewmansociety.org/catholic-curriculum-standards/explanation-catholic-curriculum-standards/

FAQ Science Religion. (n.d.). Retrieved April 02, 2017, from http://www.vaticanobservatory.va/content/specolavaticana/en/science--religion--society/faq-science-religion.html

Letter to Father George V. Coyne, Director of the Vatican Observatory (June 1, 1988) | John Paul II. (1988). Retrieved April 02, 2017, from https://w2.vatican.va/content/john-paul-ii/en/letters/1988/documents/hf_jp-ii_let_19880601_padre-coyne.html

Nguyen, A., SJ (2015, June 18). An Overview of Laudato Si. Retrieved April 02, 2017, from https://thejesuitpost.org/2015/06/an-overview-of-laudato-si/

Pope Francis (2015, May 25). Laudato Si' (24 May 2015) | Francis. Retrieved April 02, 2017, from http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html

Pope John Paul II on Science and Religion: A Deeply Appreciative Reflection. (1988). Retrieved April 02, 2017, from http://inters.org/reflection-on-John-Paul-II-science-religion

Pope John Paul II (1990). Peace with God the Creator, Peace with all of Creation. Retrieved April 2, 2017, from read:http://w2.vatican.va/content/john-paul-ii/en/messages/peace/documents/hf_jp-ii_mes_19891208_xxiii-world-day-for-peace.html

Rohr, R., OFM. (2017, February 22). Unity in Diversity. Retrieved April 02, 2017, from https://cac.org/unity-in-diversity-2017-03-03/

Seven themes of Catholic Social Teaching. (n.d.). Retrieved April 02, 2017, from http://www.usccb.org/beliefs-and-teachings/what-we-believe/catholic-social-teaching/seven-themes-of-catholic-social-teaching.cfm

Statements on Climate Change from the Popes. (n.d.). Retrieved April 03, 2017, from https://catholicclimatemovement.global/statements-on-climate-change-from-the-popes/

The Center for Theology and the Natural Sciences. (n.d.). Retrieved April 02, 2017, from http://www.ctns.org/

United States Conference of Catholic Bishops. (1991). Renewing the Earth. Retrieved April 02, 2017, from http://www.usccb.org/issues-and-action/human-life-and-dignity/environment/renewing-the-earth.cfm

United States Conference of Catholic Bishops. (n.d.). Seven themes of Catholic Social Teaching. Retrieved April 02, 2017, from http://www.usccb.org/beliefs-and-teachings/what-we-believe/catholic-social-teaching/seven-themes-of-catholic-social-teaching.cfm

United States Conference of Catholic Bishops. (n.d.). A Place at the Table. Retrieved April 02, 2017, from http://www.usccb.org/issues-and-action/human-life-and-dignity/poverty/place-at-the-table.cfm

Grades K-2 Engineering Design

K-2-ETS1 Engineering Design

K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Catholic Identity

- Noah was given precise directions to build a boat to withstand the flood (Genesis 6:14-16). This story from the Bible includes valuable data – the kind that is needed for engineering. [S]
- Building the Ark of the Covenant (Exodus 37, 38). [S]
- Simon builds a pyramid for the remains of his brother, Jonathan (1 Maccabees 13:25–30). [S]
- The skilled master worker lays the foundation and others build upon. Jesus is the foundation of Christian life (1 Corinthians 3:9-15). [S]
- The house of God is built upon the foundation of the apostles and prophets, with Jesus as the cornerstone (Ephesians 2:19-22). [S]

Scripture [S]

- "Unless the Lord builds the house, those who build it labor in vain." (Psalm 127:1)
- "Everyone then who hears these words of mine and does them will be like a wise man who built his house on the rock. And the rain fell, and the floods came, and the winds blew and beat on that house, but it did not fall, because it had been founded on the rock. And everyone who hears these words of mine and does not do them will be like a foolish man who built his house on the sand. And the rain fell, and the floods came, and the winds blew and beat against that house, and it fell, and great was the fall of it." (Matthew 7:24-27)
- "Everyone who comes to me and hears my words and does them, I will show you what he is like: he is like a man building a house, who dug deep and laid the foundation on the rock. And when a flood arose, the stream broke against that house and could not shake it, because it had been well built. But the one who hears and does not do them is like a man who built a house on the ground without a foundation. When the stream broke against it, immediately it fell, and the ruin of that house was great." (Luke 6:46-49)
- "For which of you, desiring to build a tower, does not first sit down and count the cost, whether he has enough to complete it?" (Luke 14:28)
- "As you come to him, a living stone rejected by men but in the sight of God chosen and precious, you yourselves like living stones are being built up as a spiritual house, to be a holy priesthood, to offer spiritual sacrifices acceptable to God through Jesus Christ. For it stands in Scripture: 'Behold, I am laying in Zion a stone, a cornerstone chosen and precious, and whoever believes in him will not be put to shame.' So the honor is for you who believe, but for those who do not believe, 'The stone that the builders rejected has become the cornerstone,' and 'A stone of stumbling, and a rock of offense.' They stumble because they disobey the word, as they were destined to do." (1 Peter 2:4-8)

Catholic/Christian Scientists:

- Johannes Gutenberg (Inventor of the printing press)

Saints [SA]

- St. Patrick, patron saint of engineers
- St. Isadore of Seville, patron saint of computer scientists and the Internet

K-2-ETS1 Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in K-2 builds on prior experiences and progresses to simple descriptive questions. • Ask questions based on observations to find more information about the natural and/or designed world. • Define a simple problem that can be solved through the development of a new or improved object or tool.	**ETS1.A Defining and Delimiting Engineering Problems** • A situation that people want to change or create can be approached as a problem to be solved through engineering. • Asking questions, making observations, and gathering information are helpful in thinking about problems. • Before beginning to design a solution, it is important to clearly understand the problem.	

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Identifying the phenomenon under investigation

a. Students ask questions and make observations to gather information about a situation that people want to change. Students' questions, observations, and information gathering are focused on:
  - A given situation that people wish to change.
  - Why people want the situation to change.
  - The desired outcome of changing the situation.

2. Identifying the scientific nature of the question

a. Students' questions are based on observations and information gathered about scientific phenomena that are important to the situation.

3. Identifying the problem to be solved

a. Students use the information they have gathered, including the answers to their questions, observations they have made, and scientific information, to describe the situation people want to change in terms of a simple problem that can be solved with the development of a new or improved object or tool.

4. Defining the features of the solution

a. With guidance, students describe the desired features of the tool or object that would solve the problem, based on scientific information, materials available, and potential related benefits to people and other living things.

Guided Questions

- How can creativity and curiosity help people to solve problems?

Catholic Identity Connections
• God has given each of us talents that allow us to solve problems and make the world a better place. • Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS9] • Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.2.1** Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. **W.2.6** With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. **W.2.8** Recall information from experiences or gather information from provided sources to answer a question. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **2.MD.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.
Connections to Other DCIs in Grades K-2
Connections to K-2-ETS1.A: Defining and Delimiting Engineering Problems include: Kindergarten: K-PS2-2, K-ESS3-2
Articulation to DCIs across Grade Levels
3-5.ETS1.A; **3-5.ETS1.C**

K-2-ETS1 Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, dramatization, or storyboard) that represent concrete events or design solutions. • Develop a simple model based on evidence to represent a proposed object or tool.	**ETS1.B Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.	**Structure and Function** • The shape and stability of structures of natural and designed objects are related to their function(s).

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Components of the model

a. Students develop a representation of an object and the problem it is intended to solve. In their representation, students include the following components:
   - The object.
   - The relevant shape(s) of the object.
   - The function of the object.

b. Students use sketches, drawings, or physical models to convey their representations.

2. Relationships

a. Students identify relationships between the components in their representation, including:
   - The shape(s) of the object and the object's function.
   - The object and the problem is it designed to solve.

3. Connections

a. Students use their representation (simple sketch, drawing, or physical model) to communicate the connections between the shape(s) of an object, and how the object could solve the problem.

Guided Questions

- How can creativity and curiosity help people to solve problems?

Catholic Identity Connections

- God has given each of us talents that allow us to solve problems and make the world a better place.
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS9]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **SL.2.5** Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.
Connections to Other DCIs in Grades K-2
Connections to K-2-ETS1.B: Developing Possible Solutions to Problems include: Kindergarten: K-ESS3-3, First Grade: 1-PS4-4, Second Grade: 2-LS2-2
Articulation to DCIs across Grade Levels
3-5.ETS1.A; **3-5.ETS1.B ; 3-5.ETS1.C**

K-2-ETS1 Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-3 Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Analyze data from tests of an object or tool to determine if it works as intended.	**ETS1.C Optimizing the Design Solution** • Because there is always more than one possible solution to a problem, it is useful to compare and test designs.	

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Organizing data

a. With guidance, students use graphical displays (e.g., tables, pictographs, line plots) to organize given data from tests of two objects, including data about the features and relative performance of each solution.

2. Identifying relationships

a. Students use their organization of the data to find patterns in the data, including:
   - How each of the objects performed, relative to:
     - The other object.
     - The intended performance.
   - How various features (e.g., shape, thickness) of the objects relate to their performance (e.g., speed, strength).

3. Interpreting data

a. Students use the patterns they found in object performance to describe:
   - The way (e.g., physical process, qualities of the solution) each object will solve the problem.
   - The strengths and weaknesses of each design.
   - Which object is better suited to the desired function, if both solve the problem.

Guided Questions

- How can creativity and curiosity help people to solve problems?

Catholic Identity Connections

- God has given each of us talents that allow us to solve problems and make the world a better place.
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS9]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.2.6** With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. **W.2.8** Recall information from experiences or gather information from provided sources to answer a question. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **2.MD.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.
Connections to Other DCIs in Grades K-2
Connections to K-2-ETS1.C: Optimizing the Design Solution include: Second Grade: 2-ESS2-1
Articulation to DCIs across Grade Levels
3-5.ETS1.A; 3-5.ETS1.B; **3-5.ETS1.C**

Kindergarten Standards

K-PS2 Motion and Stability: Forces and Interactions

K-PS2-1 Plan and conduct an investigation to compare the effects of different strengths on different directions of pushes and pulls on the motion of an object.
K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or pull.

Catholic/Christian Scientists

- Roger Bacon (Franciscan friar and early advocate of the scientific method)
- Marin Mersenne (acoustics)

Saints [SA]

- St. Albert the Great (Albertus Magnus) (Catholic bishop, patron saint of scientists)

K-PS3 Energy

K-PS3-1 Make observations to determine the effect of sunlight on Earth's surface.
K-PS3-2 Use tools and materials to design and build a structure that will reduce the warming effects of sunlight on an area.

Catholic/Christian Scientists

- Theodoric of Freiberg (the rainbow)

K-LS1 From Molecules to Organisms: Structures and Processes

K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive.

Catholic/Christian Scientists

- Carl Linnaeus (Botany)
- Stephan Endlicher (Botany)
- James Britton (Botany)
- Andrea Cesalpino (Botany)
- James Britten (Botany)

K-ESS2 Earth's Systems

K-ESS2-1 Use and share observations of local weather conditions to describe patterns over time.
K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

Catholic/Christian Scientists

- Evangelista Torricelli (Inventor of the barometer)
- Nicolas Steno (Bishop, and father of stratigraphy)

K-ESS3 Earth and Human Activity

K-ESS3-1 Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.
K-ESS3-2 Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.
K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

Catholic Identity

- God provides for his creation. We are called to live in harmony with the places in which we live.
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- In the biblical book of Exodus God provides the Israelites with manna in the desert and birds to eat. [S]

Scripture [S]

- "How varied are your works, Lord! In wisdom you have made them all; the earth is full of your creatures. There is the sea, great and wide! It teems with countless beings, living things both large and small. There ships ply their course and Leviathan, whom you formed to play with. All of these look to you to give them food in due time. When you give it to them, they gather; when you open your hand, they are well filled. When you hide your face, they panic. Take away their breath, they perish and return to the dust. Send forth your spirit, they are created and you renew the face of the earth." (Psalm 104:24-30)
- After the flood God makes a covenant with Noah, his sons, and all of creation:
  "God said to Noah and to his sons with him: 'See, I am now establishing my covenant with you and your descendants after you and with every living creature that was with you: the birds, the tame animals, and all the wild animals that were with you—all that came out of the ark. I will establish my covenant with you, that never again shall all creatures be destroyed by the waters of a flood; there shall not be another flood to devastate the earth.' God said: 'This is the sign of the covenant that I am making between me and you and every living creature with you for all ages to come: I set my bow in the clouds to serve as a sign of the covenant between me and the earth. When I bring clouds over the earth, and the bow appears in the clouds, I will remember my covenant between me and you and every living creature—every mortal being—so that the waters will never again become a flood to destroy every mortal being. When the bow appears in the clouds, I will see it and remember the everlasting covenant between God and every living creature—every mortal being that is on earth.' God told Noah: 'This is the sign of the covenant I have established between me and every mortal being that is on earth.'" (Genesis 9:8-17)

Catholic/Christian Scientists

- Rachel Carson
- Sr. Paula Gonzales
- Evangelista Torricelli (Inventor of the barometer)

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

K-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

K-PS2-1 Plan and conduct investigations to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.

Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.

Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • With guidance, plan and conduct an investigation in collaboration with peers. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientists use different ways to study the world.	**PS2.A Forces and Motion** • Pushes and pulls can have different strengths and directions. • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. **PS2.B Types of Interactions** • When objects touch or collide, they push on one another and can change motion. **PS3.C Relationship Between Energy and Forces** • A bigger push or pull makes things speed up or slow down more quickly. (secondary emphasis)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Identifying the phenomenon under investigation

a. With guidance, students collaboratively identify the phenomenon under investigation, which includes the effect caused by different strengths and directions of pushes and pulls on the motion of an object.

b. With guidance, students collaboratively identify the purpose of the investigation, which includes gathering evidence to support or refute student ideas about causes of the phenomenon by comparing the effects of different strengths of pushes and pulls on the motion of an object.

2. Identifying the evidence to address the purpose of the investigation

a. With guidance, students collaboratively develop an investigation plan to investigate the relationship between the strength and direction of pushes and pulls and the motion of an object (i.e., qualitative measures or expressions of strength and direction; e.g., harder, softer, descriptions of "which way").

b. Students describe how the observations they make connect to the purpose of the investigation, including how the observations of the effects on object motion allow causal relationships between pushes and pulls and object motion to be determined.

c. Students predict the effect of the push or pull on the motion of the object, based on prior experiences.

3. Planning the investigation

a. In the collaboratively developed investigation plan, students identify and describe:
   - The object whose motion will be investigated.
   - What will be in contact with the object to cause the push or pull.
   - The relative strengths of the push or pull that will be applied to the object to start or stop its motion or change its speed.
   - The relative directions of the push or pull that will be applied to the object.
   - How the motion of the object will be observed and recorded.
   - How the push or pull will be applied to vary strength or direction.

4. Collecting the data

a. According to the investigation plan they developed, and with guidance, students collaboratively make observations that would allow them to compare the effect on the motion of the object caused by changes in the strength or direction of the pushes and pulls and record their data.

Guided Questions

- How does the motion of the object change based on the strength of the push or pull?
- How does the motion of the object change based on the direction of the push or pull?

Catholic Identity Connections

- The Holy Spirit, the scriptures, the Church, the sacraments, and the beauty of creation pull us toward God. [S] [SC]
- Love is God's pull on our hearts.
- We are sometimes pushed from the path of doing what is right and pulled toward making bad decisions.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

Mathematics

MP.2 Reason abstractly and quantitatively.

K.MD.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.

K.MD.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference.

Connections to Other DCIs in Kindergarten

N/A

Articulation to DCIs across Grade Levels

3.PS2.A; 3.PS2.B; 4.PS3.A

K-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.

Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.

Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Analyze data from tests of an object or tool to determine if it works as intended.	**PS2A Forces and Motion** • Pushes and pulls can have different strengths and directions. • Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. **ETS1.A Defining Engineering Problems** • A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have acceptable solutions.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Organizing data

a. With guidance, students organize given information using graphical or visual displays (e.g., pictures, pictographs, drawings, written observations, tables, charts). The given information students organize includes:
   - The relative speed or direction of the object before a push or pull is applied (i.e., quantitative measures and expressions of speed and direction; e.g., faster, slower, descriptions of "which way").
   - The relative speed or direction of the object after a push or pull is applied.
   - How the relative strength of a push or pull affects the speed or direction of an object (i.e., qualitative measures or expressions of strength; e.g., harder, softer).

2. Identifying relationships

a. Using their organization of the given information, students describe relative changes in the speed or direction of the object caused by pushes or pulls from the design solution.

3. Interpreting data

a. Students describe the goal of the design solution.
b. Students describe their ideas about how the push or pull from the design solution causes the change in the object's motion.
c. Based on the relationships they observed in the data, students describe whether the push or pull from the design solution causes the intended change in speed or direction of motion of the object.

Guided Questions
• How does the push or pull from the design solution cause a change in the object's motion?
Catholic Identity Connections
• With the help of Jesus, we are able to follow the path in the direction of love and kindness. • What are those things that pull us more strongly and quickly towards God? • Sometimes something big happens in our lives that make us change direction. • Christian saints and heroes show us the way to God through their lives. [SA]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.K.1** With prompting and support, ask and answer questions about key details in a text. **SL.K.3** Ask and answer questions in order to seek help, get information, or clarify something that is not understood.
Connections to Other DCIs in Kindergarten
K.ETS1.A; K.ETS1.B
Articulation to DCIs across Grade Levels
2.ETS1.B; 3.PS2.A; 4.ETS1.A

K-PS3 Energy

Students who demonstrate understanding can:

K-PS3-1 Make observations to determine the effect of sunlight on Earth's surface.

Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water.

Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Make observations (firsthand or from media) to collect data that can be used to make comparisons. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientists use different ways to study the world.	**PS3.B Conservation of Energy and Energy Transfer** • Sunlight warms Earth's surface.	**Cause and Effect** • Events have causes that generate observable patterns.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students describe (with guidance) the phenomenon under investigation, which includes the idea that sunlight warms the Earth's surface.

b. Students describe (with guidance) the purpose of the investigation, which includes determining the effect of sunlight on Earth materials by identifying patterns of relative warmth of materials in sunlight and shade (e.g., sand, soil, rocks, water).

2. Identifying evidence to address the purpose of the investigation

a. Based on the given investigation plan, students describe (with guidance) the evidence that will result from the investigation, including observations of the relative warmth of materials in the presence and absence of sunlight (i.e., qualitative measures of temperature; e.g., hotter, warmer, colder).

b. Students describe how the observations they make connect to the purpose of the investigation.

3. Planning the investigation

a. Based on the given investigation plan, students describe (with guidance):
   - The materials on the Earth's surface to be investigated (e.g., dirt, sand, rocks, water, grass).
   - How the relative warmth of the materials will be observed and recorded.

4. Collecting the data

a. According to the given investigation plan and with guidance, students collect and record data that will allow them to:
   - Compare the warmth of Earth materials placed in sunlight and the same Earth materials placed in shade.
   - Identify patterns of relative warmth of materials in sunlight and shade (i.e., qualitative measures of temperature; e.g., hotter, warmer, colder).
   - Describe that sunlight warms the Earth's surface.

Guided Questions

- What are ways to reduce the warming effect of sunlight on Earth's surfaces?
- What are positive effects of the sun's warmth on the Earth?

Catholic Identity Connections

- God created the sun to provide the Earth with warmth and light.
- Jesus is the Light of the world who shines upon us and warms our hearts.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

Mathematics
K.MD.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference.

Connections to Other DCIs in Kindergarten

N/A

Articulation to DCIs across Grade Levels

1.PS4.B; 3.ESS2.D

K-PS3 Energy

Students who demonstrate understanding can:

K-PS3-2 Use tools and materials provided to design and build a structure that will reduce the warming effect of sunlight on Earth's surface.

Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.

Assessment Boundary: Assessment does not include friction as a mechanism for change in speed.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem.	**PS3.B Conservation of Energy and Energy Transfer** • Sunlight warms the Earth's surface.	**Cause and Effect** • Events have causes that generate observable patterns.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Using scientific knowledge to generate design solutions

a. Students use given scientific information about sunlight's warming effect on the Earth's surface to collaboratively design and build a structure that reduces warming caused by the sun.
b. With support, students individually describe:
   - The problem.
   - The design solution.
   - In what way the design solution uses the given scientific information.

2. Describing specific features of the design solution, including quantification when appropriate

a. Students describe that the structure is expected to reduce warming for a designated area by providing shade.
b. Students use only the given materials and tools when building the structure.

3. Evaluating potential solutions

a. Students describe whether the structure meets the expectations in terms of cause (structure blocks sunlight) and effect (less warming of the surface).

Guided Questions

- What are ways to reduce the warming effect of sunlight on Earth's surfaces?

Catholic Identity Connections

- Sometimes we take care of creation by making sure that people, plants and animals don't get too warm.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

Mathematics

K.MD.2 Directly compare two objects with a measurable attribute in common to see which object has "more of"/"less of" the attribute, and describe the difference.

Connections to Other DCIs in Kindergarten

K.ETS1.A; K.ETS1.B

Articulation to DCIs across Grade Levels

1.PS4.B; 2.ETS1.B; 4.ETS1.A

K-LS1 From Molecules to Organisms: Structures and Processes		
Students who demonstrate understanding can: **K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive.** Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations (firsthand and from media) to describe patterns in the natural world in order to answer scientific questions. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**LS1.C Organization for Matter and Energy Flow in Organisms** • All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.	**Patterns** • Patterns in the natural and human-designed world can be observed and used as evidence.
Examples of Observable Evidence of Student Performance by the End of Kindergarten		
1. Organizing data		
a. With guidance, students organize the given data from observations (firsthand and from media) using graphical displays (e.g., pictures, charts) including: • Different types of animals (including humans). • Data about the foods different animals eat. • Data about animal's drinking water. • Data about plants' need for water (e.g., observations of the effects on plants in a classroom or school when they are not watered; observations of natural areas that are very dry). • Data about plants' need for light (e.g., observations of the effects on plants in a classroom when they are kept in the dark for a long time; observations about the presence or absence of plants in very dark places, such as under rocks or porches).		

2. Identifying relationships

a. Students identify patterns in the organized data, including that:
- All animals eat food.
  - Some animals eat plants.
  - Some animals eat other animals.
  - Some animals eat both plants and animals.
- All animals drink water.
- Plants cannot live or grow if there is no water.
- Plants cannot live or grow if there is no light.

3. Interpreting data

a. Students describe that the patterns they identified in the data provide evidence that:
- Plants need light and water to live and grow.
- Animals need food and water to live and grow.
- Animals get their food from plants, other animals, or both.

Guided Questions

- What do plants and animals need to survive?
- How are plants and animals interdependent?

Catholic Identity Connections

- God created a world in which plants, animals and humans depend on the Earth and each other to survive. Everything is connected. Our bodies need food and water in order to survive. Our souls need God in order to survive.
  - Water and food are part of our physical lives and our spiritual lives. [SC]
  - Come to the water (Isaiah 55:1). [S]
  - Everyone needs to have their needs for food and water met (Life and Dignity of the Human Person; Option for the Poor and Vulnerable). [CST]
  - Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]
  - Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

Mathematics

K.MD.2 Directly compare two objects with a measurable attribute in common to see which object has "more of"/"less of" the attribute, and describe the difference.

Connections to Other DCIs in Kindergarten

N/A

Articulation to DCIs across Grade Levels

1.LS1.A; 2.LS2.A; 3.LS2.C; 3LS4.B; 5.LS1.C; 5.LS2.A

K-ESS2 Earth's Systems

Students who demonstrate understanding can:

K-ESS2-1 Use and share observations of local weather conditions to describe patterns over time.

Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days is different in different months.

Assessment Boundary: Assessment of quantitative observations is limited to whole numbers and relative measures such as warmer/cooler.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations (firsthand and from media) to describe patterns in the natural world in order to answer scientific questions. **Connections to Nature of Science** **Science Knowledge Is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**ESS2.D Weather and Climate** • Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. • People measure these conditions to describe and record the weather and to notice patterns over time.	**Patterns** • Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Organizing data

a. With guidance, students organize data from given observations (firsthand or from media) about local weather conditions using graphical displays (e.g., pictures, charts). The weather condition data could include:
   - The number of sunny, cloudy, rainy, windy, cool, or warm days.
   - The relative temperature at various times of the day (e.g., cooler in the morning, warmer during the day, cooler at night).

2. Identifying relationships

a. Students identify and describe patterns in the organized data, including:
   - The relative number of days of different types of weather conditions in a month.
   - The change in the relative temperature over the course of a day.

3. Interpreting data

a. Students describe and share that:
  - Certain months have more days of some kinds of weather than do other months (e.g., some months have more hot days, some have more rainy days).
  - The differences in relative temperature over the course of a day (e.g., between early morning and the afternoon, between one day and another) are directly related to the time of day.

Guided Questions

- How does the weather change throughout the year?
- How can knowing about the weather of a certain time of year in the past help us to predict the weather for that same time this year?

Catholic Identity Connections

- Share Biblical stories related to weather and climate: The story of Noah's Ark (Genesis 6-9); the voice of God in the great storm (Psalm 29). [S]
- Consider what it would be like to spend 40 days in the desert. [S]
- God's creation is filled with patterns, including weather patterns.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Clouds, rain, and snow may show the beauty of God.
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Saints [SA]
- St. Clare of Assisi, patron saint of good weather
- St. Eurosia, patron saint against bad weather

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them).

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
K.CC. Know number names and the count sequence.
K.MD.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object.
K.MD.3 Classify objects into given categories; count the number of objects in each category and sort the categories by count.

Connections to Other DCIs in Kindergarten

N/A

Articulation to DCIs across Grade Levels

2.ESS2.A; 3.ESS2.D; 4ESS2.A

K-ESS2 Earth's Systems

Students who demonstrate understanding can:

K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

Clarification Statement: Examples of plants and animals changing their environment could include that a squirrel digs in the ground to hide its food and tree roots can break concrete.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world. • Construct an argument with evidence to support a claim.	**ESS2.E Biogeology** • Plants and animals can change the environment. **ESS3.C Human Impacts on Earth Systems** • Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, and air, and other living things.	**Systems and System Models** • Systems in the natural and designed world have parts that work together.

Examples of Observable Evidence of Student Performance by the End of the Kindergarten

1. Supported claims

a. Students make a claim to be supported about a phenomenon. In their claim, students include the idea that plants and animals (including humans) can change the environment to meet their needs.

2. Identifying scientific evidence

a. Students identify and describe the given evidence to support the claim, including:
   - Examples of plants changing their environments (e.g., plant roots lifting sidewalks).
   - Examples of animals (including humans) changing their environments (e.g., ants building an ant hill, humans clearing land to build houses, birds building a nest, squirrels digging holes to hide food).
   - Examples of plant and animal needs (e.g., shelter, food, room to grow).

3. Evaluating and critiquing evidence

a. Students describe how the examples do or do not support the claim.

4. Reasoning and synthesis

a. Students support the claim and present an argument by logically connecting various needs of plants and animals to evidence about how plants and animals change their environments to meet their needs. Students include:
   - Examples of how plants affect other parts of their systems by changing their environments to meet their needs (e.g., roots push soil aside as they grow to better absorb water).
   - Examples of how animals affect other parts of their systems by changing their environments to meet their needs (e.g., ants, birds, rabbits, and humans use natural materials to build shelter; some animals store food for winter).

Guided Questions
• How do plants, animals, and people change their environment?
Catholic Identity Connections
• We are called to respect and care for all creation because it is a gift of God's love. • The choices we make can affect God's creation. • As Catholics we should seek to change the world in only good ways. • Care for God's creation. [CST] • Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2] **Saints [SA]** • St. Francis of Assisi, patron saint of ecologists • Saints Isadore and Maria, patron saints of farmers
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.K.1** With prompting and support, ask and answer questions about key details in a text. **W.K.1** Use a combination of drawing, dictating, pre-writing, and writing to compose opinion pieces in which they tell a reader the topic or the name of the book they are writing about and state an opinion or preference about the topic or book. **W.K.2** Use a combination of drawing, dictating, pre-writing, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.
Connections to Other DCIs in Kindergarten
N/A
Articulation to DCIs across Grade Levels
4.ESS2.E; 5.ESS2.A

K-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

K-ESS3-1 Use a model to represent the relationship between the needs of different plants and animals.

Clarification Statement: Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, dramatization, storyboard) that represent concrete events or design solutions. • Use a model to represent relationships in the natural world.	**ESS3.A Natural Resources** • Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.	**Systems and System Models** • Systems in the natural and designed world have parts that work together.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Components of the model

a. From the given model (e.g., representation, diagram, drawing, physical replica, dramatization, storyboard) of a phenomenon involving the needs of living things and their environments, students identify and describe the components that are relevant to their representations, including:
   - Different plants and animals (including humans).
   - The places where the different plants and animals live.

2. Relationships

a. Students use the given model to represent and describe relationships between the components, including:
   - The relationships between the different plants and animals and the materials they need to survive (e.g., fish need water to swim, deer need buds and leaves to eat, plants need water and sunlight to grow).
   - The relationships between places where different plants and animals live and the resources those places provide.
   - The relationships between specific plants and animals and where they live (e.g., fish live in water environments, deer live in forests where there are buds and leaves, rabbits live in fields and woods where there is grass to eat and space for burrows for homes, plants live in sunny and moist areas, humans get resources from nature [e.g., building materials from trees to help them live where they want to live]).

3. Connections

a. Students use the given model to describe:
   - The pattern of how the needs of different plants and animals are met by the various places in which they live (e.g., plants need sunlight so they are found in places that have sunlight; fish swim in water so they live in lakes, rivers, ponds, and oceans; deer eat buds and leaves so they live in the forest).
   - That plants and animals, the places in which they live, and the resources found in those places are part of a system, and that these parts of systems work together and allow living things to meet their needs.

Guided Questions

- How are the needs of different plants and animals met by the various places in which they live?
- What factors determine the optimal environment for a living thing?

Catholic Identity Connections
• Refer to Catholic Identity portion of the Kindergarten Earth and Space Science Standards overview at the beginning of this section.
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **SL.K.5** Add drawings or other visual displays to descriptions as desired to provide additional detail. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **K.CC** Counting and Cardinality
Connections to Other DCIs in Kindergarten
N/A
Articulation to DCIs across Grade Levels
1.LS1.A; 5.LS2.A; 5.ESS2.A

K-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

K-ESS3-2 Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.

Clarification Statement: Emphasis is on local forms of severe weather.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades K-2 builds on prior experiences and progresses to simple descriptive questions that can be tested. • Ask questions based on observations to find more information about the designed world. **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world.	**ESS3.B Natural Hazards** • Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. **ETS1.A Defining and Delimiting an Engineering Problem** • Asking questions, making observations, and gathering information are helpful in thinking about problems. (secondary emphasis)	**Cause and Effect** • Events have causes that generate observable patterns. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • People encounter questions about the natural world every day. **Influence of Engineering, Technology, and Science on Society and the Natural World** • People depend on various technologies in their lives; human life would be very different without technology.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Addressing phenomena of the natural world

a. Students formulate questions about local severe weather, the answers to which would clarify how weather forecasting can help people avoid the most serious impacts of severe weather events.

2. Identifying the scientific nature of the question

a. Students' questions are based on their observations.

3. Obtaining information

a. Students collect information (e.g., from questions, grade appropriate texts, media) about local severe weather warnings (e.g., tornado alerts, hurricane warnings, major thunderstorm warnings, winter storm warnings, severe drought alerts, heat wave alerts), including that:
   - There are patterns related to local severe weather that can be observed (e.g., certain types of severe weather happen more in certain places).
   - Weather patterns (e.g., some events are more likely in certain regions) help scientists predict severe weather before it happens.
   - Severe weather warnings are used to communicate predictions about severe weather.
   - Weather forecasting can help people plan for, and respond to, specific types of local weather (e.g., responses: stay indoors during severe weather, go to cooling centers during heat waves; preparations, evacuate coastal areas before a hurricane, or cover windows before storms).

Guided Questions

- How can weather forecasting help people plan for, and respond to, specific types of local weather?
- How can practicing severe weather drills help us to be prepared?

Catholic Identity Connections

- Sometimes bad weather is scary. Through prayer, we can ask for God's help and protection when we are frightened.
- Jesus calms the storm (Mark 4:35-41, Matthew 8:23, Luke 8:22). [S]

Catholic/Christian Scientists

- Evangelista Torricelli (Inventor of the barometer)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.K.1 With prompting and support, ask and answer questions about key details in a text.
SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood.

Mathematics

MP.4 Model with mathematics.
K.CC Counting and Cardinality

Connections to Other DCIs in Kindergarten

K.ETS1.A

Articulation to DCIs across Grade Levels

2.ESS1.C; 3.ESS3.B; 4.ESS3.B

K-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Communicate solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas.	**ESS3.C Human Impacts on Earth Systems** • Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. **ETS1.B Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (secondary emphasis)	**Cause and Effect** • Events have causes that generate observable patterns.

Examples of Observable Evidence of Student Performance by the End of Kindergarten

1. Communicating information

a. Students use prior experiences and observations to describe information about:
   - How people affect the land, water, air, and/or other living things in the local environment in positive and negative ways.
   - Solutions that reduce the negative effects of humans on the local environment.

b. Students communicate information about solutions that reduce the negative effects of humans on the local environment, including:
   - Examples of things that people do to live comfortably and how those things can cause changes to the land, water, air, and/or living things in the local environment.
   - Examples of choices that people can make to reduce negative impacts and the effect those choices have on the local environment.

c. Students communicate the information about solutions with others in oral and/or written form (which includes using models and/or drawings).

Guided Questions

- How can humans cause change to the local environment?
- What choices can people make to reduce negative impacts on the local environment?

Catholic Identity Connections
• As Christians we are called to make choices that do not hurt the land, water, air, and other living things. • Care for God's creation [CST] • Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2] **Saints [SA]** • St. Francis of Assisi, patron saint of ecologists • Saints Isadore and Maria, patron saints of farmers
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.K.2** Use a combination of drawing, dictating, pre-writing, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic.
Connections to Other DCIs in Kindergarten
K.ETS1.A
Articulation to DCIs across Grade Levels
2.ETS1.B; 4.ESS3.A; 5.ESS3.C

First Grade Standards

1-PS4 Waves and Their Applications in Technologies for Information Transfer

1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
1-PS4-2 Make observations to construct an evidence-based account that objects can be seen only when illuminated.
1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.
1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

Catholic/Christian Scientists

- Physics
    - Roger Bacon (Franciscan friar and early advocate of the scientific method)
    - Marin Mersenne (acoustics)
    - André-Marie Ampère (electromagnetism)
    - Antoine César Becquerel (electric and luminescent phenomena)
    - Vincenzo Viviani (Viviani's theorem, Viviani's curve and his work in determining the speed of sound)
    - Hippolyte Fizeau (the velocity of light)
    - Guglielmo Marconi (long-distance radio transmission)
    - Theodoric of Freiberg (the rainbow)
    - André-Marie Ampère (electromagnetism)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

1-LS1 From Molecules to Organisms: Structures and Processes

1-LS1-1 Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

1-LS1-2 Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

Scripture [S]

- "How varied are your works, Lord!
  In wisdom you have made them all; the earth is full of your creatures.
  There is the sea, great and wide!
  It teems with countless beings, living things both large and small." (Psalm 104: 24-25)

Catholic/Christian Scientists

- James Britten (botanist)
- Stephan Endlicher (botanist, plant classification)
- Sr. Paula González (biology)
- Antoine Laurent de Jussieu (natural classification of flowering plants)
- Carl Linnaeus (botanist, plant classification)
- Andrea Cesalpino

Saints [SA]

- St. Ambrose, patron saint of beekeepers
- St. Ansovinus, patron saint of gardeners
- St. Anthony of Padua, patron saint of harvests and lost animals
- St. Dorothy, patron saint of horticulture
- St. Gall, patron saint of birds
- St. Isadore the Farmer, patron saint of farmers
- St. Phocus, patron saint of gardeners, agricultural workers, farm workers, farmers and field hands
- St. Urban, patron saint of grape growers

1-LS3 Heredity: Inheritance and Variation of Traits

1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

Catholic/Christian Scientists

- Gregor Mendel (genetics through plant research)
- James Britten (botanist, member of the Catholic Truth Society and Knight Commander of the Order of St. Gregory the Great)
- Stephan Endlicher (botanist, plant classification)
- Sr. Paula González (biology)
- Antoine Laurent de Jussieu (natural classification of flowering plants)
- Theodor Schwann (theory of the cellular structure of animal organisms)
- Jérôme Lejeune (the link of diseases to chromosome abnormalities)

1-ESS1 Earth's Place in the Universe

1-ESS1-1 Use observations of the sun, moon, and stars to describe patterns that can be predicted.
1-ESS1-2 Make observations at different times of year to relate the amount of daylight to the time of year.

Catholic/Christian Scientists

- G.G. Coriolis Galileo Galilei (astronomer)
- Martin Stanislaus Brennan (priest, astronomer and writer)
- Giovanni Domenico Cassini (first to observe four of Saturn's moons and the co-discoverer of the Great Red Spot on Jupiter)
- Christopher Clavius (Jesuit, the Gregorian calendar)
- Nicolas Louis de Lacaille (French astronomer, cataloged stars, nebulous objects, and constellations)
- Pierre-Simon Laplace (the "Newton of France")
- Paolo dal Pozzo Toscanelli (Italian mathematician, astronomer and cosmographer)
- Eduard Heis (contributed the first true delineation of the Milky Way)
- Gaspard-Gustave Coriolis (laws regarding rotating systems - the Corialis effect)
- Léon Foucault (the Foucault pendulum - measures the effect of the earth's rotation)

Saints [SA]

- St. Dominic, patron saint of astronomers

1-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.

Clarification Statement: Examples of vibrating materials that make sound include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct investigations collaboratively to produce evidence to answer a question. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Science investigations begin with a question. • Scientists use different ways to study the world.	**PS4.A Wave Properties** • Sound can make matter vibrate, and vibrating matter can make sound.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Identifying the phenomenon under investigation

a. Students identify and describe the phenomenon and purpose of the investigation, which include providing evidence to answer questions about the relationship between vibrating materials and sound.

2. Identifying the evidence to address the purpose of the investigation

a. Students collaboratively develop an investigation plan and describe the evidence that will result from the investigation, including:
   - Observations that sound can cause materials to vibrate.
   - Observations that vibrating materials can cause sounds.
   - How the data will provide evidence to support or refute ideas about the relationship between vibrating materials and sound.

b. Students individually describe (with support) how the evidence will address the purpose of the investigation.

3. Planning the investigation

a. In the collaboratively developed investigation plan, students individually identify and describe:
- The materials to be used.
- How the materials will be made to vibrate to make sound.
- How resulting sounds will be observed and described.
- What sounds will be used to make materials vibrate.
- How it will be determined that a material is vibrating.

4. Collecting the data

a. According to the investigation plan they develop, students collaboratively collect and record observations about:
- Sounds causing materials to vibrate.
- Vibrating materials causing sounds.

Guided Questions

- How do vibrating materials cause sound?
- How does sound cause materials to vibrate?

Catholic Identity Connections

- God gave us our senses which allow us to hear sound and see and feel vibrations. Our senses help us to know God's creation.
- Other creatures can also hear us and each other.
- Value the human body as the temple of the Holy Spirit. [CS S.K6 GS3]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

SL.1.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.

Connections to Other DCIs in First Grade

N/A

Articulation to DCIs across Grade Levels

N/A

1-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

1-PS4-2 Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.

Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an eternal light source or by an object giving off its own light.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	**PS4.B Electromagnetic Radiation** • Objects can be seen if light is available to illuminate them or if they give off their own light.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including that when an object in the dark is lit (e.g., turning on a light in the dark space or from light the object itself gives off), it can be seen.

b. Students use evidence and reasoning to construct an evidence-based account of the phenomenon.

2. Evidence

a. Students make observations (firsthand or from media) to serve as the basis for evidence, including:
   - The appearance (e.g., visible, not visible, somewhat visible but difficult to see) of objects in a space with no light.
   - The appearance (e.g., visible, not visible, somewhat visible but difficult to see) of objects in a space with light.
   - The appearance (e.g., visible, not visible, somewhat visible but difficult to see) of objects (e.g., light bulbs, glow sticks) that give off light in a space with no other light.

b. Students describe how their observations provide evidence to support their explanation.

3. Reasoning

a. Students logically connect the evidence to support the evidence-based account of the phenomenon. Students describe lines of reasoning that include:
   - The presence of light in a space causes objects to be able to be seen in that space.
   - Objects cannot be seen if there is no light to illuminate them, but the same object in the same space can be seen if a light source is introduced.
   - The ability of an object to give off its own light causes the object to be seen in a space where there is no other light.

Guided Questions
• Why is light necessary for us to see objects?
Catholic Identity Connections
• God gave us the gift of sight so that we can see and appreciate the world around us. • We delight in the world around us. God is the Light in the darkness. This light illuminates our lives. • Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.1.2** Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure. **W.1.7** Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). **W.1.8** With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. **SL.1.1** Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.
Connections to Other DCIs in First Grade
N/A
Articulation to DCIs across Grade Levels
4.PS4.B

1-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

1-PS4-3 Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light.

Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard) and reflective (such as a mirror).

Assessment Boundary: Assessment does not include the speed of light.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct investigations collaboratively to produce evidence to answer a question.	**PS4.B Electromagnetic Radiation** • Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Identifying the phenomenon under investigation

a. Students identify and describe the phenomenon and purpose of the investigation, which include:
   - Answering a question about what happens when objects made of different materials (that allow light to pass through them in different ways) are placed in the path of a beam of light.
   - Designing and conducting an investigation to gather evidence to support or refute student ideas about putting objects made of different materials in the path of a beam of light.

2. Identifying evidence to address the purpose of the investigation

a. Students collaboratively develop an investigation plan and describe the data that will result from the investigation, including:
   - Observations of the effect of placing objects made of different materials in a beam of light, including:
     - A material that allows all light through results in the background lighting up.
     - A material that allows only some light through results in the background lighting up, but looking darker than when the material allows all light in.
     - A material that blocks all of the light will create a shadow.
     - A material that changes the direction of the light will light up the surrounding space in a different direction.

b. Students individually describe how these observations provide evidence to answer the question under investigation.

3. Planning the investigation

a. In the collaboratively developed investigation plan, students individually describe (with support):
• The materials to be placed in the beam of the light, including:
  • A material that allows light through (e.g., clear plastic, clear glass).
  • A material that allows only some light through (e.g., clouded plastic, wax paper).
  • A material that blocks all of the light (e.g., cardboard, wood).
  • A material that changes the direction of the light (e.g., mirror, aluminum foil).
• How the effect of placing different materials in the beam of light will be observed and recorded.
• The light source used to produce the beam of light.

4 Collecting the data
a. Students collaboratively collect and record observations about what happens when objects made of materials that allow light to pass through them in different ways are placed in the path of a beam of light, according to the developed investigation plan.
Guided Questions
• What happens when light is directed toward different types of materials?
Catholic Identity Connections
• We are each called to let our light shine for all to see. What kinds of things block the Light of God from shining on us?
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.1.7** Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). **W.1.8** With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. **SL.1.1** Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups.
Connections to Other DCIs in First Grade
N/A
Articulation to DCIs across Grade Levels
2.PS1.A

1-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones", and a pattern of drum beats.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Use tools and materials provided to design a device that solves a specific problem.	**PS4.C Information Technologies and Instrumentation** • People use a variety of devices to communicate (send and receive information) over long distances.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • People depend on various technologies in their lives; human life would be very different without technology.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Using scientific knowledge to generate design solutions

a. Students describe a given problem involving people communicating over long distances.
b. With guidance, students design and build a device that uses light or sound to solve the given problem.
c. With guidance, students describe the scientific information they use to design the solution.

2. Describing specific features of the design solution, including quantification when appropriate

a. Students describe that specific expected or required features of the design solution should include:
   - The device is able to send or receive information over a given distance.
   - The device must use light or sound to communicate.

b. Students use only the materials provided when building the device.

3. Evaluating potential solutions

a. Students describe whether the device:
   - Have the expected or required features of the design solution.
   - Provides a solution to the problem involving people communicating over a distance by using light or sound.

b. Students describe how communicating over long distances helps people.

Guided Questions

- How can people communicate over a long distance using light or sound?
- How does communicating over long distances help people?

Catholic Identity Connections

- We demonstrate our love for others through respectful communication.
- Prayer is the way we communicate with God.
- How does God communicate with us (scriptures, Mass, sacraments, each other, creation)?
- Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

Mathematics
MP.5 Use appropriate tools strategically.
1.MD.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object.
1.MD.2 Express the length of an object as a whole number of length units, by layering multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps.

Connections to Other DCIs in First Grade

N/A

Articulation to DCIs across Grade Levels

K.ETS1.A, 2.ETS1.B, 4.PS4.C, 4.ETS1.A

Diocese of Owensboro Science Standards
Grade 1

1-LS1 From Molecules to Organisms: Structures and Processes		
Students who demonstrate understanding can: **1-LS1-1 Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.** Clarification Statement: Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Use materials to design a device that solves a specific problem or a solution to a specific problem.	**LS1.A Structure and Function** • All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. **LS1.D Information Processing** • Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs.	**Structure and Function** • The shape and stability of structures of natural and designed objects are related to their function(s). **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.
Examples of Observable Evidence of Student Performance by the End of First Grade		
1. Using scientific knowledge to generate design solutions		
a. Students describe a given human problem to be solved by the design. b. With guidance, students use given scientific information about plants and/or animals to design the solution, including: • How external structures are used to help the plant and/or animal grow and/or survive. • How internal structures are used to help animals (including humans) to grow and/or survive. • How animals use external structures to capture and convey different kinds of information they need. • How plants and/or animals respond to information they receive from the environment.		

c. Students design a device (using student-suggested materials) that provides a solution to the given human problem by mimicking how plants and/or animals use external structures to survive, grow, and/or meet their needs. This may include:
   - Mimicking the way a plant and/or animal uses an external structure to help it survive, grow, and/or meet its needs.
   - Mimicking the way an external structure of an animal captures and conveys information.
   - Mimicking the way an animal and/or plant responds to information from the environment.

2. Describing specific features of the design solution, including quantification when appropriate

a. Students describe the specific expected or required features in their designs and devices, including:
   - The device provides a solution to the given human problem.
   - The device mimics plant and/or animal external parts, and/or animal information-processing.
   - The students use the provided materials to develop solutions.

3. Evaluating potential solutions

a. Students describe how the design solution is expected to solve the human problem.
b. Students determine and describe whether their device meets the specific required features.

Guided Questions

- How do plants and animals respond to information they receive from the environment?
- How do their external structures help plants and animals survive?
- What human problem could be solved by mimicking plant or animal parts?

Catholic Identity Connections

- God has given plants and animals the capabilities to survive.
- A sunflower changes direction as the sun moves across the sky so that the flower is always facing the sun. There are some kinds of solar panels that follow the sun across the sky like sunflowers. Scripture, the church, and the sacraments help us to keep our faces turned toward God. [S] [T] [SA]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

Connections to Other DCIs in First Grade

N/A

Articulation to DCIs across Grade Levels

K.ETS1.A; 4.LS1.A; 4.LS1.D; 4.ETS1.A

1-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

1-LS1-2 Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.

Clarification Statement: Examples of patterns of behaviors could include the signals that offspring make (such as crying, chirping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Scientists look for patterns and order when making observations about the world.	**LS1.B Growth and Development of Organisms** • Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.	**Patterns** • Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Obtaining information

a. Students use grade-appropriate books and other reliable media to obtain the following scientific information:
- Information about the idea that both plants and animals can have offspring.
- Information about behaviors of animal parents that help offspring survive (e.g., keeping offspring safe from predators by circling the young, feeding offspring).
- Information about behaviors of animal offspring that help the offspring survive (e.g., crying, chirping, nuzzling for food).

2. Evaluating information

a. Students evaluate the information to determine and describe the patterns of what animal parents and offspring do to help offspring survive (e.g., when a baby cries, the mother feeds it; when danger is present, parents protect offspring; some young animals become silent to avoid predators).

Guided Questions

- What patterns are observed that demonstrate the care of an offspring in order to help it survive?

Catholic Identity Connections

- God, our Heavenly Father, helps us to live happy, healthy lives.
- God provides animal parents with the necessary behaviors to help their offspring survive and thrive.
- What patterns can we develop in our lives to help plants, animals and others, especially the poor, to survive?
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.1.1	Ask and answer questions about key details in a text.
RI.1.2	Identify the main topic and retell key details of a text.
RI.1.10	With prompting and support, read informational texts appropriately complex for grade.

Mathematics

1.NBT.3	Compare two two-digit numbers based on the meanings of the tens and one digits, recording the results of comparisons with the symbols >, =, and <.
1.NBT.4	Add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning uses. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten.
1.NBT.5	Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used.
1.NBT.6	Subtract multiples of 10 in the range 10-90 from multiples of 10 in the range 10-90 (positive or zero differences), using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.

Connections to Other DCIs in First Grade

N/A

Articulation to DCIs across Grade Levels

3.LS2.D

Diocese of Owensboro Science Standards
Grade 1

1-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.

Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include that leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.

Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand and from media) to construct an evidence-based account for natural phenomena.	**LS3.A Inheritance of Traits** • Young animals are very much, but not exactly, like their parents. Plants also are very much, but not exactly, like their parents. **LS3.B Variation of Traits** • Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.	**Patterns** • Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates a given phenomenon to a scientific idea, including the idea that young plants and animals are like, but not exactly like, their parents (not to include animals that undergo complete metamorphosis, such as insects or frogs).

b. Students use evidence and reasoning to construct an evidence-based account of the phenomenon.

2. Evidence

a. Students describe evidence from observations (firsthand or from media) about patterns of features in plants and animals, including:
   - Key differences between different types of plants and animals (e.g., features that distinguish dogs versus those that distinguish fish, oak trees versus bean plants).
   - Young plants and animals of the same type have similar, but not identical, features (e.g., size and shape of body parts, color and/or type of any hair, leaf shape, stem rigidity).
   - Adult plants and animals (i.e., parents) of the same type have similar, but not identical, features (e.g., size and shape of body parts, color and/or type of any hair, leaf shape, stem rigidity).
   - Patterns of similarities and differences in features between parents and offspring.

3. Reasoning

a. Students logically connect the evidence of observed patterns in features to support the evidence-based account by describing chains of reasoning that include:
   - Young plants and animals are very similar to their parents.
   - Young plants and animals are not exactly the same as their parents.
   - Similarities and differences in features are evidence that young plants and animals are very much, but not exactly, like their parents.
   - Similarities and differences in features are evidence that although individuals of the same type of animal or plant are recognizable as similar, they can also vary in many ways.

Guided Questions

- How are plants and animals like and different from their parents?

Catholic Identity Connections

- God made all people in His likeness, yet each of us is different.
- When we sin we damage the image of God in us.
- All people deserve respect, even those who are different than us. [CST]
- Diversity is a good thing because it is part of God's plan, and no one plant or animal can totally reflect God's goodness (Aquinas). [TH]
- Value the human body as the temple of the Holy Spirit. [CS S.K6 GS3]
- Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.1.1 Ask and answer questions about key details in a text.

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.5 Use appropriate tools strategically.

1.MD.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object.

Connections to Other DCIs in First Grade

N/A

Articulation to DCIs across Grade Levels

3.LS3.A; 3.LS3.B

1-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

1-ESS1-1 Use observations of the sun, moon, and stars to describe patterns that can be predicted.

Clarification Statement: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.

Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations (firsthand and from media) to describe patterns in the natural world in order to answer scientific questions.	**ESS1.A The Universe and Its Stars** • Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.	**Patterns** • Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes natural events happen today as they happened in the past. • Many events are repeated.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Organizing data

a. With guidance, students use graphical displays (e.g., picture, chart) to organize data from given observations (firsthand or from media), including:
   - Objects (i.e., sun, moon, stars) visible in the sky during the day.
   - Objects (i.e., sun, moon, stars) visible in the sky during the night.
   - The position of the sun in the sky at various times during the day.
   - The position of the moon in the sky at various times during the day or night.

2. Identifying relationships

a. Students identify and describe patterns in the organized data, including:
   - Stars are not seen in the sky during the day, but they are seen in the sky during the night.
   - The sun is at different positions in the sky at different times of the day, appearing to rise in one part of the sky in the morning and appearing to set in another part of the sky in the evening.
   - The moon can be seen during the day and at night, but the sun can only be seen during the day.
   - The moon is at different positions in the sky at different times of the day or night, appearing to rise in one part of the sky and appearing to set in another part of the sky.

3. Interpreting data

a. Students use the identified patterns of the motions of objects in the sky to provide evidence that future appearances of those objects can be predicted (e.g., if the moon is observed to rise in one part of the sky, a prediction can be made that the moon will move across the sky and appear to set in a different portion of the sky. If the sun is observed to rise in one part of the sky, a prediction can be made about approximately where the sun will be at different times of day).
b. Students use patterns related to the appearance of objects in the sky to provide evidence that future appearances of those objects can be predicted (e.g., when the sun sets and can no longer be seen, a prediction can be made that the sun will rise again in the morning).

Guided Questions

- Why do the sun and moon appear in the sky at different times?
- What is an example of a pattern of an object in space that can be used to predict future appearances?

Catholic Identity Connections

- God's presence is everywhere.
- God created an orderly world according to His plan, and it is good.
- God has created a world in which such things as day and night follow a predictable pattern.
- God’s love and forgiveness is a predictable pattern. The love of God always follows night, no matter how dark it gets.
- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God’s love and goodness and, therefore, is “sacramental” in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God’s creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Scripture [S]

- “He took him outside and said: Look up at the sky and count the stars, if you can. Just so, He added, will your descendants be.” (Genesis 15:5)
- “Just as the host of heaven cannot be numbered and the sands of the sea cannot be counted, so I will multiply the descendants of David My servant and the Levites who minister to Me.” (Jeremiah 33:22)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions).

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.

Connections to Other DCIs in First Grade

N/A

Articulation to DCIs across Grade Levels

3.PS2.A; 5.PS2.B; 5.ESS1.B

1-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

1-ESS1-2 Make observations at different times of year to relate the amount of daylight to the time of year.

Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.

Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Make observations (firsthand or from media) to collect data that can be used to make comparisons.	**ESS1.B Earth and the Solar System** • Seasonal patterns of sunrise and sunset can be observed, described, and predicted.	**Patterns** • Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.

Examples of Observable Evidence of Student Performance by the End of First Grade

1. Identifying the phenomenon under investigation

a. Students identify and describe the phenomenon and purpose of the investigation, which include the relationship between the amount of daylight and the time of year.

2. Identifying evidence to address the purpose of the investigation

a. Based on the given plan for the investigation, students (with support) describe the data and evidence that will result from the investigation, including observations (firsthand or from media) of relative length of the day (sunrise to sunset) throughout the year.

b. Students individually describe how these observations could reveal the pattern between the amount of daylight and the time of year (i.e., relative lightness and darkness at different times of the day and throughout the year).

3. Planning the investigation

a. Based on the given investigation plan, students describe (with support):
- How the relative length of the day will be determined (e.g., whether it will be light or dark when waking in the morning, at breakfast, when having dinner, or going to bed at night).
- When observations will be made and how they will be recorded, both within a day and across the year.

4. Collecting the data

a. According to the given investigation plan, students collaboratively make and record observations about the relative length of the day in different seasons to make relative comparisons between the amount of daylight at different times of the year (e.g., summer, winter, fall, spring).

Guided Questions

- How does the relative length of the day change compared to the amount of daylight at different times of the year?

Diocese of Owensboro Science Standards
Grade 1

Catholic Identity Connections
• There are seasons and feasts in the Church that follows the seasons of the year. For example, Christmas comes shortly after the darkest day of the year and shows that the baby Jesus was the light coming back into the world. Easter happens during the Spring, when nature comes back to life again after winter. • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2] • Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3] • Give examples of the beauty evident in God's creation. [CS S.K6 IS4] • Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.1.7** Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). **W.1.8** With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **1.OA.1** Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and composing, with unknowns in all positions (e.g., by using objects, drawings, and equations to represent the problem). **1.MD.4** Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.
Connections to Other DCIs in First Grade
N/A
Articulation to DCIs across Grade Levels
5.PS2.B; 5.ESS1.B

Second Grade Standards

2-PS1 Matter and Its Interactions

2-PS1-1 Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
2-PS1-3 Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
2-PS1-4 Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

2-LS2 Ecosystems: Interactions, Energy, and Dynamics

2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.
2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.

Scripture [S]

- "Send forth your spirit, they are created and you renew the face of the earth." (Psalm 104:30)
- After the flood God makes a covenant with Noah, his sons, and all of creation:
  "God said to Noah and to his sons with him: 'See, I am now establishing my covenant with you and your descendants after you and with every living creature that was with you: the birds, the tame animals, and all the wild animals that were with you—all that came out of the ark. I will establish my covenant with you, that never again shall all creatures be destroyed by the waters of a flood; there shall not be another flood to devastate the earth.' God said: 'This is the sign of the covenant that I am making between me and you and every living creature with you for all ages to come: I set my bow in the clouds to serve as a sign of the covenant between me and the earth. When I bring clouds over the earth, and the bow appears in the clouds, I will remember my covenant between me and you and every living creature—every mortal being—so that the waters will never again become a flood to destroy every mortal being. When the bow appears in the clouds, I will see it and remember the everlasting covenant between God and every living creature—every mortal being that is on earth.' God told Noah: 'This is the sign of the covenant I have established between me and every mortal being that is on earth.'" (Genesis 9:8-17)

Catholic/Christian Scientists

- Rachel Carson
- Sr. Paula Gonzales,

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

2-LS4 Biological Evolution: Unity and Diversity

2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats.

Scripture [S]

- "How varied are your works, Lord!
  In wisdom you have made them all; the earth is full of your creatures.
  There is the sea, great and wide!
  It teems with countless beings, living things both large and small." (Psalm 104: 24-25)

2-ESS1 Earth's Place in the Universe

2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

Catholic/Christian Scientists

- Georgius Agricola (mineralogy)
- Jean Baptiste Julien d'Omalius d'Halloy (geology)
- René Just Haüy (crystallography)
- Abraham Ortelius (created the first modern atlas and theorized on continental drift)
- Wilhelm Heinrich Waagen (geologist and paleontologist)
- Johann Joachim Winckelmann (archaeology)
- Teilhard de Chardin (paleontology)
- Nicolas Steno (stratigraphy)

Saints [SA]

- St. Barbara, patron saint of geology
- St. Clare of Assisi, patron saint of good weather
- St. Eurosia, patron saint against bad weather

2-ESS2 Earth's Systems

2-ESS2-1 Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.
2-ESS2-2 Develop a model to represent the shapes and kinds of land and bodies of water in an area.
2-ESS2-3 Obtain information to identify where water is found on Earth and that it can be solid or liquid.

Catholic/Christian Scientists

- Georgius Agricola (mineralogy)
- Jean Baptiste Julien d'Omalius d'Halloy (geology)
- René Just Haüy (crystallography)
- Abraham Ortelius (created the first modern atlas and theorized on continental drift)
- Wilhelm Heinrich Waagen (geologist and paleontologist)
- Johann Joachim Winckelmann (archaeology)
- Teilhard de Chardin (paleontology)
- Nicolas Steno (stratigraphy)

Saints [SA]

- St. Barbara, patron saint of geology

2-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-1 Plan and conduct investigations to describe and classify different kinds of materials by their observable properties.

Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	**PS1.A Structure and Properties of Matter** • Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.	**Patterns** • Patterns in the natural and human-designed world can be observed.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Identifying the phenomenon under investigation

a. Students identify and describe the phenomenon under investigation, which includes the idea that different kinds of matter have different properties, and sometimes the same kind of matter has different properties depending on temperature.
b. Students identify and describe the purpose of the investigation, which includes answering a question about the phenomenon under investigation by describing and classifying different kinds of materials by their observable properties.

2. Identifying the evidence to address the purpose of the investigation

a. Students collaboratively develop an investigation plan and describe the evidence that will be collected, including the properties of matter (e.g., color, texture, hardness, flexibility, whether it is a solid or a liquid) of the materials that would allow for classification, and the temperature at which those properties are observed.
b. Students individually describe that:
   - The observations of the materials provide evidence about the properties of different kinds of materials.
   - Observable patterns in the properties of materials provide evidence to classify the different kinds of materials.

3. Planning the investigation

a. In the collaboratively developed investigation plan, students include:
   - Which materials will be described and classified (e.g., different kinds of metals, rocks, wood, soil, powders).
   - Which materials will be observed at different temperatures, and how those temperatures will be determined (e.g., using ice to cool and a lamp to warm) and measured (e.g., qualitatively or quantitatively).
   - How the properties of the materials will be determined.
   - How the materials will be classified (i.e., sorted) by the pattern of the properties.
b. Students individually describe how the properties of materials, and the method for classifying them, are relevant to answering the question.

4. Collecting the data

a. According to the developed investigation plan, students collaboratively collect and record data on the properties of the materials.

Guided Questions

- How can materials be described by their observable properties?
- How can materials be classified by the pattern of the properties?

Catholic Identity Connections

- God created an orderly universe.
- The value of things and people comes from being created by God.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

W.2.8 Recall information from experiences or gather information from provided sources to answer a question.

Mathematics

MP.4 Model with mathematics.

2.MD.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

5.PS1.A

2-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Clarification Statement: Examples of properties could include strength, flexibility, hardness, texture, and absorbency.

Assessment Boundary: Assessment of quantitative measurements is limited to length.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Analyze data from tests of an object or tool to determine if it works as intended.	**PS1.A Structure and Properties of Matter** • Different properties are suited to different purposes.	**Cause and Effect** • Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Connections to Engineering, Technology, and Applications of Science** **Influences of Engineering, Technology, and Science on Society and the Natural World** • Every human-made product is designed by applying some knowledge of the natural world and is built using materials derived from the natural world.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Organizing data

a. Using graphical displays (e.g., pictures, charts, grade-appropriate graphs), students use the given data from tests of different materials to organize those materials by their properties (e.g., strength, flexibility, hardness, texture, ability to absorb).

2. Identifying relationships

a. Students describe relationships between materials and their properties (e.g., metal is strong, paper is absorbent, rocks are hard, sandpaper is rough).
b. Students identify and describe relationships between properties of materials and some potential uses or purposes (e.g., hardness is good for breaking objects or supporting objects; roughness is good for keeping objects in place; flexibility is good for keeping materials from breaking, but not good for keeping materials rigidly in place).

3. Interpreting data

a. Students describe which properties allow a material to be well suited for a given intended use (e.g., ability to absorb for cleaning up spills, strength for building material, hardness for breaking a nut).
b. Students use their organized data to support or refute their ideas about which properties of materials allow the object or tool to be best suited for the given intended purpose relative to the other given objects/tools (e.g., students could support the idea that hardness allows a wooden shelf to be better suited for supporting materials placed on it than a sponge would be, based on the patterns relating property to a purpose; students could refute an idea that a thin piece of glass is better suited to be a shelf than a wooden plank would be because it is harder than the wood by using data from tests of hardness; which could be refuted by an idea that the wood is better suited to be the shelf from tests of strength to give evidence that the glass is less strong than the wood).

c. Students describe how the given data from the test provides evidence of the suitability of different materials for the intended purpose.

Guided Questions

- What properties could be used in determining how suitable an object is for a given purpose?

Catholic Identity Connections

- Students will explore human-made products using natural materials created by God.
- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.2.8 Describe how reasons support specific points the author makes in a text.

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

W.2.8 Recall information from experiences or gather information from provided sources to answer a question.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

2.MD.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

S.PS1.A

2-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-3 Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.

Clarification Statement: Examples of pieces could include building blocks or other assorted small objects.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.	**PS1.A Structure and Properties of Matter** • Different properties are suited to different purposes. • A great variety of objects can be built from a small set of pieces.	**Energy and Matter** • Objects may break into smaller pieces and be put together into larger pieces, or change shapes.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including that an object made of a small set of pieces can be disassembled and made into a new object.
b. Students use evidence and reasoning to construct an evidence-based account of the phenomenon.

2. Evidence

a. Students describe evidence from observations (firsthand or from media), including:
   - The characteristics (e.g., size, shape, arrangement of parts) of the original object.
   - That the original object was disassembled into pieces.
   - That the pieces were reassembled into a new object or objects.
   - The characteristics (e.g., size, shape, arrangement of parts) of the new object or objects.

3. Reasoning

a. Students use reasoning to connect the evidence to support an explanation. Students describe a chain of reasoning that includes:
   - The original object was disassembled into its pieces and is reassembled into a new object or objects.
   - Many different objects can be built from the same set of pieces.
   - Compared to the original object, the new object or objects can have different characteristics, even though they were made of the same set of pieces.

Guided Questions

- How can a set of materials be reassembled to make a new object?
- How are the characteristics of two objects built from the same materials alike and different?

Catholic Identity Connections
• People can use the talents given by God to create objects for the betterment of the common good. • When we reuse items and create new ones with recycled materials, we show our care for our environment. • When we give our lives to God, we allow ourselves to be remade in God's image. • Describe God's relationship with humans and nature. [CS S.K6 IS6]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.2.7** Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). **W.2.8** Recall information from experiences or gather information from provided sources to answer a question.
Connections to Other DCIs in Second Grade
N/A
Articulation to DCIs across Grade Levels
4.ESS2.A; 5.PS1.A; 5.LS2.A

2-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-4 Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.

Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg or freezing a plant leaf.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world. • Construct an argument with evidence to support a claim. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Scientists search for cause and effect relationships to explain natural events.	**PS1.B Chemical Reactions** • Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.	**Cause and Effect** • Events have causes that generate observable patterns.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Supported claims

a. Students make a claim to be supported about a phenomenon. In their claim, students include the idea that some changes caused by heating or cooling can be reversed and some cannot.

2. Identifying scientific evidence

a. Students describe the given evidence, including:
- The characteristics of the material before heating or cooling.
- The characteristics of the material after heating or cooling.
- The characteristics of the material when the heating or cooling is reversed.

3. Evaluating and critiquing the evidence

a. Students evaluate the evidence to determine:
- The change in the material after heating (e.g., ice becomes water, an egg becomes solid, solid chocolate becomes liquid).
- Whether the change in the material after heating is reversible (e.g., water becomes ice again, a cooked egg remains a solid, liquid chocolate becomes solid but can be a different shape).
- The change in the material after cooling (e.g., when frozen, water becomes ice and a plant leaf dies).
- Whether the change in the material after cooling is reversible (e.g., ice becomes water again, a plant leaf does not return to normal).

b. Students describe whether the given evidence supports the claim and whether additional evidence is needed.

4. Reasoning and synthesis

a. Students use reasoning to connect the evidence to the claim. Students describe the following chain of reasoning:
   - Some changes caused by heating or cooling can be reversed by cooling or heating (e.g., ice that is heated can melt into water, but the water can be cooled and can freeze back into ice [and vice versa]).
   - Some changes caused by heating or cooling cannot be reversed by cooling or heating (e.g., a raw egg that is cooked by heating cannot be turned back into a raw egg by cooling the cooked egg, cookie dough that is baked does not return to its uncooked form when cooled, charcoal that is formed by heating wood does not return to its original form when cooled).

Guided Questions

- How do heating and cooling change the characteristics of materials?
- What are some examples of changes that can be reversed by heating and cooling?
- What are some examples of changes that cannot be reversed by heating and cooling?

Catholic Identity Connections

- Some of the changes we make to the world around us can be reversed and some cannot. We must always consider the common good when making changes.
- We have a responsibility to respect all of God's creation.
- God gives us the freedom to make choices.
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]
- Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]
- Accept the premise that nature should not be manipulated simply at man's will or only viewed as a thing to be used, but that man must cooperate with God's plan for himself and for nature. [CS S.K6 DS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.2.1 Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.

RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.

RI.2.8 Describe how reasons support specific points the author makes in a text.

W.2.1 Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., because, and, also) to connect opinion and reasons, and provide a concluding statement or section).

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

5.PS1.B

2-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow.

Assessment Boundary: Assessment is limited to testing one variable at a time.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	**LS2.A Interdependent Relationships in Ecosystems** • Plants depend on water and light to grow.	**Cause and Effect** • Events have causes that generate observable patterns.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Identifying the phenomenon under investigation

a. Students identify and describe the phenomenon and purpose of the investigation, which includes answering a question about whether plants need sunlight and water to grow.

2. Identifying the evidence to address the purpose of the investigation

a. Students describe the evidence to be collected, including:
   - Plant growth with both light and water.
   - Plant growth without light but with water.
   - Plant growth without water but with light.
   - Plant growth without water and without light.

b. Students describe how the evidence will allow them to determine whether plants need light and water to grow.

3. Planning the investigation

a. Students collaboratively develop an investigation plan. In the investigation plan, students describe the features to be part of the investigation, including:
   - The plants to be used.
   - The source of light.
   - How plants will be kept with/without light in both the light/dark test and the water/no water test.
   - The amount of water plants will be given in both the light/dark test and the water/no water test.
   - How plant growth will be determined (e.g., observations of plant height, number and size of leaves, thickness of the stem, number of branches).

b. Students individually describe how the plan allows them to answer the question.

4. Collecting the data

a. According to the investigation plan developed, students collaboratively collect and record data on the effects of plant growth by:
   - Providing both light and water.
   - Withholding light but providing water.
   - Withholding water but providing light.
   - Withholding both water and light.

Guided Questions

- What do plants need to survive and thrive?
- How do light and darkness affect the growth of a plant?
- How does withholding water affect the growth of a plant?

Catholic Identity Connections

- Plant growth is dependent on God's gifts of light and water.
- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

W.2.8 Recall information from experiences or gather information from provided sources to answer a question.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

2.MD.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

K.LS1.C; K.ESS3.A; 5.LS1.C

2-LS2 Ecosystems: Interactions, Energy, and Dynamics		
Students who demonstrate understanding can: **2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, dramatization, or storyboard) that represent concrete events or design solutions. • Develop a simple model based on evidence to represent a proposed object or tool.	**LS2.A Interdependent Relationships in Ecosystems** • Plants depend on animals for pollination or to move their seeds around. **ETS1.B Developing Possible Solutions** • Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (secondary emphasis)	**Structure and Function** • The shape and stability of structures of natural and designed objects are related to their functions.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Components of the model

a. Students develop a simple model that mimics the function of an animal in seed dispersal or pollination of plants. Students identify the relevant components of their model, including those components that mimic the natural structure of an animal that helps it disperse seeds (e.g., hair that snares seeds, squirrel cheek pouches that transport seeds) or that mimic the natural structure of an animal that helps it pollinate plants (e.g., bees have fuzzy bodies to which pollen sticks, hummingbirds have bills that transport pollen). The relevant components of the model include:
- Relevant structures of the animal.
- Relevant structures of the plant.
- Pollen or seeds from plants.

2. Relationships

a. In the model, students describe relationships between components, including evidence that the developed model mimics how plant and animal structures interact to move pollen or disperse seeds.
- Students describe the relationships between components that allow for movement of pollen or seeds.
- Students describe the relationships between the parts of the model they are developing and the parts of the animal they are mimicking.

3. Connections

a. Students use the model to describe:
- How the structure of the model gives rise to its function.
- Structure/function relationships in the natural world that allow some animals to disperse seeds or pollinate plants.

Guided Questions

- How do animals help disperse seeds or pollinate plants?
- How do models help us learn about the function of a structure?

Catholic Identity Connections

- Everything is connected in God's creation. Everything works together for the common good.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.

Mathematics

MP.2 Model with mathematics.

2.MD.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

K.ETS1.A; 5.LS1.C; 5.LS2.A

<table>
<tr><th colspan="3">2-LS4 Biological Evolution: Unity and Diversity</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats.
Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.
Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.
• Make observations (firsthand or from media) to collect data which can be used to make comparisons.

Connections to Nature of Science

Scientific Knowledge Is Based on Empirical Evidence
• Scientists look for patterns and order when making observations about the world.</td><td>LS4.D Biodiversity and Humans
• There are many different kinds of living things in any area, and they exist in different places on land and in water.</td><td></td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Second Grade</th></tr>
<tr><td colspan="3">1. Identifying the phenomenon under investigation</td></tr>
<tr><td colspan="3">a. Students identify and describe phenomenon and the purpose of the investigation, which includes comparisons of plant and animal diversity of life in different habitats.</td></tr>
<tr><td colspan="3">2. Identifying the evidence to address the purpose of the investigation</td></tr>
<tr><td colspan="3">a. Based on the given plan for investigation, students describe the following evidence to be collected:
• Descriptions based on observations (firsthand or from media) of habitats, including land habitats (e.g., playground, garden, forest, parking lot) and water habitats (e.g., pond, stream, lake).
• Descriptions based on observations (firsthand or from media) of different types of living things in each habitat (e.g., trees, grasses, bushes, flowering plants, lizards, squirrels, ants, fish).
• Comparisons of the different types of living things that can be found in different habitats.
b. Students describe how these observations provide evidence for patterns of plant and animal diversity across habitats.</td></tr>
<tr><td colspan="3">3. Planning the investigation</td></tr>
<tr><td colspan="3">a. Based on the given investigation plan, students describe how the different plants and animals in the habitats will be observed, recorded, and organized.</td></tr>
</table>

4. Collecting the data

a. Students collect, record, and organize data on different types of plants and animals in the habitats.

Guided Questions

- How do habitats differ to support different types of plants and animals?
- What types of living things are found in different habitats?

Catholic Identity Connections

- There is a great diversity of life in God's creation. Diversity is part of God's plan. It is a good thing.
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Diversity: St. Thomas Aquinas wrote, "For He brought things into being in order that His goodness might be communicated to creatures, and be represented by them; and because His goodness could not be adequately represented by one creature alone, He produced many and diverse creatures, that what was wanting to one in the representation of the divine goodness might be supplied by another. For goodness, which in God is simple and uniform, in creatures is manifold and divided and hence the whole universe together participates the divine goodness more perfectly, and represents it better than any single creature whatever" (Summa Theologiae, First Part, Question 47). [TH]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

W.2.8 Recall information from experiences or gather information from provided sources to answer a question.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

2.MD.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

3.LS4.C; 3.LS4.D; 5.LS2.A

2-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly.

Clarification Statement: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly.

Assessment Boundary: Assessment does not include quantitative measurements of timescales.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations from several sources to construct an evidence-based account for natural phenomena.	**ESS1.C The History of Planet Earth** • Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.	**Stability and Change** • Things may change slowly or rapidly.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including that Earth events can occur very quickly or very slowly.
b. Students use evidence and reasoning to construct an evidence-based account of the phenomenon.

2. Evidence

a. Students describe the evidence from observations (firsthand or from media [e.g., books, videos, pictures, historical photos]), including:
   - That some Earth events occur quickly (e.g., the occurrence of a flood, severe storm, volcanic eruption, earthquake, landslide, erosion of soil).
   - That some Earth events occur slowly.
   - Some results of Earth events that occur quickly.
   - Some results of Earth events that occur very slowly (e.g., erosion of rocks, weathering of rocks).
   - The relative amount of time it takes for the given Earth events to occur (e.g., slowly, quickly, hours, days, years).

b. Students make observations using at least three sources.

3. Reasoning

a. Students use reasoning to logically connect the evidence to construct an evidence-based account. Students describe their reasoning, including:
   - In some cases, Earth events and the resulting changes can be directly observed; therefore those events must occur rapidly.
   - In other cases, the resulting changes of Earth events can be observed only after long periods of time; therefore those Earth events occur slowly, and change happens over a time period that is much longer than one can observe.

Guided Questions

- How can Earth events change the Earth's surface?
- What are some changes that happen quickly?
- What are some changes that happen slowly?
- What are effects of Earth events?

Catholic Identity Connections

- Natural processes occur according to God's timing and wisdom.
- Spiritual growth sometimes happens slowly and sometimes quickly. Prayer and the sacraments can help us to grow quickly.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.2.1 Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text.
RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.
W.2.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.
W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).
W.2.8 Recall information from experiences or gather information from provided sources to answer a question.
SL.2.2 Recount or describe key ideas or details from a text read aloud or information presented orally or through other media.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
2.NBT.A Understand place value.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

3.LS2.C; 4.ESS1.C; 4.ESS2.A

2-ESS2 Earth's Systems

Students who demonstrate understanding can:

2-ESS2-1 Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.

Clarification Statement: Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Compare multiple solutions to a problem.	**ESS2.A Earth Materials and Systems** • Wind and water can change the shape of the land. **ETS1.C Optimizing the Design Solution** • Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (secondary emphasis)	**Stability and Change** • Things may change slowly or rapidly. **Connections to Engineering, Technology, and Applications of Science** **Influences of Engineering, Technology, and Science on Society and the Natural World** • Developing and using technology has impacts on the natural world. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientists study the natural and material world.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Using scientific knowledge to generate design solutions

a. Students describe the given problem, which includes the idea that wind or water can change the shape of the land by washing away soil or sand.
b. Students describe at least two given solutions in terms of how they slow or prevent wind or water from changing the shape of the land.

2. Describing specific features of the design solution, including quantification where appropriate

a. Students describe the specific expected or required features for the solutions that would solve the given problem, including:
   - Slowing or preventing wind or water from washing away soil or sand.
   - Addressing problems caused by both slow and rapid changes in the environment (such as many mild rainstorms or a severe storm and flood).

3. Evaluating potential solutions

a. Students evaluate each given solution against the desired features to determine and describe whether and how well the features are met by each solution.
b. Using the evaluation, students compare the given solutions to each other.

Guided Questions

- How can changes caused by wind or water in the shape of the land be slowed or prevented?

Catholic Identity Connections
• Creation is ever changing. We can be good stewards of creation by preventing damage to creation. • Describe God's relationship with humans and nature. [CS S.K6 IS6] • Share concern and care for the environment as a part of God's creation. [CS S.K6 DS3]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.2.3** Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text. **RI.2.9** Compare and contrast the most important points presented by two texts on the same topic. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **2.MD.5** Use addition and subtraction within 100 to solve word problems involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem.
Connections to Other DCIs in Second Grade
N/A
Articulation to DCIs across Grade Levels
K.ETS1.A; 4.ESS2.A; 4.ETS1.A; 4.ETS1.B; 4.ETS1.C; 5.ESS2.A

2-ESS2 Earth's Systems

Students who demonstrate understanding can:

2-ESS2-2 Develop a model to represent the shapes and kinds of land and bodies of water in an area.

Assessment Boundary: Assessment does not include quantitative scaling in models.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, dramatization, or storyboard) that represent concrete events or design solutions. • Develop a model to represent patterns in the natural world.	**ESS2.B Plate Tectonics and Large-Scale System Interactions** • Maps show where things are located. One can map the shapes and kinds of land and water in any area.	**Patterns** • Patterns in the natural world can be observed.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Components of the model

a. Students develop a model (i.e., a map) that identifies the relevant components, including components that represent both land and bodies of water in an area.

2. Relationships

a. In the model, students identify and describe relationships between components using a representation of the specific shapes and kinds of land (e.g., playground, park, hill) and specific bodies of water (e.g., creek, ocean, lake, river) within a given area.
b. Students use the model to describe the patterns of water and land in a given area (e.g., an area may have many small bodies of water; an area may have many different kinds of land that come in different shapes).

3. Connections

a. Students describe that because they can map the shapes and kinds of land and water in any area, maps can be used to represent many different types of areas.

Guided Questions

- What is the relationship between shapes and kinds of land and bodies of water within a given area?

Catholic Identity Connections

- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
2.NBT.3 Read and write numbers to 1000 using base-ten numerals, number names, and expanded form.

Connections to Other DCIs in Second Grade

N/A

Articulation to DCIs across Grade Levels

4.ESS2.B; 5.ESS2.C

2-ESS2 Earth's Systems

Students who demonstrate understanding can:

2-ESS2-3 Obtain information to identify where water is found on Earth and that it can be solid or liquid.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Obtain information using various texts, text features (e.g., headings, tables of content, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question.	**ESS2.C The Roles of Water in Earth's Surface Processes** • Water is found in oceans, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.	**Patterns** • Patterns in the natural world can be observed.

Examples of Observable Evidence of Student Performance by the End of Second Grade

1. Obtaining information

a. Students use books and other reliable media as sources for scientific information to answer scientific questions about:
- Where water is found on Earth, including in oceans, rivers, lakes, and ponds.
- The idea that water can be found on Earth as liquid water or solid ice (e.g., a frozen pond, liquid pool, frozen lake).
- Patterns of where water is found, and what form it is in.

2. Evaluating information

a. Students identify which sources of information are likely to provide scientific information (e.g., versus opinion).

Guided Questions

- Where is water found on Earth?
- What forms of water can be found on Earth?

Catholic Identity Connections

- Just as water can take different forms, so can God. God the Father, the Son and the Holy Spirit make up the Trinity.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.2.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers.

W.2.8 Recall information from experiences or gather information from provided sources to answer a question.

Connections to Other DCIs in Second Grade

2.PS1.A

Articulation to DCIs across Grade Levels

5.ESS2.C

Grades 3-5 Engineering Design

3-5-ETS1 **Engineering Design**

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
3-5-ETS1-2 Generate and compare multiple possible solutions
3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Catholic Identity

- God has given us the mental capacity to consider solutions from various angles to determine which best meets the criteria and constraints of the problem.
- Engineering may be aligned with Catholic Social Teaching, depending upon the problem being solved.
- Noah was given precise directions to build a boat to withstand the flood (Genesis 6:14-16). This story from the Bible includes valuable data – the kind that is needed for engineering. [S]
- Building the Ark of the Covenant (Exodus 37, 38). [S]
- Simon builds a pyramid for the remains of his brother, Jonathan (1 Maccabees 13:25–30). [S]
- The skilled master worker lays the foundation and others build upon. Jesus is the foundation of Christian life (1 Corinthians 3:9-15). [S]
- The house of God is built upon the foundation of the apostles and prophets, with Jesus as the cornerstone (Ephesians 2:19-22). [S]

Scripture [S]

- "Unless the Lord builds the house, those who build it labor in vain." (Psalm 127:1)
- "Everyone then who hears these words of mine and does them will be like a wise man who built his house on the rock. And the rain fell, and the floods came, and the winds blew and beat on that house, but it did not fall, because it had been founded on the rock. And everyone who hears these words of mine and does not do them will be like a foolish man who built his house on the sand. And the rain fell, and the floods came, and the winds blew and beat against that house, and it fell, and great was the fall of it." (Matthew 7:24-27)
- "Everyone who comes to me and hears my words and does them, I will show you what he is like: he is like a man building a house, who dug deep and laid the foundation on the rock. And when a flood arose, the stream broke against that house and could not shake it, because it had been well built. But the one who hears and does not do them is like a man who built a house on the ground without a foundation. When the stream broke against it, immediately it fell, and the ruin of that house was great." (Luke 6:46-49)
- "For which of you, desiring to build a tower, does not first sit down and count the cost, whether he has enough to complete it?" (Luke 14:28)
- "He is before all things, and in him all things hold together." (Colossians 1:17)
- "As you come to him, a living stone rejected by men but in the sight of God chosen and precious, you yourselves like living stones are being built up as a spiritual house, to be a holy priesthood, to offer spiritual sacrifices acceptable to God through Jesus Christ. For it stands in Scripture: 'Behold, I am laying in Zion a stone, a cornerstone chosen and precious, and whoever believes in him will not be put to shame.' So the honor is for you who believe, but for those who do not believe, 'The stone that the builders rejected has become the cornerstone,' and 'A stone of stumbling, and a rock of offense.' They stumble because they disobey the word, as they were destined to do." (1 Peter 2:4-8)

Catholic/Christian Scientists

- Johannes Gutenberg (Inventor of the printing press)

Saints [SA]

- St. Patrick, patron saint of engineers
- St. Isadore of Seville, patron saint of computer scientists and the Internet

3-5-ETS1 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for successes and constraints on materials, time, or cost.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3-5 builds on grades K-2 experiences and progresses to specifying qualitative relationships. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.	**ETS1.A Defining and Delimiting Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	**Influence of Engineering, Technology, and Science on Society and the Natural World** • People's needs and wants change over time, as do their demands for new and improved technologies.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Identifying the problem to be solved

a. Students use given scientific information and information about a situation or phenomenon to define a simple design problem that includes responding to a need or want.
b. The problem students define is one that can be solved with the development of a new or improved object, tool, process, or system.
c. Students describe that people's needs and wants change over time.

2. Defining the boundaries of the system

a. Students define the limits within which the problem will be addressed, which include addressing something people want and need at the current time.

3. Defining the criteria and constraints

a. Based on the situation people want to change, students specify criteria (required features) of a successful solution.
b. Students describe the constraints or limitations on their design, which may include:
   - Cost
   - Materials
   - Time

Guided Questions

- Why is it important to consider multiple solutions before determining the best possible solution for a given problem?
- How have engineers developed new products and technologies to meet the ever-changing needs and wants of people?
- How have the needs and wants of people changed over time?
- How can we distinguish between our needs and wants?

Catholic Identity Connections
• Refer to Catholic Identity portion of the Grades 3-5 Engineering Design Standards overview at the beginning of this section.
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.5.7** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. **W.5.8** Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. **W.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **3-5.OA** Operations and Algebraic Thinking
Connections to Other DCIs in Fifth Grade
Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include: Fourth Grade: 4-PS3-4
Articulation to DCIs across Grade-Levels
K-2.ETS1.A; **MS.ETS1.A**; **MS.ETS1.B**

3-5-ETS1 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem.	**ETS1.B Developing Possible Solutions** • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions to an important part of the design process, and shared ideas can lead to improved designs.	**Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Using scientific knowledge to generate design solutions

a. Students use grade-appropriate information from research about a given problem, including the causes and effects of the problem and relevant scientific information.
b. Students generate at least two possible solutions to the problem based on scientific information and understanding of the problem.
c. Students specify how each design solution solves the problem.
d. Students share ideas and findings with others about design solutions to generate a variety of possible solutions.
e. Students describe the necessary steps for designing a solution to a problem, including conducting research and communicating with others throughout the design process to improve the design [note: emphasis is on what is necessary for designing solutions, not on a step-wise process].

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe:
- The given criteria (required features) and constraints (limits) for the solutions, including increasing benefits, decreasing risks/costs, and meeting societal demands as appropriate.
- How the criteria and constraints will be used to generate and test the design solutions.

3. Evaluating potential solutions

a. Students test each solution under a range of likely conditions and gather data to determine how well the solutions meet the criteria and constraints of the problem.
b. Students use the collected data to compare solutions based on how well each solution meets the criteria and constraints of the problem.

Guided Questions

- Why is it important to consider multiple solutions before determining the best possible solution for a given problem?
- How have engineers developed new products and technologies to meet the ever-changing needs and wants of people?
- How have the needs and wants of people changed over time?
- How can we distinguish between our needs and wants?

Catholic Identity Connections

- God has given different people different gifts and talents which allow us to design solutions to problems that exist in the world.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.
RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
MP.5 Use appropriate tools strategically.
3-5.OA Operations and Algebraic Thinking

Connections to Other DCIs in Fifth Grade

Connections to 3-5-ETS1.B: Defining and Delimiting Engineering Problems include: Fourth Grade: 4-ESS3-2

Articulation to DCIs across Grade-Levels

K-2.ETS1.A ;K-2.ETS1.B ; K-2.ETS1.C ; MS.ETS1.B; MS.ETS1.C

3-5-ETS1 Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to save as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**ETS1.B Developing Possible Solutions** • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. **ETS1.C Optimizing the Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Identifying the purpose of the investigation

a. Students describe the purpose of the investigation, which includes finding possible failure points or difficulties to identify aspects of a model or prototype that can be improved.

2. Identifying the evidence to be address the purpose of the investigation

a. Students describe the evidence to be collected, including:
   - How well the model/prototype performs against the given criteria and constraints.
   - Specific aspects of the prototype or model that do not meet one or more of the criteria or constraints (i.e., failure points or difficulties).
   - Aspects of the model/prototype that can be improved to better meet the criteria and constraints.

b. Students describe how the evidence is relevant to the purpose of the investigation.

3. Planning the investigation

a. Students create a plan for the investigation that describes different tests for each aspect of the criteria and constraints. For each aspect, students describe:
   - The specific criterion or constraint to be used.
   - What is to be changed in each trial (the independent variable).
   - The outcome (dependent variable) that will be measured to determine success.
   - What tools and methods are to be used for collecting data.
   - What is to be kept the same from trial to trial to ensure a fair test.

4. Collecting the data

a. Students carry out the investigation, collecting and recording data according to the developed plan.

Guided Questions

- Why is it important to consider multiple solutions before determining the best possible solution for a given problem?
- How have engineers developed new products and technologies to meet the ever-changing needs and wants of people?
- How have the needs and wants of people changed over time?
- How can we distinguish between our needs and wants?

Catholic Identity Connections

- Jesus is prototype for humanity. Unlike all others who have come after him, he cannot be improved.
- God has given different people different gifts and talents which allow us to design solutions to problems that exist in the world.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

Connections to Other DCIs in Fifth Grade

Connections to 3-5-ETS1.C: Optimizing the Design Solution include: Fourth Grade: 4-PS4-3

Articulation to DCIs across Grade-Levels

K-2.ETS1.A; **K-2.ETS1.C**; **MS.ETS1.B**; **MS.ETS1.C**

Third Grade Standards

3-PS2 Motion and Stability: Forces and Interactions

3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets.

Catholic/Christian Scientists

- Physics
  - Roger Bacon (Franciscan friar and early advocate of the scientific method)
  - André-Marie Ampère (electromagnetism)
  - Antoine César Becquerel (electric and luminescent phenomena)
  - André-Marie Ampère (electromagnetism)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

3-LS1 From Molecules to Organisms: Structures and Processes

3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

Catholic/Christian Scientists

- Bartolomeo Eustachi (human anatomy)
- Sr. Paula González (biology)
- Antoine Laurent de Jussieu (natural classification of flowering plants)
- Andreas Vesalius (modern human anatomy)
- Theodor Schwann (theory of the cellular structure of animal organisms)
- Botany
  - Carl Linnaeus
  - Stephan Endlicher
  - James Britton
  - Andrea Cesalpino
  - James Britten

Saints [SA]

- St. Ambrose, patron saint of beekeepers
- St. Ansovinus, patron saint of gardeners
- St. Anthony of Padua, patron saint of harvests and lost animals
- St. Dorothy, patron saint of horticulture
- St. Gall, patron saint of birds
- St. Isadore the Farmer, patron saint of farmers
- St. Phocus, patron saint of gardeners, agricultural workers, farm workers, farmers and field hands
- St. Urban, patron saint of grape growers
- St. Alexandra, patron saint of humanity

3-LS2 Ecosystems: Interactions, Energy, and Dynamics

3-LS2-1 Construct an argument that some animals form groups that help members survive.

Scripture [S]

- After the flood God makes a covenant with Noah, his sons, and all of creation: "God said to Noah and to his sons with him: 'See, I am now establishing my covenant with you and your descendants after you and with every living creature that was with you: the birds, the tame animals, and all the wild animals that were with you—all that came out of the ark. I will establish my covenant with you, that never again shall all creatures be destroyed by the waters of a flood; there shall not be another flood to devastate the earth.' God said: 'This is the sign of the covenant that I am making between me and you and every living creature with you for all ages to come: I set my bow in the clouds to serve as a sign of the covenant between me and the earth. When I bring clouds over the earth, and the bow appears in the clouds, I will remember my covenant between me and you and every living creature—every mortal being—so that the waters will never again become a flood to destroy every mortal being. When the bow appears in the clouds, I will see it and remember the everlasting covenant between God and every living creature—every mortal being that is on earth.' God told Noah: 'This is the sign of the covenant I have established between me and every mortal being that is on earth.'" (Genesis 9:8-17)

Catholic/Christian Scientists

- Rachel Carson
- Sr. Paula Gonzales

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

3-LS3 Heredity: Inheritance and Variation of Traits

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.
3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.

Catholic/Christian Scientists

- Gregor Mendel (genetics through plant research)
- Jérôme Lejeune (the link of diseases to chromosome abnormalities)

Saints [SA]

- The Virgin Mary, said "yes" to Life
- St. Margaret of Castello, patron saint of pro-life groups
- St. Maximilian Kolbe, patron saint of the pro-life movement

3-LS4 Biological Evolution: Unity and Diversity

3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.
3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.
3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there change.

Scripture [S]

- Plants in the Bible:
    - http://ww2.odu.edu/~lmusselm/plant/bible/allbibleplantslist.php
    - http://www.newadvent.org/cathen/12149a.htm
    - Below is a list of the flowers dedicated to the Blessed Mother. (https://www.catholicculture.org/culture/library/view.cfm?recnum=5855)
        - White Lily "Annunciation Lily", symbol of Mary's Immaculate Purity.
        - Impatiens "Our Lady's Earrings", symbolical pure adornments of the ears of Mary who heard the word of God and kept it.
        - Violet symbol of Mary's humility "regarded by the Lord".
        - Lady-Slipper "Our Lady's Slipper", symbol of Mary's graceful Visitation trip to visit Elizabeth in the hill country: "All her steps were most beauteous."
        - Thistle-Down another Visitation symbol, from its graceful movement in air currents.
        - Rose symbol of the Blessed Virgin of prophecy, the Rose plant bearing the flower, Christ.
        - Daisy "Mary's Flower of God".
        - Periwinkle "Virgin Flower", emblem of the Blessed Virgin.
        - Columbine symbol of the dove of the Holy Spirit, Mary's overshadowing, indwelling, divine Spouse.
        - Pansy "Trinity Flower", symbol of the Trinity, first revealed to Mary.
        - Strawberry "Fruitful Virgin", in flower and fruit at the same time.

- "How varied are your works, Lord!
  In wisdom you have made them all; the earth is full of your creatures.
  There is the sea, great and wide!
  It teems with countless beings, living things both large and small." (Psalm 104: 24-25)

3-ESS2 Earth's Systems

3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
3-ESS2-2 Obtain and combine information to describe climates in different regions of the world.

Catholic/Christian Scientists

- Evangelista Torricelli (Inventor of the barometer)

3-ESS3 Earth and Human Activity

3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

Saints [SA]

- St. Clare of Assisi, patron saint of good weather
- St. Eurosia, patron saint against bad weather

3-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Clarification Statement: Examples could include that an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.

Assessment Boundary: Assessment is limited to gravity being addressed as a force that pulls objects down.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. **Connections to Nature of Science Scientific** **Investigations Use a Variety of Methods** • Science investigations use a variety of methods, tools, and techniques.	**PS2.A Forces and Motion** • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces, are used at this level.) **PS2.B Types of Interactions** • Objects in contact exert forces on each other.	**Cause and Effect** • Cause and effect relationships are routinely identified.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Identifying the phenomenon under investigation

a. Students identify and describe the phenomenon under investigation, which includes the effects of different forces on an object's motion (e.g., starting, stopping, or changing direction).

b. Students describe the purpose of the investigation, which includes producing data to serve as the basis for evidence for how balanced and unbalanced forces determine an object's motion.

2. Identifying the evidence to address the purpose of the investigation

a. Students collaboratively develop an investigation plan. In the investigation plan, students describe the data to be collected, including:
- The change in motion of an object at rest after:
  - Different strengths and directions of balanced forces (forces that sum to zero) are applied to the object.
  - Different strengths and directions of unbalanced forces (forces that do not sum to zero) are applied to the object (e.g., strong force on the right, weak force on the left).
- What causes the forces on the object.

b. Students individually describe how the evidence to be collected will be relevant to determining the effects of balanced and unbalanced forces on an object's motion.

3. Planning the investigation

a. In the collaboratively developed investigation plan, students describe how the motion of the object will be observed and recorded, including defining the following features:
   - The object whose motion will be investigated.
   - The objects in contact that exert forces on each other.
   - Changing one variable at a time (e.g., control strength and vary the direction, or control direction and vary the strength).
   - The number of trials that will be conducted in the investigation to produce the sufficient data.

b. Students individually describe how their investigation plan will allow them to address the purpose of the investigation.

4. Collecting the data

a. Students collaboratively collect and record data according to the investigation plan they developed, including data from observations and/or measurements of:
   - An object at rest and the identification of the forces acting on the object.

Guided Questions

- How do you explain and investigate the effect of balanced and unbalanced forces on an object?
- Why don't balanced forces pushing on an object result in any motion?

Catholic Identity Connections

- God calls each of us to constantly move toward a life of grace.
- All creation is a system of interrelated parts.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

W.3.7 Conduct short research projects that build knowledge about a topic.

W.3.8 Recall information from experiences or legally and ethically gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.5 Use appropriate tools strategically.

3.MD.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.

Connections to Other DCIs in Third Grade

N/A

Articulation to DCIs across Grade-Levels

K.PS2.A; K.PS2.B; K.PS3.C; 5.PS2.B; MS.PS2.A; MS.ESS1.B; MS.ESS2.C

3-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. **Connections to Nature of Science** **Science Knowledge is Based on Empirical Evidence** • Science findings are based on recognizing patterns.	**PS2.A Forces and Motion** • The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.)	**Patterns** • Patterns of change can be used to make predictions.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students identify and describe the phenomenon under investigation, which includes observable patterns in the motion of an object.
b. Students identify and describe the purpose of the investigation, which includes providing evidence for an explanation of the phenomenon that includes the idea that patterns of motion can be used to predict future motion of an object.

2. Identifying the evidence to address the purpose of the investigation

a. Based on a given investigation plan, students identify and describe the data to be collected through observations and/or measurements, including data on the motion of the object as it repeats a pattern over time (e.g., a pendulum swinging, a ball moving on a curved track, a magnet repelling another magnet).
b. Students describe how the data will serve as evidence of a pattern in the motion of an object and how that pattern can be used to predict future motion.

3. Planning the investigation

a. From the given investigation plan, students identify and describe how the data will be collected, including how:
   - The motion of the object will be observed and measured.
   - Evidence of a pattern in the motion of the object will be identified from the data on the motion of the object.
   - The pattern in the motion of the object can be used to predict future motion.

4. Collecting the data

a. Students make observations and/or measurements of the motion of the object, according to the given investigation plan, to identify a pattern that can be used to predict future motion.

Guided Questions

- How do you explain and investigate the effect of an outside force on an object's pattern of motion?
- How do you predict the future motion of an object based on past patterns of motion?

Catholic Identity Connections

- God created a world in which predictable patterns can be observed all around us.
- We live in a world of harmony and balance.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature.[CS S.K6 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.3.7 Conduct short research projects that build knowledge about a topic.

W.3.8 Recall information from experiences or legally and ethically gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

Connections to Other DCIs in Third Grade

N/A

Articulation to DCIs across Grade-Levels

1.ESS1.A; 4.PS4.A; MS.PS2.A; MS.ESS1.B

3-PS2 Motion and Stability: Forces and Interactions		
Students who demonstrate understanding can: **3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.** Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Asking Questions and Defining Problems Asking questions and defining problems in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated based on patterns such as cause and effect relationships.	**PS2.B Types of Interactions** • Electric forces, and magnetic forces between a pair of objects, do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change.
Examples of Observable Evidence of Student Performance by the End of Third Grade		
1. Addressing phenomena of the natural world		
a. Students ask questions that arise from observations of two objects not in contact with each other interacting through electric or magnetic forces, the answers to which would clarify the cause and effect relationships between: • The sizes of the forces on the two interacting objects due to the distance between the two objects. • The relative orientation of two magnets and whether the force between the magnets is attractive or repulsive. • The presence of a magnet and the force the magnet exerts on other objects. • Electrically charged objects and an electric force.		
2. Identifying the scientific nature of the question		
a. Students' questions can be investigated within the scope of the classroom.		
Guided Questions		
• How do variables affect the relationship between electric and magnetic forces? • How can you determine the cause and effect relationships of electric and magnetic interactions between two objects not in contact with each other?		
Catholic Identity Connections		
• Even when we are not in direct contact with another, our actions can still have an impact. • All creation is interdependent. • Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]		

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.3** Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. **RI.3.8** Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence). **SL.3.3** Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
MS.PS2.B

3-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets.

Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Define a simple problem that can be solved through the development of a new or improved object or tool.	**PS2.B Types of Interactions** • Electric, and magnetic forces between a pair of objects, do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.	**Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Identifying the problem to be solved

a. Students identify and describe a simple design problem that can be solved by applying a scientific understanding of the forces between interacting magnets.
b. Students identify and describe the scientific ideas necessary for solving the problem, including:
   - Force between objects does not require that those objects be in contact with each other.
   - The size of the force depends on the properties of objects, distance between the objects, and orientation of magnetic objects relative to one another.

2. Defining the criteria and constraints

a. Students identify and describe the criteria (desirable features) for a successful solution to the problem.
b. Students identify and describe the constraints (limits) such as:
   - Time
   - Cost
   - Materials

Guided Questions

- How do you create a simple design to explain and apply understanding of magnetic forces?
- How can objects not in contact with each other still demonstrate the effects of magnetic force?

Catholic Identity Connections

- God has given us the capabilities to examine and consider problems from multiple perspectives.
- God gives us the freedom to make choices.
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]
- Accept the premise that nature should not be manipulated simply at people's will or only viewed as a thing to be used, but that we must cooperate with God's plan for himself and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections
N/A
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
K.ETS1.A; 4.ETS1.A; MS.PS2.B

<table>
<tr><th colspan="3">3-LS1 From Molecules to Organisms: Structures and Processes</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.
Clarification Statement: Changes organisms go through during their life form a pattern.
Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Developing and Using Models
Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.
• Develop models to describe phenomena.

Connections to Nature of Science Scientific

Knowledge is Based on Empirical Evidence
• Science findings are based on recognizing patterns.</td><td>LS1.B Growth and Development of Organisms
• Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles.</td><td>Patterns
• Patterns of change can be used to make predictions.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Third Grade</th></tr>
<tr><td colspan="3">1. Components of the model</td></tr>
<tr><td colspan="3">a. Students develop models (e.g., conceptual, physical, drawing) to describe the phenomenon. In their models, students identify the relevant components of their models, including:
Organisms (both plant and animal).
• Birth
• Growth
• Reproduction
• Death</td></tr>
<tr><td colspan="3">2. Relationships</td></tr>
<tr><td colspan="3">a. In the models, students describe relationships between components, including:
• Organisms are born, grow, and die in a pattern known as a life cycle.
• Different organisms' life cycles can look very different.
• A causal direction of the cycle (e.g., without birth, there is no growth; without reproduction, there are no births).</td></tr>
<tr><td colspan="3">3. Connections</td></tr>
<tr><td colspan="3">a. Students use the models to describe that although organisms can display life cycles that look different, they all follow the same pattern.
b. Students use the models to make predictions related to the phenomenon, based on patterns identified among life cycles (e.g., prediction could include that if there are no births, deaths will continue and eventually there will be no more of that type of organism).</td></tr>
</table>

Guided Questions
• How does the life cycle of a plant or animal support the continuation of the species?
Catholic Identity Connections
• Birth, growth, reproduction, and death are God's design for all living things in creation. Our spiritual lives have cycles too. • The Church has cycles and seasons that help us to enter deeply into the life of Christ. • Whereas the life cycles of living things here on Earth ends with death, Jesus rose from the dead, and in doing so he made it possible for us to have life after death with Him in heaven. • Through the Eucharist, we enter into the death and resurrection of Jesus in a special way. Like Jesus, we can be blessed, broken, given and sent out into the world. [SC] • Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1] • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2] • Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.3.7** Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). **SL.3.5** Create engaging audio recordings of stories or poems that demonstrate fluid reading at an understandable pace; add visual displays when appropriate to emphasize or enhance certain facts or details. **Mathematics** **MP.4** Model with mathematics. **3.NBT** Number and Operations in Base Ten **3.NF** Number and Operations—Fractions
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
MS.LS1.B

3-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

3-LS2-1 Construct an argument that some animals form groups to help members survive.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Construct an argument with evidence, data, and/or a model.	**LS2.D Social Interactions and Group Behavior** • Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Supported claims

a. Students make a claim to be supported about a phenomenon. In their claim, students include the idea that some animals form groups and that being a member of that group helps each member survive.

2. Identifying scientific evidence

a. Students describe the given evidence, data, and/or models necessary to support the claim, including:
   - Identifying types of animals that form or live in groups of varying sizes.
   - Multiple examples of animals in groups of various sizes:
     - Obtaining more food for each individual animal compared to the same type of animal looking for food individually.
     - Displaying more success in defending themselves than those same animals acting alone.
     - Making faster or better adjustments to harmful changes in their ecosystem than would those same animals acting alone.

3. Evaluating and critiquing evidence

a. Students evaluate the evidence to determine its relevance, and whether it supports the claim that being a member of a group has a survival advantage.
b. Students describe whether the given evidence is sufficient to support the claim and whether additional evidence is needed.

4. Reasoning and synthesis

a. Students use reasoning to construct an argument connecting the evidence, data, and/or models to the claim. Students describe the following reasoning in their argument:
   - The causal evidence that being part of a group can have the effect of animals being more successful in obtaining food, defending themselves, and coping with change supports the claim that being a member of a group helps animals survive.
   - The causal evidence that an animal losing its group status can have the effect of the animal obtaining less food, not being able to defend itself, and not being able to cope with change supports the claim that being a member of a group helps animals survive.

Guided Questions

- What are the factors that enable groups to survive while those alone become extinct or endangered?
- How can organisms interact in groups to benefit individuals?

Catholic Identity Connections

- Animals, including humans, can experience positive results when they live in groups and work for the good of each other.
- All creation is mutually dependent for survival.
- We support one another spiritually through the church.
- Catholics believe in the communion of saints, which means that we are also supported by those who have already gone to God in heaven.
- Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.

Mathematics

MP.4 Model with mathematics.

3.NBT Number and Operations in Base Ten

Connections to Other DCIs in Third Grade

N/A

Articulation to DCIs across Grade-Levels

1.LS1.B; MS.LS2.A

3-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.

Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.

Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Analyze and interpret data to make sense of the phenomena using logical reasoning.	**LS3.A Inheritance of Traits** • Many characteristics of organisms are inherited from their parents. **LS3.B Variation of Traits** • Different organisms vary in how they look and function because they have different inherited information.	**Patterns** • Similarities and differences in patterns can be used to sort and classify natural phenomena.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Organizing data

a. Students organize the data (e.g., from students' previous work, grade-appropriate existing datasets) using graphical displays (e.g., table, chart, graph). The organized data include:
   - Traits of plant and animal parents.
   - Traits of plant and animal offspring.
   - Variations in similar traits in a grouping of similar organisms.

2. Identifying relationships

a. Students identify and describe patterns in the data, including:
   - Similarities in the traits of a parent and the traits of an offspring (e.g., tall plants typically have tall offspring).
   - Similarities in traits among siblings (e.g., siblings often resemble each other).
   - Differences in traits in a group of similar organisms (e.g., dogs come in many shapes and sizes, a field of corn plants have plants of different heights).
   - Differences in traits of parents and offspring (e.g., offspring do not look exactly like their parents).
   - Differences in traits among siblings (e.g., kittens from the same mother may not look exactly like their mother).

3. Interpreting data

a. Students describe that the pattern of similarities in traits between parents and offspring, and between siblings, provides evidence that traits are inherited.
b. Students describe that the pattern of differences in traits between parents and offspring, and between siblings, provides evidence that inherited traits can vary.
c. Students describe that the variation in inherited traits results in a pattern of variation in traits in groups of organisms that are of a similar type.

Guided Questions

- How do you organize data using graphical displays to identify and explain the idea that plants and animals have traits inherited from parents, including similarities and variances of these traits?

Catholic Identity Connections

- God's plan for creation is relationships. Everything is interdependent.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea.

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

3.MD.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.

Connections to Other DCIs in Third Grade

N/A

Articulation to DCIs across Grade-Levels

1.LS3.A; 1.LS3.B; MS.LS3.A; MS.LS3.B

3-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.

Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., observations, patterns) to support an explanation.	**LS3.A Inheritance of Traits** • Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. **LS3.B Variation of Traits** • The environment also affects the traits that an organism develops.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Articulating the explanation of phenomena

a. Students identify the given explanation to be supported, including a statement that relates the phenomenon to a scientific idea, including that many inherited traits can be influenced by the environment.

2. Evidence

a. Students describe the given evidence that supports the explanation, including:
   - Environmental factors that vary for organisms of the same type (e.g., amount of food, amount of water, amount of exercise an animal gets, chemicals in the water) that may influence organisms' traits.
   - Inherited traits that vary between organisms of the same type (e.g., height or weight of a plant or animal, color or quantity of the flowers).
   - Observable inherited traits of organisms in varied environmental conditions.

3. Reasoning

a. Students use reasoning to connect the evidence and support an explanation about environmental influences on inherited traits in organisms. In their claim of reasoning, students describe a cause and effect relationship between a specific causal environmental factor and its effect on a given variation in a trait (e.g., not enough water produces plants that are shorter and have fewer flowers than plants that have more water available).

Guided Questions

- What evidence can you use to explain how different environmental factors influence traits of an organism?

Catholic Identity Connections

- As the Body of Christ, we are called to create loving and nurturing environments so that we develop positive traits

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.2** Determine the main idea of a text; recount the key details and explain how they support the main idea. **RI.3.3** Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. **W.3.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **SL.3.4** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **3.MD.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
1.LS3.A; 1.LS3.B; MS.LS3.A; MS.LS3.B

3-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.

Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.

Assessment Boundary: Assessments do not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Analyze and interpret data to make sense of phenomena using logical reasoning.	**LS4.A Evidence of Common Ancestry and Diversity** • Some kinds of plants and animals that once lived on Earth are no longer found anywhere. • Fossils provide evidence about all types of organisms that lived long ago and also about the nature of their environments.	**Scale, Proportion, and Quantity** • Observable phenomena exist from very short to very long time periods. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Organizing data

a. Students use graphical displays (e.g., table, chart, graph) to organize the given data, including data about:
   - Fossils of animals (e.g., information on type, size, type of land on which it was found).
   - Fossils of plants (e.g., information on type, size, type of land on which it was found).
   - The relative ages of fossils (e.g., from a very long time ago).
   - Existence of modern counterparts to the fossilized plants and animals and information on where they currently live.

2. Identifying relationships

a. Students identify and describe relationships in the data, including:
   - That fossils represent plants and animals that lived long ago.
   - The relationships between the fossils of organisms and the environments in which they lived (e.g., marine organisms, like fish, must have lived in water environments).
   - The relationships between types of fossils (e.g., those of marine animals) and the current environments where similar organisms are found.
   - That some fossils represent organisms that lived long ago and have no modern counterparts.
   - The relationships between fossils of organisms that lived long ago and their modern counterparts.
   - The relationships between existing animals and the environments in which they currently live.

3. Interpreting data
a. Students describe that: • Fossils provide evidence of organisms that lived long ago but have become extinct (e.g., dinosaurs, mammoths, and other organisms that have no clear modern counterpart). • Features of fossils provide evidence of organisms that lived long ago and of what types of environments those organisms must have lived in (e.g., fossilized seashells indicate shelled organisms that lived in aquatic environments). • By comparing data about where fossils are found and what those environments are like, fossilized plants and animals can be used to provide evidence that some environments look very different now than they did a long time ago (e.g., fossilized seashells found on land that is now dry suggest that the area in which those fossils were found used to be aquatic; tropical plant fossils found in Antarctica, where tropical plants cannot live today, suggest that the area used to be tropical).
Guided Questions
• How do you use graphic displays to describe and analyze data on fossils from long ago? • How do fossil records show patterns of change over time?
Catholic Identity Connections
• God is the creator of all things. • Fossils provide evidence that God created a world that continues to change over time. • Spiritually we continue to change over time as we grow closer to God. • Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS K6 IS1] • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2] • Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.2** Determine the main idea of a text; recount the key details and explain how they support the main idea. **RI.3.3** Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. **W.3.1** Write opinion pieces on topics or texts, supporting a point of view with reasons. **W.3.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. **W.3.8** Recall information from experiences or legally and ethically gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **3.MD.4** Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
4.ESS1.C; MS.LS2.A; MS.LS4.A; MS.ESS1.C; MS.ESS2.B

3-LS4 Biological Evolution: Unity and Diversity		
Students who demonstrate understanding can: **3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.** Clarification Statement: Examples of cause and effect relationships could be plants that have longer thorns than other plants may be less likely to be eaten by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., observations, patterns) to construct an explanation.	**LS4.B Natural Selection** • Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including that variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.
b. Students use evidence and reasoning to construct an explanation for the phenomenon.

2. Evidence

a. Students describe the given evidence necessary for the explanation, including:
   - A given characteristic of a species (e.g., thorns on a plant, camouflage of an animal, the coloration of moths).
   - The patterns of variation of a given characteristic among individuals in a species (e.g., longer or shorter thorns on individual plants, dark or light coloration of animals).
   - Potential benefits of a given variation of the characteristics (e.g., the coloration of some moths makes them difficult to see on the bark of a tree).

3. Reasoning

a. Students use reasoning to logically connect the evidence to support the explanation for the phenomenon. Students describe a chain of reasoning that includes:
   - That certain variations in characteristics make it harder or easier for an animal to survive, find mates, and reproduce (e.g., longer thorns prevent predators more effectively and increase the likelihood of survival; light coloration of some moths provides camouflage in certain environments, making it more likely that they will live long enough to be able to mate and reproduce).
   - That the characteristics that make it easier for some organisms to survive, find a mate, and reproduce give those organisms an advantage over other organisms of the same species that don't have those traits.
   - That there can be a cause and effect relationship between a specific variation in a characteristic (e.g., longer thorns, coloration of moths) and its effect on the ability of the individual organism to survive and reproduce (e.g., plants with longer thorns are less likely to be eaten, darker moths are less likely to be seen and eaten on dark trees).

Guided Questions

- How does the unique design of an organism enable the survival in a specific environment?
- How do adaptations and characteristics provide organisms advantages for survival?

Catholic Identity Connections

- This is where religion differs from a purely scientific approach.
    - Theme 1: As Catholics, we believe in the life and dignity of every person, including those who are not as physically or mentally able to survive as others.
    - Theme 4: The USCCB writes: "A basic moral test is how our most vulnerable members are faring. We are thus instructed to put the needs of the poor and vulnerable first."
    - Theme 6: We are all one family in solidarity with one another.
    - Theme 7: We are to care for all of creation, including vulnerable ecosystems. [CST]
- The Church provides a spiritual environment in which humans can survive and thrive. Jesus instituted the sacraments to give us the grace we need.
- God knows us and our needs (Psalm 139). [S]
- Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Explain how science properly limits its focus to "how" things physically exist and is not designed to answer issues of meaning, the value of things, or the mysteries of the human person. [CS S.K6 IS8]
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9]
- Analyze the false assumption that science can replace faith. [CS S.K6 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea.

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

3.MD.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

Connections to Other DCIs in Third Grade

3.LS4.C

Articulation to DCIs across Grade-Levels

MS.LS2.A; MS.LS3.B; MS.LS4.B

3-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Construct an argument with evidence.	**LS4.C Adaptation** • For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Supported claims

a. Students make a claim to be supported about a phenomenon. In their claim, students include the idea that in a particular habitat, some organisms can survive well, some can survive less well, and some cannot survive at all.

2. Identifying scientific evidence

a. Students describe the given evidence necessary for supporting the claim, including:
   - Characteristics of a given particular environment (e.g., soft earth, trees and shrubs, seasonal flowering plants).
   - Characteristics of a particular organism (e.g., plants with long, sharp leaves; rabbit coloration).
   - Needs of a particular organism (e.g., shelter from predators, food, water).

3. Evaluating and critiquing evidence

a. Students evaluate the evidence to determine:
   - The characteristics of organisms that might affect survival.
   - The similarities and differences in needs among at least three types of organisms.
   - How and what features of the habitat meet the needs of each of the organisms (i.e., the degree to which a habitat does not meet the needs of an organism).
   - How and what feature of the habitat do not meet the needs of each of the organisms (i.e., the degree to which a habitat does not meet the needs of an organism).

b. Students evaluate the evidence to determine whether it is relevant to and supports the claim.

c. Students describe whether the given evidence is sufficient to support the claim, and whether additional evidence is needed.

4. Reasoning and synthesis

a. Students use reasoning to construct an argument, connecting the relevant and appropriate evidence to the claim, including describing that any particular environment meets different organisms' needs to different degrees due to the characteristics of that environment and the needs of the organisms. Students describe a chain of reasoning in their argument, including the following cause and effect relationships:
   - If an environment fully meets the needs of an organism, that organism can survive well within that environment.
   - If an environment partially meets the needs of an organism, that organism can survive less well (e.g., lower survival rate, increased sickliness, shorter lifespan) than organisms whose needs are met within that environment.
   - If an environment does not meet the needs of the organism, that organism cannot survive within that environment.
   - Together, the evidence suggests a causal relationship within the system between the characteristics of a habitat and the survival of organisms within it.

Guided Questions

- How do you explain the idea that an organism may or may not survive in a given environment, depending on the needs of the organism and characteristics of the environment?
- How do the parts of living systems work together to sustain life?

Catholic Identity Connections

- As Catholics we seek out environments that support healthy physical, emotional and spiritual growth.
- The Church and the sacraments are good soil in which we can grow closer to God and one another. [T] [SA]
- The parable of the sower and the seed (Matthew 13: 1-29; 36-43). [S]
- Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea.

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

3.MD.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs.

Connections to Other DCIs in Third Grade

3.ESS2.D

Articulation to DCIs across Grade-Levels

K.ESS3.A; 3.LS2.A; 2.LS4.D; MS.LS2.A; MS.LS4.B; MS.LS4.C; MS.ESS1.C

3-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there change.

Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.
Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	**LS2.C Ecosystem Dynamics, Functioning, and Resilience** • When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (secondary emphasis) **LS4.D Biodiversity and Humans** • Populations live in a variety of habitats, and change in those habitats affects the organisms living there.	**Systems and System Models** • A system can be described in terms of its components and their interactions. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Engineering, Technology, and Science on Society and the Natural World** • Knowledge of relevant scientific concepts and research findings is important in engineering.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Supported claims

a. Students make a claim about the merit of a given solution to a problem that is caused when the environment changes, which results in changes in the types of plants and animals that live there.

2. Identifying scientific evidence

a. Students describe the given evidence about how the solution meets the given criteria and constraints. This evidence includes:
   - A system of plants, animals, and a given environment within which they live before the given environmental change occurs.
   - A given change in the environment.
   - How the change in the given environment causes a problem for the existing plants and animals living within that area.
   - The effect of the solution on the plants and animals within the environment.
   - The resulting changes to plants and animals living within that changed environment, after the solution has been implemented.

3. Evaluating and critiquing evidence

a. Students evaluate the solution to the problem to determine the merit of the solution. Students describe how well the proposed solution meets the given criteria and constraints to reduce the impact of the problem created by the environmental change in the system, including:
   - How well the proposed solution meets the given criteria and constraints to reduce the impact of the problem created by the environmental change in the system, including:
   - How the solution makes changes to one part (e.g., a feature of the environment) of the system, affecting the other parts of the system (e.g., plants and animals).
   - How the solution affects plants and animals.

b. Students evaluate the evidence to determine whether it is relevant to and supports the claim.

c. Students describe whether the given evidence is sufficient to support the claim, and whether additional evidence is needed.

Guided Questions

- Why do changes to a given environment impact the plants and animals living there?
- What can humans do about the changes they cause to the environment?

Catholic Identity Connections

- God calls each of us to consider the well-being of other people, as well as plants, animals, and the environment when making choices.
- We are called to adapt and change in order to always make choices that affirm the dignity of all life.
- Choices must be made for the good of God's creation.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]
- Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]
- Accept the premise that nature should not be manipulated simply at people's will or only viewed as a thing to be used, but that we must cooperate with God's plan for us and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

RI.3.2 Determine the main idea of a text; recount the key details and explain how they support the main idea.

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs in Third Grade

3.ESS3.B

Articulation to DCIs across Grade-Levels

K.ESS3.A; K.ETS1.A; 2.LS2.A; 2.LS4.D; 4.ESS3.B; 4.ETS1.A; MS.LS2.A; MS.LS2.C; MS.LS4.C; MS.ESS1.C; MS.ESS3.C

3-ESS2 Earth's Systems

Students who demonstrate understanding can:

3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

Clarification Statement: Examples of data could include average temperature, precipitation, wind direction, and understanding of the water cycle.

Assessment Boundary: Assessment does not include climate change.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and various graphical displays (bar graphs and pictographs) to reveal patterns that indicate relationships.	**ESS2.D Weather and Climate** • Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next.	**Patterns** • Patterns of change can be used to make predictions.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Organizing data

a. Students use graphical displays (e.g., table, chart, graph) to organize the given data by season using tables, pictographs, and/or bar charts, including:
- Weather condition data from the same area across multiple seasons (e.g., average temperature, precipitation, wind direction).
- Weather condition data from different areas (e.g., hometown and nonlocal areas such as a town in another state).

2. Identifying relationships

a. Students identify and describe patterns of weather conditions across:
- Different seasons (e.g., cold and dry in the winter, hot and wet in the summer; more or less wind in a particular season).
- Different areas (e.g., certain areas [defined by location, such as a town in the Pacific Northwest], have high precipitation, while different areas [based on location or type, such as a town in the Southwest] have very little precipitation).

3. Interpreting data

a. Students use patterns of weather conditions in different seasons and different areas to predict:
- The typical weather conditions expected during a particular season (e.g., "In our town in the summer, it is typically hot, while in the winter, it is typically cold; therefore, the prediction is that next summer it will be hot and next winter it will be cold.").
- The typical weather conditions expected during a particular season in different areas.

Guided Questions

- How do you use graphical displays to organize weather data by season in a particular area?
- How can weather cycles and patterns be used to understand history or predict future events?

Catholic Identity Connections
• There is order and harmony in God's creation. • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
Mathematics **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Use appropriate tools strategically. **3.MD.2** Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. **3.MD.3** Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs.
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
K.ESS2.D; 4.ESS2.A; 5.ESS2.A; MS.ESS2.C; MS.ESS2.D

3-ESS2 Earth's Systems

Students who demonstrate understanding can:

3-ESS2-2 Obtain and combine information to describe climates in different regions of the world.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3-5 builds on K-2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Obtain and combine information from books and other reliable media to explain phenomena.	**ESS2.D Weather and Climate** • Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years.	**Patterns** • Patterns of change can be used to make predictions.

Examples of Observable Evidence of Student Performance by the End of Third Grade

1. Obtaining information

a. Students use books and other reliable media to gather information about:
   - Climates in different regions of the world (e.g., equatorial, polar, coastal, mid-continental).
   - Variations in climates within different regions of the world (e.g., variations could include an area's average temperatures and precipitation during various months over several years or an area's average rainfall and temperatures during the rainy season over several years).

2. Evaluating information

a. Students combine obtained information to provide evidence about the climate pattern in a region that can be used to make predictions about typical weather conditions in that region.

3. Communicating information

a. Students use the information they obtained and combined to describe:
   - Climates in different regions of the world.
   - Examples of how patterns in climate could be used to predict typical weather conditions.
   - That climate can vary over years in different regions of the world.

Guided Questions

- How can you use reliable media, tools, and technology to gather information and describe climate in different regions of the world?

Catholic Identity Connections

- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.3.1** Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. **RI.3.9** Compare and contrast the most important points and key details presented in two texts on the same topic. **W.3.8** Recall information from experiences or legally and ethically gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics.
Connections to Other DCIs in Third Grade
N/A
Articulation to DCIs across Grade-Levels
MS.ESS2.C; MS.ESS2.D

3-ESS3 Earth and Human Activity		
Students who demonstrate understanding can: **3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.** Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.	**ESS3.B Natural Hazards** • A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones).
Examples of Observable Evidence of Student Performance by the End of Third Grade		
1. Supported claims		
a. Students make a claim about the merit of a given design solution that reduces the impact of a weather-related hazard.		
2. Identifying scientific evidence		
a. Students describe the given evidence about the design solution, including evidence about: • The given weather-related hazard (e.g., heavy rain or snow, strong winds, lightning, flooding along river banks). • Problems caused by the weather-related hazard (e.g., heavy rains cause flooding, lightning causes fires). • How the proposed solution addresses the problem (e.g., dams and levees are designed to control flooding, lightning rods reduce the chance of fires) [note: mechanisms are limited to simple observable relationships that rely on logical reasoning].		
3. Evaluating and critiquing evidence		
a. Students evaluate the evidence using given criteria and constraints to determine: • How the proposed solution addresses the problem, including the impact of the weather-related hazard after the design solution has been implemented. • The merits of a given solution in reducing the impact of a weather-related hazard (i.e., whether the design solution meets the given criteria and constraints). • The benefits and risks a given solution poses when responding to the societal demands to reduce the impact of a hazard.		

Guided Questions

- Given a solution to a problem caused by a weather-related hazard, how can you support or contradict the merit of the solution?

Catholic Identity Connections

- By using their God-given talents, people can design solutions that reduce the impact of weather-related hazards. The poor often suffer the most from weather-related hazards. Catholic Social Teaching tells us to have special consideration for the needs of the poor. [CST]
- We have a responsibility to respect all of God's creation.
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons.

W.3.7 Conduct short research projects that build knowledge about a topic.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs in Third Grade

N/A

Articulation to DCIs across Grade-Levels

K.ESS3.B; K.ETS1.A; 4.ESS3.B; 4.ETS1.A; MS.ESS3.B

Fourth Grade Standards

4-PS3 Energy

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.
4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.
4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Catholic/Christian Scientists

- Physics
  - Roger Bacon (Franciscan friar and early advocate of the scientific method)
  - André-Marie Ampère (electromagnetism)
  - Antoine César Becquerel (electric and luminescent phenomena)
  - Vincenzo Viviani (Viviani's theorem, Viviani's curve and his work in determining the speed of sound)
  - Hippolyte Fizeau (the velocity of light)
  - Alessandro Volta (invention of the battery)
  - André-Marie Ampère (electromagnetism)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

4-PS4 Waves and Their Applications to Technologies for Information Transfer

4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.
4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.

Catholic/Christian Scientists

- Guglielmo Marconi (long-distance radio transmission)

Saints [SA]

- St. Isadore of Seville, patron saint of computer scientists and the Internet
- St. Lucia (or St. Lucy), patron saint of vision

4-LS1 From Molecules to Organisms: Structures and Processes

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

Catholic Identity

- Plants in the Bible:
    - http://ww2.odu.edu/~lmusselm/plant/bible/allbibleplantslist.php
    - http://www.newadvent.org/cathen/12149a.htm
    - Below is a list of the flowers dedicated to the Blessed Mother. (https://www.catholicculture.org/culture/library/view.cfm?recnum=5855)
        - White Lily "Annunciation Lily", symbol of Mary's Immaculate Purity.
        - Impatiens "Our Lady's Earrings", symbolical pure adornments of the ears of Mary who heard the word of God and kept it.
        - Violet symbol of Mary's humility "regarded by the Lord".
        - Lady-Slipper "Our Lady's Slipper", symbol of Mary's graceful Visitation trip to visit Elizabeth in the hill country: "All her steps were most beauteous."
        - Thistle-Down another Visitation symbol, from its graceful movement in air currents.
        - Rose symbol of the Blessed Virgin of prophecy, the Rose plant bearing the flower, Christ.
        - Daisy "Mary's Flower of God".
        - Periwinkle "Virgin Flower", emblem of the Blessed Virgin.
        - Columbine symbol of the dove of the Holy Spirit, Mary's overshadowing, indwelling, divine Spouse.
        - Pansy "Trinity Flower", symbol of the Trinity, first revealed to Mary.
        - Strawberry "Fruitful Virgin", in flower and fruit at the same time.

Catholic/Christian Scientists

- Louis Pasteur (bacteriology)
- Gregor Mendel (genetics through plant research)
- Bartolomeo Eustachi (one of the founders of human anatomy)
- Sr. Paula González (biology)
- Antoine Laurent de Jussieu (natural classification of flowering plants)
- Andreas Vesalius (modern human anatomy)
- Theodor Schwann (theory of the cellular structure of animal organisms)

- Botany
    - Carl Linnaeus
    - Stephan Endlicher
    - James Britton
    - Andrea Cesalpino
    - James Britten

Saints [SA]

- St. Dorothy, patron saint of horticulture;
- St. Isadore the Farmer, patron saint of farmers
- St. Franics of Assisi, patron saint of animals and ecology
- St. Gall, patron saint of birds

4-ESS1 Earth's Place in the Universe

4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

Catholic/Christian Scientists

- Nicolas Steno (stratigraphy)
- Georgius Agricola (mineralogy)
- Jean Baptiste Julien d'Omalius d'Halloy (modern geology)
- René Just Haüy (crystallography)
- Abraham Ortelius (created the first modern atlas and theorized on continental drift)
- Wilhelm Heinrich Waagen (geologist and paleontologist)
- Johann Joachim Winckelmann (scientific archaeology)
- Teilhard de Chardin (paleontology)

Saints [SA]

- St. Barbara, patron saint of geology

4-ESS2 Earth's Systems

4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

Catholic/Christian Scientists

- Nicolas Steno (stratigraphy)
- Georgius Agricola (mineralogy)
- Jean Baptiste Julien d'Omalius d'Halloy (modern geology)
- René Just Haüy (crystallography)
- Abraham Ortelius (created the first modern atlas and theorized on continental drift)
- Wilhelm Heinrich Waagen (geologist and paleontologist)
- Johann Joachim Winckelmann (scientific archaeology)
- Teilhard de Chardin (paleontology)

Saints [SA]

- St. Barbara, patron saint of geology

4-ESS3 Earth and Human Activity

4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

Scripture [S]

- After the flood God makes a covenant with Noah, his sons, and all of creation:
  "God said to Noah and to his sons with him: 'See, I am now establishing my covenant with you and your descendants after you and with every living creature that was with you: the birds, the tame animals, and all the wild animals that were with you—all that came out of the ark. I will establish my covenant with you, that never again shall all creatures be destroyed by the waters of a flood; there shall not be another flood to devastate the earth.' God said: 'This is the sign of the covenant that I am making between me and you and every living creature with you for all ages to come: I set my bow in the clouds to serve as a sign of the covenant between me and the earth. When I bring clouds over the earth, and the bow appears in the clouds, I will remember my covenant between me and you and every living creature—every mortal being—so that the waters will never again become a flood to destroy every mortal being. When the bow appears in the clouds, I will see it and remember the everlasting covenant between God and every living creature—every mortal being that is on earth.' God told Noah: 'This is the sign of the covenant I have established between me and every mortal being that is on earth.'"
  (Genesis 9:8-17)

Catholic/Christian Scientists

- Rachel Carson
- Sr. Paula Gonzales

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

4-PS3 Energy

Students who demonstrate understanding can:

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.

Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation.	**PS3.A Definitions of Energy** • The faster a given object is moving, the more energy it possesses.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including that the speed of a given object is related to the energy of the object (e.g., the faster an object is moving, the more energy it possesses).
b. Students use the evidence and reasoning to construct an explanation for the phenomenon.

2. Evidence

a. Students identify and describe the relevant given evidence for the explanation, including:
   - The relative speed of the object (e.g., faster vs. slower objects).
   - Qualitative indicators of the amount of energy of the object, as determined by a transfer of energy from the object (e.g., more or less sound produced in a collision, more or less heat produced when objects rub together, relative speed of a ball that was stationary following a collision with a moving object, more or less distance a stationary object is moved).

3. Reasoning

a. Students use reasoning to connect the evidence to support an explanation for the phenomenon. In the explanation, students describe a chain of reasoning that includes:
   - Motion can indicate the energy of an object.
   - The faster a given object is moving, the more observable impact it can have on another object (e.g., a fast-moving ball striking something [a gong, a wall] makes more noise than does the same ball moving slowly and striking the same thing).
   - The observable impact of a moving object interacting with its surroundings reflects how much energy was able to be transferred between objects and therefore relates to the energy of the moving object.
   - Because faster objects have a larger impact on their surroundings than objects moving more slowly, they have more energy due to motion (e.g., a fast-moving ball striking a gong makes more noise than a slow-moving ball doing the same thing because it has more energy that can be transferred to the gong, producing more sound). (Note: This refers only to relative bulk motion energy, not potential energy, to remain within the DCI.) Therefore, the speed of an object is related to the energy of the object.

Guided Questions

- How is the speed of an object related to the energy of that object?

Catholic Identity Connections

- God's creation is one of order and harmony.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

W.4.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes, categorize information, and provide a list of sources.

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

MS.PS3.A

4-PS3 Energy		
Students who demonstrate understanding can: **4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** Assessment Boundary: Assessment does not include quantitative measurements of energy.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.	**PS3.A Definitions of Energy** • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B Conservation of Energy and Energy Transfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • Light also transfers energy from place to place. • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students describe the phenomenon under investigation, which includes the following ideas:
   - The transfer of energy, including:
     - Collisions between objects.
     - Light traveling from one place to another.
     - Electric currents producing motion, sound, heat, or light.
     - Sound traveling from one place to another.
     - Heat passing from one object to another.
     - Motion, sound, heat, and light causing a different type of energy to be observed after an interaction (e.g., in a collision between two objects, one object may slow down or stop, the other object may speed up, and the objects and surrounding air may be heated; a specific sound may cause the movement of an object; the energy associated with the motion of an object, via an electrical current, may be used to turn on a light).

b. Students describe the purpose of the investigation, which includes providing evidence for an explanation of the phenomenon, including the idea that energy can be transferred from place to place by moving objects, sound, light, heat, and electric currents.
   - Moving objects
   - Sound
   - Light
   - Heat
   - Electric currents

2. Identifying the evidence to address the purpose of the investigation

a. From the given investigation plan, students describe the data to be collected that will serve as the basis for evidence, including:
   - The motion and collision of objects before and after an interaction (e.g., when a given object is moving fast, it can move another object farther than when the same object is moving more slowly).
   - The relative presence of sound, light, or heat (including the surrounding air) before and after an interaction (e.g., shining a light on an object can increase the temperature of the object; a sound can move an object).
   - The presence of electric currents flowing through wires causally linking one form of energy output (e.g., a moving object) to another form of energy output (e.g., another moving object; turning on a light bulb).

b. Students describe how their observations will address the purpose of the investigation, including how the observations will provide evidence that energy, in the form of light, sound, heat, and motion, can be transferred from place to place by sound, light, heat, or electric currents (e.g., in a system in which the motion of an object generates an observable electrical current to turn on a light, energy (from the motion of an object) must be transferred to another place (energy in the form of the light bulb) via the electrical current, because the motion doesn't cause the light bulb to light up if the wire is not completing a circuit between them; when a light is directed at an object, energy (in the form of light) must be transferred from the source of the light to its destination and can be observed in the form of heat, because if light is blocked, the object isn't warmed.

3. Planning the investigation

a. From the given investigation plan, students identify and describe how the data will be observed and recorded, including the tools and methods for collecting data on:
   - The motion and collision of objects, including any sound or heat producing the motion/collision, or produced by the motion/collision.
   - The presence of energy in the form of sound, light, or heat in one place as a result of sound, light, or heat in a different place.
   - The presence of electric currents in wires and the presence of energy (in the form of sound, light, heat, or motion resulting from the flow of electric currents through a device).

b. Students describe the number of trials, controlled variables, and experimental set up.

4. Collecting the data

a. Students make and record observations according to the given investigation plan to provide evidence that:
   - Energy is present whenever there are moving objects, sound, light, or heat.
   - Energy has been transferred from place to place (e.g., a bulb in a circuit is not lit until a switch is closed and it lights, indicating that energy is transferred through electric current in a wire to light the bulb; a stationary ball is struck by a moving ball, causing the stationary ball to move and the moving ball to slow down, indicating that energy has been transferred from the moving ball to the stationary one).

Guided Questions

- Using an investigation plan, how can you describe and provide evidence to support that energy can be transferred from place to place by sound, light, heat, and electrical currents?

Catholic Identity Connections

- Light, sound, heat, and motion indicate that an energy transfer is occurring. They make the transfer of energy perceptible. Still there are many energy transfers that we do not see. The sacraments are outward signs, instituted by Christ, to give grace. They indicate the energy of God's love and presence in our lives. [S]
- We do not see Transubstantiation, in which the bread and wine become the Body and Blood of Jesus, yet we know through faith that it is occurring.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

MS.PS2.B; MS.PS3.A; MS.PS3.B; MS.PS4.B

4-PS3 Energy		
Students who demonstrate understanding can: **4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.** Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. Assessment Boundary: Assessment does not include quantitative measurements of energy.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Asking Questions and Defining Problems Asking questions and defining problems in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	**PS3.A Definitions of Energy** • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B Conservation of Energy and Energy Transfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Addressing phenomena of the natural world

a. Students ask questions about the changes in energy that occur when objects collide, the answers to which would clarify:
   - A qualitative measure of energy (e.g., relative motion, relative speed, relative brightness) of the object before the collision.
   - The mechanism of energy transfer during the collision, including:
     - The transfer of energy by contact forces between colliding objects that results in a change in the motion of the objects.
     - The transfer of energy to the surrounding air when objects collide resulting in sound and heat.

b. Students predict reasonable outcomes about the changes in energy that occur after objects collide, based on patterns linking object collision and energy transfer between objects and the surrounding air.

2. Identifying the scientific nature of the question

a. Students ask questions that can be investigated within the scope of the classroom or an outdoor environment.

Guided Questions

- How is energy transferred when objects collide?
- What predictions can you make about the changes in energy when two objects collide?

Catholic Identity Connections
• How is energy transferred when we collide with each other in negative ways? In positive ways? • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.4.7** Conduct short research projects that build knowledge through investigation of different aspects of a topic. **W.4.8** Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and organize information, and provide a list of sources.
Connections to Other DCIs in Fourth Grade
N/A
Articulation to DCIs across Grade-Levels
K.PS2.B; 3.PS2.A; MS.PS2.A; MS.PS2.B; MS.PS3.A; MS.PS3.B; MS.PS3.C

4-PS3 Energy		
Students who demonstrate understanding can: **4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.** Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound: and a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device. Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Apply scientific ideas to solve design problems.	**PS3.B Conservation of Energy and Energy Transfer** • Energy can be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. **PS3.D Energy in Chemical Processes and Everyday Life** • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. **ETS1.A Defining Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary emphasis)	**Energy and Matter** • Energy can be transferred in various ways and between objects. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones. **Connections to Nature of Science** **Science Is a Human Endeavor** • Most scientists and engineers work in teams. • Science affects everyday life.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Using scientific knowledge to generate design solutions

a. Given a problem to solve, students collaboratively design a solution that converts energy from one form to another. In the design, students:
   - Specify the initial and final forms of energy (e.g., electrical energy, motion, light).
   - Identify the device by which the energy will be transformed (e.g., a light bulb to convert electrical energy into light energy, a motor to convert electrical energy into energy of motion).

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe the given criteria and constraints of the design, which include:
   - Criteria:
     - The initial and final forms of energy.
     - Description of how the solution functions to transfer energy from one form to another.
   - Constraints:
     - The materials available for the construction of the device.
     - Safety considerations.

3. Evaluating potential solutions

a. Students evaluate the proposed solution according to how well it meets the specified criteria and constraints of the problem.

4. Modifying the design solution

a. Students test the device and use the results of the test to address problems in the design or improve its functioning.

Guided Questions

- How would you design, analyze, and test devices that convert energy from one form to another?
- What is required of a device to convert energy from one form to another?

Catholic Identity Connections

- In Jesus Christ our God becomes human, changing form, yet still maintaining divinity. God is present in three forms or persons in the Trinity.
- We can work together to solve problems in order to benefit the common good.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Mathematics

4.OA.3 Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

K.ETS1.A; 2.ETS1.B; 5.PS3.D; 5.LS1.C; MS.PS3.A; MS.PS3.B; MS.ETS1.B; MS.ETS1.C

4-PS4	Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.

Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.

Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or qualitative models of amplitude and wavelength.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle. **Connections to Nature of Science Scientific** **Knowledge Is Based on Empirical Evidence** • Science findings are based on recognizing patterns.	**PS4.A Wave Properties** • Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets a beach. • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).	**Patterns** • Similarities and differences in patterns can be used to sort, classify, and analyze simple rates of change for natural phenomena.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Components of the model

a. Students develop a model (e.g., diagrams, analogies, examples, abstract representations, physical models) to make sense of a phenomenon that involves wave behavior. In the model, students identify the relevant components, including:
   - Waves.
   - Wave amplitude.
   - Wavelength.
   - Motion of objects.

2. Relationships

a. Students identify and describe the relevant relationships between components of the model, including:
   - Waves can be described in terms of patterns of repeating amplitude and wavelength (e.g., in a water wave, there is a repeating pattern of water being higher and then lower than the baseline level of the water).
   - Waves can cause an object to move.
   - The motion of objects varies with the amplitude and wavelength of the wave carrying it.

3. Connections

a. Students use the model to describe:
   - The patterns in the relationships between a wave passing, the net motion of the wave, and the motion of an object caused by the wave as it passes.
   - How waves may be initiated (e.g., by disturbing surface water or shaking a rope or string).
   - The repeating pattern produced as a wave is propagated.

b. Students use the model to describe that waves of the same type can vary in terms of amplitude and wavelength and describe how this might affect the motion, caused by a wave, of an object.

c. Students identify similarities and differences in patterns underlying waves and use these patterns to describe simple relationships involving wave amplitude, wavelength, and the motion of an object (e.g., when the amplitude increases, the object moves more).

Guided Questions

- How do you develop a model that describes patterns in wave behavior that cause motion?

Catholic Identity Connections

- Just as energy moves through a wave, the movements of the Holy Spirit move through the Church and through us. They can be set in motion through reading the scriptures, prayer, reflection, teachers and ministers of the church, Mass, the sacraments, sacramentals, and each other.
- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.

Mathematics

MP.4 Model with mathematics.

4.G.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.

Connections to Other DCIs in Fourth Grade

4.PS3.A; 4.PS3.B

Articulation to DCIs across Grade-Levels

MS.PS4.A

4-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.	**PS4.B Electromagnetic Radiation** • An object can be seen when light reflected from its surface enters the eyes.	**Cause and Effect** • Cause and effect relationships are routinely identified.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Components of the model

a. Students develop a model to make sense of a phenomenon involving the relationship between light reflection and visibility of objects. In the model, students identify the relevant components, including:
   - Light (including the light source).
   - Objects.
   - The path that light follows.
   - The eye.

2. Relationships

a. Students identify and describe causal relationships between the components, including:
   - Light enters the eye, allowing objects to be seen.
   - Light reflects off of objects, and then can travel and enter the eye.
   - Objects can be seen only if light follows a path between a light source, the object, and the eye.

3. Connections

a. Students use the model to describe that in order to see objects that do not produce their own light, light must reflect off the object and into the eye.
b. Students use the model to describe the effects of the following on seeing an object:
   - Removing, blocking, or changing the light source (e.g., a dimmer light).
   - Closing the eye.
   - Changing the path of the light (e.g., using mirrors to direct the path of light to allow the visualization of a previously unseen object or to change the position in which the object can be seen; using an opaque or translucent barrier between 1) the light source and the object or 2) the object and the eye to change the path light follows and the visualization of the object).

Guided Questions

- How do you develop a model that demonstrates the relationship between light reflecting from an object and what is seen by the eye?
- What needs to happen in order for us to be able to see an object that does not produce its own light?

Catholic Identity Connections

- God has given us the gift of sight which allows us to see objects that receive light from various sources.
- As Catholics, we may think of light both physically and spiritually, as Jesus is the Light of the world, reflecting God's love for us.
- Are we able to see the light of God's love in our lives? What things or people reflect God's love to us? What things or people keep us from reflecting God's love, as Jesus did?
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.

Mathematics
MP.4 Model with mathematics.
4.G.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures.

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

1.PS4.B; MS.PS4.B; MS.LS1.D

4-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

4-PS4-3 Generate and compare multiple solutions that use patterns to transfer information.

Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**PS4.C Information Technologies and Instrumentation** • Digitalized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information - convert it from digitized form to voice - and vice versa. **ETS1.C Optimizing the Design Solution** • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (secondary emphasis)	**Patterns** • Similarities and differences in patterns can be used to sort and classify designed products. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Using scientific knowledge to generate design solutions

a. Students generate at least two design solutions for a given problem that use patterns to transmit a given piece of information (e.g., picture, message). Students describe how the design solution is based on:
   - Knowledge of digitized information transfer (e.g., information can be converted from a sound wave into a digital signal such as patterns of 1's and 0's and vice versa; visual or verbal messages can be encoded in patterns of flashes of light to be decoded by someone else across the room).
   - Ways that high-tech devices convert and transmit information (e.g., cell phones convert sound waves into digital signals so they can be transmitted long distances and then converted back into sound waves; a picture or message can be encoded using light signals to transmit the information over a long distance).

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe the given criteria for the design solutions, including the accuracy of the final transmitted information and that digitized information (patterns) transfer is used.

b. Students describe the given constraints of the design solutions, including:
   - The distance over which information is transmitted.
   - Safety considerations.
   - Materials available.

3. Evaluating potential solutions

a. Students compare the proposed solutions based on how well each meets the criteria and constraints.
b. Students identify similarities and differences in the types of patterns used in the solutions to determine whether some ways of transmitting information are more effective than others at addressing the problem.

Guided Questions

- How do tools and technology transfer information?
- How do you design and test a system that uses patterns to transfer information?

Catholic Identity Connections

- We can use science and technology to build communities of love through effective communication.
- Let us be mindful of our patterns of speech and cultivate a language of love.
- We have a responsibility to communicate with others in a respectful and considerate manner, whether it be verbally, in print or digitally.
- Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.
RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

Connections to Other DCIs in Fourth Grade

4.ETS1.A

Articulation to DCIs across Grade-Levels

K.ETS1.A; 1.PS4.C; 2.ETS1.B; 2.ETS1.C; 3.PS2.A; MS.PS4.C; MS.ETS1.B

4-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, skin, and body systems.
Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Construct an argument with evidence, data, and/or a model.	**LS1.A Structure and Function** • Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Supported claims

a. Students make a claim to be supported about a phenomenon. In the claim, students include the idea that plants and animals have internal and external structures that function together as part of a system to support survival, growth, behavior, and reproduction.

2. Identifying scientific evidence

a. Students describe the given evidence, including:
   - The internal and external structures of selected plants and animals.
   - The primary functions of those structures.

3. Evaluating and critiquing evidence

a. Students determine the strengths and weaknesses of the evidence, including whether the evidence is relevant and sufficient to support a claim about the role of internal and external structures of plants and animals in supporting survival, growth, behavior, and/or reproduction.

4. Reasoning and synthesis

a. Students use reasoning to connect the relevant and appropriate evidence and construct an argument that includes the idea that plants and animals have structures that, together, support survival, growth, behavior, and/or reproduction. Students describe a chain of reasoning that includes:
   - Internal and external structures serve specific functions within plants and animals (e.g., the heart pumps blood to the body, thorns discourage predators).
   - The functions of internal and external structures can support survival, growth, behavior, and/or reproduction in plants and animals (e.g., the heart pumps blood throughout the body, which allows the entire body access to oxygen and nutrients; thorns prevent predation, which allows the plant to grow and reproduce).
   - Different structures work together as part of a system to support survival, growth, behavior, and/or reproduction (e.g., the heart works with the lungs to carry oxygenated blood throughout the system; thorns protect the plant, allowing reproduction via stamens and pollen to occur).

Guided Questions
• How do you support an argument that parts of living systems work together to sustain life?
Catholic Identity Connections
• All of God's creation is designed in such a way as to ensure the physical continuation of life. • Just as plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction, we humans have internal and external structures that lead us to a sustained life in Christ. • Our outward actions and our inner spiritual lives are to be oriented toward life in God, as we are created in the image and likeness of God. • The church helps to nurture and sustain our inner spiritual lives through the scriptures, prayer, Mass, the sacraments, sacramental and community activities. [S] [SA] • Our inner spiritual life is also nurtured by the beauty of creation. When we diminish the grandeur of creation, we diminish the grandeur of our souls. • Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1] • Value the human body as the temple of the Holy Spirit. [CS S.K6 GS3] • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2] • Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3] • Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.4.1** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. **Mathematics** **4.G.3** Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.
Connections to Other DCIs in Fourth Grade
N/A
Articulation to DCIs across Grade-Levels
1.LS1.A; 3.LS3.B; MS.LS1.A

4-LS1 From Molecules to Organisms: Structures and Processes		
Students who demonstrate understanding can: **4-LS1-2 Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.** Clarification Statement: Emphasis is on systems of information transfer. Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use a model to test interactions concerning the functioning of a natural system.	**LS1.D Information Processing** • Different sense receptors are specialized to particular kinds of information, which may then be processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade
1. Components of the model
a. From a given model, students identify and describe the relevant components for testing interactions concerning the functioning of a given natural system, including: • Different types of information about the surroundings (e.g., sound, light, odor, temperature). • Sense receptors able to detect different types of information from the environment. • Brain. • Animals' actions.
2. Relationships
a. Students describe the relationships between components in the model, including: • Different types of sense receptors detect specific types of information within the environment. • Sense receptors send information about the surroundings to the brain. • Information that is transmitted to the brain by sense receptors can be processed immediately as perception of the environment and/or stored as memories.
3. Connections
a. Students use the model to describe that: • Information in the environment interacts with animal behavioral output via interactions, mediated by the brain. • Different types of sensory information are relayed to the brain via different sensory receptors, allowing experiences to be perceived, stored as memories, and influence behavior (e.g., an animal sees a brown, rotten fruit and smells a bad odor - this sensory information allows the animal to use information about other fruits that appear to be rotting to make decisions about what to eat; an animal sees a red fruit and a green fruit - after eating them both, the animal learns that the red fruit is sweet and the green fruit is bitter, and then uses this sensory information, perceived and stored as memories, to guide fruit selection next time). • Sensory input, the brain, and behavioral output are all parts of a system that allow animals to engage in appropriate behaviors.

b. Students use the model to test interactions involving sensory perception and its influence on animal behavior within a natural system, including interactions between:
   - Information in the environment.
   - Different types of sense receptors.
   - Perception and memory of sensory information.

Guided Questions

- How do you analyze sensory information, skills, and experiences to apply them to real-world situations?

Catholic Identity Connections

- In God's creation everything is in relationship with everything else through sensory perception.
- God has given animals (including humans) senses that allow them to process information and the ability to use memories to guide future actions. These God-given gifts are to be used on behalf of the common good.
- Our senses are attuned to the beauty of God's creation; we are hard-wired for God.
- Perception and memory are part of the sacred story of God's people. The story of the Exodus is the defining story of the ancient Hebrew people. The life, death and resurrection of Jesus is the defining story for Christians. These defining stories are recorded in the Bible as a history of God's love for us. [S]
- The sacraments and sacramentals engage our senses and help us to perceive God in our midst. [SA]
- Value the human body as the temple of the Holy Spirit. [CS S.K6 GS3]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes.

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

1.LS1.D; MS.LS1.A; MS.LS1.D

4-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.

Clarification Statement: Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time, and, a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.

Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables, that describe and predict phenomena, and in designing multiple solutions to design problems. • Identify the evidence that supports particular points in an explanation.	**ESS1.C The History of Planet Earth** • Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed.	**Patterns** • Patterns can be used as evidence to support an explanation. **Connections to the Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Articulating the explanation of phenomena

a. Students identify the given explanation for a phenomenon, which includes a statement about the idea that landscapes change over time.
b. From the given explanation, students identify the specific aspects of the explanation they are supporting with evidence.

2. Evidence

a. Students identify the evidence relevant to supporting the explanation, including local and regional patterns in the following:
   - Different rock layers found in an area (e.g., rock layers taken from the same location show marine fossils in some layers and land fossils in other layers).
   - Ordering of rock layers (e.g., layer with marine fossils is found below layer with land fossils).
   - Presence of particular fossils (e.g., shells, land plants) in specific rock layers.
   - The occurrence of events (e.g., earthquakes) due to Earth forces.

3. Reasoning

a. Students use reasoning to connect the evidence to support particular points of the explanation, including the identification of a specific pattern of rock layers and fossils (e.g., a rock layer containing shells and fish below a rock layer containing fossils of land animals and plants is a pattern indicating that, at one point, the landscape had been covered by water and later it was dry land). Students describe reasoning for how the evidence supports particular points of the explanation, including:
- Specific rock layers in the same location show specific fossil patterns (e.g., some lower rock layers have marine fossils, while some higher rock layers have fossils of land plants).
- Since lower layers were formed first then covered by upper layers, this pattern indicates that the landscape of the area was transformed into the landscape indicated by the upper layer (e.g., lower marine fossils indicate that, at one point, the landscape was covered by water, and upper land fossils indicate that later the landscape was dry land).
- Irregularities in the patterns of rock layers indicate disruptions due to Earth forces (e.g., a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock).

Guided Questions

- How do patterns in rock formations and fossils in rock layers show changes in landscape over time?

Catholic Identity Connections

- God created the Earth and all its systems in different phases. Fossils in layers of rock tell the story of God's ever-changing creation.
- The transformations of creation over time can help us to think about the spiritual transformations that we experience in our lives of faith.
- We are continually transformed by God's love. If we review the layered stories of our lives, we will find the 'fossil' evidence of God's love, sometimes hidden in places we didn't expect.
- The story of salvation is a story of transformations. [S]
- Jesus transformed death when he rose from the dead.
- Through transubstantiation the bread and wine are transformed into the body and blood of Jesus in the Eucharist. [SC]
- Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and organize information, and provide a list of sources.

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. (4-ESS1-1)

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

2.ESS1.C; 3.LS4.A; MS.LS4.A; MS.ESS1.C; MS.ESS2.A; MS.ESS2.B

4-ESS2 Earth's Systems

Students who demonstrate understanding can:

4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.

Assessment Boundary: Assessment is limited to a single form of weathering or erosion.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	**ESS2.A Earth Materials and Systems** • Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. **ESS2.E Biogeology** • Living things affect the physical characteristics of their regions.	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students identify the phenomenon under investigation, which includes the effects of weathering or the rate of erosion of Earth's materials.
b. From the given investigation plan, students identify the purpose of the investigation, which includes providing evidence for an explanation of the phenomenon.

2. Identifying the evidence to address the purpose of the investigation

a. From the given investigation plan, students describe the data to be collected that will serve as the basis for evidence.
b. From the given investigation plan, students describe the evidence needed, based on observations and/or measurements made during the investigation, including:
    - The change in the relative steepness of slope of the area (e.g., no slope, slight slope, steep slope).
    - The kind of weathering or erosion to which Earth material is exposed.
    - The change in the shape of Earth materials as the result of weathering or the rate of erosion by one of the following:
        - Motion of water.
        - Ice (including melting and freezing processes).
        - Wind (speed and direction).
        - Vegetation.
c. Students describe how the data collected will serve as evidence to address the purpose of the investigation, including to help identify cause and effect relationships between weathering or erosion and Earth materials.

3. Planning the investigation

a. From the given investigation plan, students identify and describe how the data will be collected, including:
   - The relative speed of the flow of air or water.
   - The number of cycles of freezing and thawing.
   - The number and types of plants growing in the Earth material.
   - The relative amount of soil or sediment transported by erosion.
   - The number or size of rocks transported by erosion.
   - The breakdown of materials by weathering (e.g., ease of breaking before or after weathering, size/number of rocks broken down).

b. Students describe the controlled variables, including:
   - Those variables that affect the movement of water (e.g., flow speed, volume, slope).
   - Those variables that affect the movement of air.
   - The water temperature and forms of matter (e.g., freezing, melting, room temperature).
   - The presence or absence of plants growing in or on the Earth model.

4. Collecting the data

a. Students make and record observations according to the given investigation plan to provide evidence for the effects of weathering or the rate of erosion on Earth materials (e.g., rocks, soils, and sediment).

Guided Questions

- Given an investigation plan, what observations and/or measurements can you provide to identify the effects of weathering and erosion?

Catholic Identity Connections

- God's creation continues to change over time.
- How are we changed through our relationship with God? How are the rough places of resistance to God's love eroded and worn down over time?
- Isaiah 40:4 speaks of changes in landforms as a way of preparing for the coming of the Messiah. It refers to the road makers of the time creating a highway on which the Messiah would come. It also refers to the raising up of the poor and the lowering of the mighty. [S]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.4.7** Conduct short research projects that build knowledge through investigation of different aspects of a topic. **W.4.8** Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and organize information, and provide a list of sources. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **MP.5** Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **4.MD.1** Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. **4.MD.2** Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.
Connections to Other DCIs in Fourth Grade
N/A
Articulation to DCIs across Grade-Levels
2.ESS1.C; 2.ESS2.A; 5.ESS2.A

4-ESS2 Earth's Systems

Students who demonstrate understanding can:

4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.

Clarification Statement: Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Analyze and interpret data to make sense of phenomena using logical reasoning.	**ESS2.B Plate Tectonics and Large-Scale System Interactions** • The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth.	**Patterns** • Patterns can be used as evidence to support an explanation.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Organizing data

a. Students organize data using graphical displays (e.g., table, chart, graph) from maps of Earth's features (e.g., locations of mountains, continental boundaries, volcanoes, earthquakes, deep ocean trenches, ocean floor structures).

2. Identifying relationships

a. Students identify patterns in the location of Earth features, including the locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes. These relationships include:
   - Volcanoes and earthquakes occur in bands that are often along the boundaries between continents and oceans.
   - Major mountain chains form inside continents or near their edges.

3. Interpreting data

a. Students use logical reasoning based on the organized data to make sense of and describe a phenomenon. In their description, students include that Earth features occur in patterns that reflect information about how they are formed or occur (e.g., mountain ranges tend to occur on the edges of continents or inside them, the Pacific Ocean is surrounded by a ring of volcanoes, all continents are surrounded by water [assume Europe and Asia are identified as Eurasia]).

Guided Questions

- How can topographical maps of various regions help us to determine patterns in Earth's features?
- When looking at maps of areas of the world, how can we predict the likely locations for certain landforms?

Catholic Identity Connections
• God's creation is orderly and patterned. • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.4.7** Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. **Mathematics** **4.MD.2** Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.
Connections to Other DCIs in Fourth Grade
N/A
Articulation to DCIs across Grade-Levels
2.ESS2.B; 2.ESS2.C; 5.ESS2.C; MS.ESS1.C; MS.ESS2.A; MS.ESS2.B

4-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3-5 builds on K-2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Obtain and combine information from books and other reliable media to explain phenomena.	**ESS3.A Natural Resources** • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering. **Influence of Engineering, Technology, and Science on Society and the Natural World** • Over time, people's needs and wants change, as do their demands for new and improved technologies.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Obtaining information

a. Students gather information from books and other reliable media about energy resources and fossil fuels (e.g., fossil fuels, solar, wind, water, nuclear), including:
   - How they are derived from natural sources (e.g., which natural resource they are derived from) [note: mechanisms should be limited to grade appropriate descriptions, such as comparing the different ways energy resources are each derived from a natural resource].
   - How they address human energy needs.
   - The positive and negative environmental effects of using each energy resource.

2. Evaluating information

a. Students combine the obtained information to provide evidence about:
   - The effects on the environment of using a given energy resource.
   - Whether the energy resource is renewable.
   - The role of technology, including new and improved technology, in improving or mediating the environmental effects of using a given resource.

3. Communicating information

a. Students use the information they obtained and combined to describe the causal relationships between:
   - Energy resources and the environmental effects of using that energy.
   - The role of technology in extracting and using an energy resource.

Guided Questions

- How does our use of energy and fuels impact the environment?
- How do renewable and non-renewable sources of energy differ?

Catholic Identity Connections

- We have a responsibility to use energy and fuels in a way that promotes the common good.
- God gives us the freedom to make choices.
- In Pope John Paul II's World Day of Peace Address in 1990 he identified the environment as the overarching issue of the 21st century. [M]
- In 1991 the USCCB (United States Conference of Catholic Bishops) published a teaching called "Renewing the Earth," which calls us to awareness of creation as sacramental and to be stewards of creation. Care of creation is the seventh theme of Catholic Social Teaching. It has also been added to the corporal and spiritual works of mercy. [CST]
- In 2015 Pope Francis issued an encyclical entitled ***Laudato Si'***, *On Care for our Common Home*, which calls us to care for creation.
- Our sacramental lives rely upon gifts of the creation – water, bread, wine, fire, oil. We need to preserve the dignity and purity of creation for the preservation and dignity of our spiritual lives as well as our physical lives. [SA]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
- Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]
- Accept the premise that nature should not be manipulated simply by people's will or only viewed as a thing to be used, but that we must cooperate with God's plan for us and nature. [CS S.K6 DS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and organize information, and provide a list of sources.

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

4.OA.1 Interpret a multiplication equation as a comparison, e.g., interpret $35 = 5 \times 7$ as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations.

Connections to Other DCIs in Fourth Grade

N/A

Articulation to DCIs across Grade-Levels

5.ESS3.C; MS.PS3.D; MS.ESS2.A; MS.ESS3.A; MS.ESS3.C; MS.ESS3.D

4-ESS3 Earth and Human Activity		
Students who demonstrate understanding can: **4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.** Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity. Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	**ESS3.B Natural Hazards** • A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. **ETS1.B Designing Solutions to Engineering Problems** • Testing a solution involves investigating how well it performs under a range of likely conditions. (secondary emphasis)	**Cause and Effect** • Cause and effect relationships are routinely identified, tested, and used to explain change. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands.

Examples of Observable Evidence of Student Performance by the End of Fourth Grade

1. Using scientific knowledge to generate design solutions

a. Given a natural Earth process that can have a negative effect on humans (e.g., an earthquake, volcano, flood, landslide), students use scientific information about that Earth process and its effects to design at least two solutions that reduce its effect on humans.
b. In their design solutions, students describe and use cause and effect relationships between the Earth process and its observed effect.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe the given criteria for the design solutions, including using scientific information about the Earth process to describe how well the design must alleviate the effect of the Earth process on humans.
b. Students describe the given constraints of the solution (e.g., cost, materials, time, relevant scientific information), including performance under a range of likely conditions.

3. Evaluating potential solutions

a. Students evaluate each design solution based on whether and how well it meets each of the given criteria and constraints.
b. Students compare the design solutions to each other based on how well each meets the given criteria and constraints.
c. Students describe the design solutions in terms of how each alters the effect of the Earth process on humans.

Guided Questions

- What solutions could be designed to reduce the impact of a natural Earth process on people?
- How would design solutions differ based on the natural hazard?

Catholic Identity Connections
• Although we cannot eliminate the natural hazards, God has given humans the wisdom to determine solutions to reduce the impact. • We are called to make choices that take the good of all creation into consideration. • Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3] • Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5] • Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.4.1** Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. **RI.4.9** Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **4.OA.1** Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations.
Connections to Other DCIs in Fourth Grade
4.ETS1.C
Articulation to DCIs across Grade-Levels
K.ETS1.A; 2.ETS1.B; 2.ESS1.C; MS.ESS2.A; MS.ESS3.B; MS.ETS1.B

Fifth Grade Standards

5-PS1 Matter and Its Interactions

5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.
5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
5-PS1-3 Make observations and measurements to identify materials based on their properties.
5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

Catholic/Christian Scientists

- Physics:
    - Blaise Pascal (mathematician, physicist, inventor)
- Chemistry:
    - Amedeo Avogadro
    - Roger Joseph Bosovich
    - Jean-Baptiste Dumas
    - Joseph Louis Gay Lussac
    - Antoine Lavoisier
- Physiology/Medicine:
    - Karl Landsteiner
    - Leonardo da Vinci
    - Lazzaro Spallanzani
- Pharmacology:
    - Illia Delio, O.S.F.
- Roger Bacon (Franciscan friar and early advocate of the scientific method)

Saints [SA]

- St. Albert the Great (Albertus Magnus) (Catholic bishop), patron saint of scientists
- Sts. Cosmas and Damian, (pharmacists) patron saints of chemistry
- St. John Leonardi, patron saint of pharmacologists

5-PS2 Motion and Stability: Forces and Interactions

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.

5-PS3 Energy

5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

Catholic Identity

- Plants in the Bible:
    - http://ww2.odu.edu/~lmusselm/plant/bible/allbibleplantslist.php
    - http://www.newadvent.org/cathen/12149a.htm
    - Below is a list of the flowers dedicated to the Blessed Mother. (https://www.catholicculture.org/culture/library/view.cfm?recnum=5855)
        - White Lily "Annunciation Lily", symbol of Mary's Immaculate Purity.
        - Impatiens "Our Lady's Earrings", symbolical pure adornments of the ears of Mary who heard the word of God and kept it.
        - Violet symbol of Mary's humility "regarded by the Lord".
        - Lady-Slipper "Our Lady's Slipper", symbol of Mary's graceful Visitation trip to visit Elizabeth in the hill country: "All her steps were most beauteous."
        - Thistle-Down another Visitation symbol, from its graceful movement in air currents.
        - Rose symbol of the Blessed Virgin of prophecy, the Rose plant bearing the flower, Christ.
        - Daisy "Mary's Flower of God".
        - Periwinkle "Virgin Flower", emblem of the Blessed Virgin.
        - Columbine symbol of the dove of the Holy Spirit, Mary's overshadowing, indwelling, divine Spouse.
        - Pansy "Trinity Flower", symbol of the Trinity, first revealed to Mary.
        - Strawberry "Fruitful Virgin", in flower and fruit at the same time.

Catholic/Christian Scientists

- Sr. Paula González (biology)
- Theodor Schwann (theory of the cellular structure of animal organisms)
- Botany
    - Carl Linnaeus
    - Stephan Endlicher
    - James Britton
    - Andrea Cesalpino

Saints [SA]

- St. Anthony of Padua, patron saint of harvests and lost animals
- St. Gall, patron saint of birds
- St. Isadore the Farmer, patron saint of farmers
- St. Phocus, patron saint of gardeners, agricultural workers, farm workers, farmers and field hands
- St. Francis of Assisi, patron saint of animals and ecology

5-LS1 From Molecules to Organisms: Structures and Processes

5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.

Catholic Identity (same as above)

5-LS2 Ecosystems: Interactions, Energy, and Dynamics

5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Catholic Identity (Same as above)

5-ESS1 Earth's Place in the Universe

5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.
5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Catholic Identity

Biblical star and constellation names:

- Kimah, the Pleiades
- Kesil, Orion
- Ash, or Ayish, the Hyades
- Mezarim, the Bears (Great and Little)
- Mazzaroth, Venus (Lucifer and Hesperus)
- Hadre theman — "the chambers of the south" — Canopus, the Southern Cross, and a Centauri
- Nachash, Draco.

  (For more on Astronomy in the Bible, see: http://www.newadvent.org/cathen/02029a.htm

Catholic/Christian Scientists

- Nicolaus Copernicus (astronomer)
- G.G. Coriolis Galileo Galilei (astronomer)
- Giovanni Domenico Cassini (first to observe four of Saturn's moons and the co-discoverer of the Great Red Spot on Jupiter)
- Christopher Clavius (Jesuit, the Gregorian calendar)
- Nicolas Louis de Lacaille (cataloged stars, nebulous objects, and constellations)
- Pierre-Simon Laplace (the "Newton of France")
- Paolo dal Pozzo Toscanelli (astronomer and cosmographer)

- Eduard Heis (contributed the first true delineation of the Milky Way)
- Gaspard-Gustave Coriolis (the Corialis effect)
- Léon Foucault (the Foucault pendulum)
- Daniello Bartoli, Jean-Baptiste Biot.
  (There are many more Catholic astronomers to research. This is just a sampling.)

Saints [SA]

- St. Dominic, patron saint of astronomers

5-ESS2 Earth's Systems

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
5-ESS2-2 Describe and graph the amounts and percentages of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.

Catholic/Christian Scientists

- Evangelista Torricelli (Inventor of the barometer)
- Nicolas Steno (stratigraphy)
- Georgius Agricola (mineralogy)
- Jean Baptiste Julien d'Omalius d'Halloy (modern geology)
- René Just Haüy (crystallography)
- Abraham Ortelius (created the first modern atlas and theorized on continental drift)
- Wilhelm Heinrich Waagen (geologist and paleontologist)
- Johann Joachim Winckelmann (scientific archaeology)
- Teilhard de Chardin (paleontology)

Saints [SA]

- St. Barbara, patron saint of geology
- St. Clare of Assisi, patron saint of good weather
- St. Eurosia, patron saint against bad weather

5-ESS3 Earth and Human Activity

5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Scripture [S]

- After the flood God makes a covenant with Noah, his sons, and all of creation:
  "God said to Noah and to his sons with him: 'See, I am now establishing my covenant with you and your descendants after you and with every living creature that was with you: the birds, the tame animals, and all the wild animals that were with you—all that came out of the ark. I will establish my covenant with you, that never again shall all creatures be destroyed by the waters of a flood; there shall not be another flood to devastate the earth.' God said: 'This is the sign of the covenant that I am making between me and you and every living creature with you for all ages to come: I set my bow in the clouds to serve as a sign of the covenant between me and the earth. When I bring clouds over the earth, and the bow appears in the clouds, I will remember my covenant between me and you and every living creature—every mortal being—so that the waters will never again become a flood to destroy every mortal being. When the bow appears in the clouds, I will see it and remember the everlasting covenant between God and every living creature—every mortal being that is on earth.' God told Noah: 'This is the sign of the covenant I have established between me and every mortal being that is on earth.'" (Genesis 9:8-17)

Catholic/Christian Scientists

- Rachel Carson
- Sr. Paula Gonzales
- Fr. Thomas Berry (Passionist priest – religion, ecology, cultural history)

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

5-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen.

Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, dissolving sugar in water, and evaporating salt water.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use models to describe phenomena.	**PS1.A Structure and Properties of Matter** • Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Components of the model

a. Students develop a model to describe a phenomenon that includes the idea that matter is made of particles too small to be seen. In the model, students identify the relevant components for the phenomenon, including:
   - Bulk matter (macroscopic observable matter; e.g., as sugar, air, water).
   - Particles of matter that are too small to be seen.

2. Relationships

a. In the model, students identify and describe relevant relationships between components, including the relationships between:
   - Bulk matter and tiny particles that cannot be seen (e.g., tiny particles of matter that cannot be seen make up bulk matter).
   - The behavior of a collection of many tiny particles of matter and observable phenomena involving bulk matter (e.g., an expanding balloon, evaporating liquids, substances that dissolve in a solvent, effects of wind).

3. Connections

a. Students use the model to describe how matter composed of tiny particles too small to be seen can account for observable phenomena (e.g., air inflating a basketball, ice melting into water).

Guided Questions

- How do you develop a model to demonstrate that matter is made of particles too small to be seen?
- How do you provide evidence from the model to support what happens when matter changes?

Catholic Identity Connections

• The Nicene Creed states: "We believe in one God, the Father, the Almighty, Maker of all that is, seen and unseen."
• All of God's creation is made up of particles too small to be seen. We humans share this condition with the rest of creation; everything is related in one sacred whole.
  ◦ Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
  ◦ Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
  ◦ Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
  ◦ Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.5.7** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics. **5.NBT.1** Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. **5.NF.7** Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. **5.MD.3** Recognize volume as an attribute of solid figures and understand concepts of volume measurement. **5.MD.4** Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units.
Connections to Other DCIs in Fifth Grade
N/A
Articulation to DCIs across Grade-Levels
2.PS1.A; MS.PS1.A

5-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that form new substances.

Assessment Boundary: Assessment does not include distinguishing mass and weight.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 3-5 builds on K-2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Measure and graph quantities such as weight to address scientific and engineering questions and problems.	**PS1.A Structure and Properties of Matter** • The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. **PS1.B Chemical Reactions** • No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.)	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. **Connections to the Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes consistent patterns in natural systems.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Representation

a. Students measure and graph the given quantities using standard units, including:
   - The weight of substances before they are heated, cooled, or mixed.
   - The weight of substances, including any new substances produced by a reaction, after they are heated, cooled, or mixed.

2. Mathematical/computational analysis

a. Students measure and/or calculate the difference between the total weight of the substances (using standard units) before and after they are heated, cooled, and/or mixed.
b. Students describe the changes in properties they observe during and/or after heating, cooling, or mixing substances.
c. Students use their measurements and calculations to describe that the total weights of the substances did not change, regardless of the reaction or changes in properties that were observed.
d. Students use measurements and descriptions of weight, as well as the assumption of consistent patterns in natural systems, to describe evidence to address scientific questions about the conservation of the amount of matter, including the idea that the total weight of matter is conserved after heating, cooling, or mixing substances.

Guided Questions

- How do you measure and graph quantities to provide evidence to show what happens to the total weight of matter when substances react and change?

Catholic Identity Connections

- Analogy: Although humans change and grow, at the level of the soul we have an unchanging identity.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

5.MD.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

2.PS1.A; 2.PS1.B; MS.PS1.A; MS.PS1.B

5-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

5-PS1-3 Make observations and measurements to identify materials based on their properties.

Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.

Assessment Boundary: Assessment does not include density or distinguishing mass and weight.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon.	**PS1.A Structure and Properties of Matter** • Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.)	**Scale, Proportion, and Quantity** • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students identify the phenomenon under investigation, which includes the observable and measurable properties of materials.
b. Students identify the purpose of the investigation, which includes collecting data to serve as the basis for evidence for an explanation about the idea that materials can be identified based on their observable and measurable properties.

2. Identifying the evidence to address the purpose of the investigation

a. From the given investigation plan, students describe the evidence from data (e.g., qualitative observations and measurements) that will be collected, including:
   - Properties of materials that can be used to identify those materials (e.g., color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility).
b. Students describe how the observations and measurements will provide the data necessary to address the purpose of the investigation.

3. Planning the investigation

a. From the given investigation plan, students describe how the data will be collected. Examples could include:
   - Quantitative measures of properties, in standard units (e.g., grams, liters).
   - Observations of properties such as color, conductivity, and reflectivity.
   - Determination of conductors vs. nonconductors and magnetic vs. nonmagnetic materials.
b. Students describe how the observations and measurements they make will allow them to identify materials based on their properties.

4. Collecting the data

a. Students collect and record data according to the given investigation plan.

Guided Questions

- How do you measure and compare data to identify materials based on properties of matter?

Catholic Identity Connections

- "And they'll know we are Christians by our love."
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

2.PS1.A; MS.PS1.A

5-PS1 Matter and Its Interactions		
Students who demonstrate understanding can: **5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances.**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.	**PS1.B Chemical Reactions** • When two or more different substances are mixed, a new substance with different properties may be formed.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students describe the phenomenon under investigation, which includes the mixing of two or more substances.
b. Students identify the purpose of the investigation, which includes providing evidence for whether new substances are formed by mixing two or more substances, based on the properties of the resulting substance.

2. Identifying the evidence to address the purpose of the investigation

a. From the given investigation plan, students describe the evidence from data that will be collected, including:
   - Quantitative (e.g., weight) and qualitative (e.g., state of matter, color, texture, odor) properties of the substances to be mixed.
   - Quantitative and qualitative properties of the resulting substances.

b. Students describe how the collected data can serve as evidence for whether the mixing of the two or more tested substances results in one or more new substances.

3. Planning the investigation

a. From the given investigation plan, students describe how the data will be collected, including:
   - How quantitative and qualitative properties of the two or more substances to be mixed will be determined and measured.
   - How the quantitative and qualitative properties of the substances that resulted from the mixture of the two or more substances will be determined and measured.
   - Number of tests for the investigation.
   - How variables will be controlled to ensure a fair test (e.g., the temperature at which the substances are mixed, the number of substances mixed together in each trial).

4 Collecting the data

a. According to the investigation plan, students collaboratively collect and record data, including data about the substances before and after mixing.

Guided Questions
• How do you design an investigation to determine what happens when two or more substances are mixed?
Catholic Identity Connections
• When two or more Christians come together they create something new – Christian community. Individually and together, we, the Body of Christ on Earth, have observable characteristics. • Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **W.5.7** Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. **W.5.8** Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **W.5.9** Draw evidence from literary or informational texts to support analysis, reflection, and research.
Connections to Other DCIs in Fifth Grade
N/A
Articulation to DCIs across Grade-Levels
2.PS1.B; MS.PS1.A; MS.PS1.B

5-PS2 Motion and Stability: Forces and Interaction		
Students who demonstrate understanding can: **5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.** Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Support an argument with evidence, data, or a model.	**PS2.B Types of Interactions** • The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.	**Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Supported claims

a. Students identify a given claim to be supported about a phenomenon. The claim includes the idea that the gravitational force exerted by Earth on objects is directed down toward the center of Earth.

2. Identifying scientific evidence

a. Students identify and describe the given evidence, data, and/or models that support the claim, including:
   - Multiple lines of evidence that indicate that the Earth's shape is spherical (e.g., observation of ships sailing beyond the horizon, the shape of the Earth's shadow on the moon during an eclipse, the changing height of the North Star above the horizon as people travel north and south).
   - That objects dropped appear to fall straight down.
   - That people live all around the spherical Earth, and they all observe that objects appear to fall straight down.

3. Evaluation and critique

a. Students evaluate the evidence to determine whether it is sufficient and relevant to support the claim.
b. Students describe whether any additional evidence is needed to support the claim.

4. Reasoning and synthesis

a. Students use reasoning to connect the relevant and appropriate evidence to support the claim with argumentation. Students describe a chain of reasoning that includes:
   - If Earth is spherical, and all observers see objects near them falling directly "down" to the Earth's surface, then all observers would agree that objects fall toward the Earth's center.
   - Since an object that is initially stationary when held moves downward when it is released, there must be a force (gravity) acting on the object that pulls the object toward the center of Earth.

Guided Questions

- How can you provide the evidence to explain the effect of Earth's gravitational force on objects towards the center of the Earth?

Catholic Identity Connections

- God pulls us toward Himself. God is the center of gravity of our spiritual lives. We are drawn together as we are pulled collectively toward God. The scripture, tradition, Church, and sacraments pull us toward God.
- He holds everything in existence according to His plan. [CS S.K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

3.PS2.A; 3.PS2.B; MS.PS2.B; MS.ESS1.B; MS.ESS2.C

5-PS3 Energy

Students who demonstrate understanding can:

5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.

Clarification Statement: Examples of models could include diagrams and flow charts.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Use models to describe phenomena.	**PS3.D Energy in Chemical Processes and Everyday Life** • The energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter from air and water. **LS1.C Organization for Matter and Energy Flow in Organisms** • Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. (secondary emphasis)	**Energy and Matter** • Energy can be transferred in various ways and between objects.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Components of the model

a. Students use models to describe a phenomenon that includes the idea that energy in animals' food was once energy from the sun. Students identify and describe the components of the model that are relevant for describing the phenomenon, including:
   - Energy.
   - The sun.
   - Animals, including their bodily functions (e.g., body repair, growth, motion, body warmth maintenance).
   - Plants.

2. Relationships

a. Students identify and describe the relevant relationships between components, including:
   - The relationship between plants and the energy they get from sunlight to produce food.
   - The relationship between food and the energy and materials that animals require for bodily functions (e.g., body repair, growth, motion, body warmth maintenance).
   - The relationship between animals and the food they eat, which is either other animals or plants (or both), to obtain energy for bodily functions and materials for growth and repair.

3. Connections

a. Students use the models to describe causal accounts of the relationships between energy from the sun and animals' needs for energy, including that:
   - Since all food can eventually be traced back to plants, all of the energy that animals use for body repair, growth, motion, and body warmth maintenance is energy that once came from the sun.
   - Energy from the sun is transferred to animals through a chain of events that begins with plants producing food and then being eaten by animals.

Guided Questions

- How can you create a model to demonstrate that energy obtained from food was originally energy from the sun?

Catholic Identity Connections

- Just as the Sun is the source of energy and nourishment for animals and humans, God is the source of energy and nourishment for the people of God. We receive this food through the Eucharist. Just as Jesus is blessed, broken and given to us, so too are we called to be blessed, broken and given to one another in the service of Christ (Henri Nouwen, *Life of the Beloved*, 2002). [SA]
- His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS S.K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

K.LS1.C; 2.LS2.A; 4.PS3.A; 4.PS3.B; 4.PS3.D; MS.PS3.D; MS.PS4.B; MS.LS1.C; MS.LS2.B

5-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

5-LS1-1 Support an argument that plants get the materials they need for growth chiefly from air and water.

Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil. Emphasis includes photosynthesis.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Support an argument with evidence, data, or a model.	**LS1.C Organization for Matter and Energy Flow in Organisms** • Plants acquire their material for growth chiefly from air and water.	**Energy and Matter** • Matter is transported into, out of, and within systems.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Supported claims

a. Students identify a given claim to be supported about a given phenomenon. The claim includes the idea that plants acquire the materials they need for growth chiefly from air and water.

2. Identifying scientific evidence

a. Students describe the given evidence, data, and/or models that support the claim, including evidence of:
- Plant growth over time.
- Changes in the weight of soil and water within a closed system with a plant, including:
  - Soil does not provide most of the material for plant growth (e.g., changes in weight of soil and a plant in a pot over time, hydroponic growth of plants).
  - Plants' inability to grow without water.
- Plants' inability to grow without air.
- Air is matter (e.g., empty object vs. air filled object).

3. Evaluating and critiquing evidence

a. Students determine whether the evidence supports the claim, including:
- Whether a particular material (e.g., air, soil) is required for growth of plants.
- Whether a particular material (e.g., air, soil) may provide sufficient matter to account for an observed increase in weight of a plant during growth.

4. Reasoning and synthesis

a. Students use reasoning to connect the evidence to support the claim with argumentation. Students describe a chain of reasoning that includes:
- During plant growth in soil, the weight of the soil changes very little over time, whereas the weight of the plant changes significantly. Additionally, some plants can be grown without soil at all.
- Because some plants don't need soil to grow and others show increases in plant matter (as measured by weight) but not accompanying decreases in soil matter, the materials from soil must not enter the plant in sufficient quantities to be the chief contributor to plant growth.
- Therefore, plants do not acquire most of the materials for growth from soil.
- A plant cannot grow without water or air. Because both air and water are matter and are transported into the plant system, they can provide the materials plants need for growth.
- Since soil cannot account for the change in weight as a plant grows and since plants take in water and air, both of which could contribute to the increase in weight during plant growth, plant growth must come chiefly from water and air.

Guided Questions

- How do you critique evidence to explain where plants acquire what they need for growth?

Catholic Identity Connections

- Engaging in arguments from evidence is a skill we Catholics need not only for science, but also for apologetics and evangelization. Faith and reason are both important to Catholic education.
- Plants are able to get what they need primarily from the air and water. In turn, through photosynthesis, they make food for other creatures. All of creation is interconnected and participates in the web of life, in the unity of the Holy Spirit.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9]

Scripture [S]

- "Look at the birds in the sky; they do not sow or reap, they gather nothing into barns, yet your heavenly Father feeds them. Are not you more important than they? Can any of you by worrying add a single moment to your life-span? Why are you anxious about clothes? Learn from the way the wild flowers grow. They do not work or spin. But I tell you that not even Solomon in all his splendor was clothed like one of them. If God so clothes the grass of the field, which grows today and is thrown into the oven tomorrow, will he not much more provide for you, O you of little faith? So do not worry and say, 'What are we to eat?' or 'What are we to drink?' or 'What are we to wear?' All these things the pagans seek. Your heavenly Father knows that you need them all. But seek first the kingdom [of God] and his righteousness, and all these things will be given you besides." (Mathew 6:26-33)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

5.MD.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Connections to Other DCIs in Fifth Grade

5.PS1.A

Articulation to DCIs across Grade-Levels

K.LS1.C; 2.LS2.A; MS.LS1.C

5-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model to describe phenomena. **Connections to the Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Science explanations describe the mechanisms for natural events.	**LS2.A Interdependent Relationships in Ecosystems** • The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as "decomposers". • Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. **LS2.B Cycles of Matter and Energy Transfer in Ecosystems** • Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. • Organisms obtain gases and water from the environment and release waste matter (gas, liquid, or solid) back into the environment.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Components of the model

a. Students develop a model to describe a phenomenon that includes the movement of matter within an ecosystem. In the model, students identify the relevant components, including:
   - Matter.
   - Plants.
   - Animals.
   - Decomposers, such as fungi and bacteria.
   - Environment.

2. Relationships

a. Students describe the relationships among components that are relevant for describing the phenomenon, including:
   - The relationships in the system between organisms that consume other organisms, including:
     - Animals that consume other animals.
     - Animals that consume plants.
     - Organisms that consume dead plants and animals.
     - The movement of matter between organisms during consumption.
   - The relationship between organisms and the exchange of matter from and back into the environment (e.g., organisms obtain matter from their environments for life processes and release waste back into the environment; decomposers break down plant and animal remains to recycle some materials back into the soil).

3. Connections

a. Students use the model to describe:
   - The cycling of matter in the system between plants, animals, decomposers, and the environment.
   - How interactions in the system of plants, animals, decomposers, and the environment allow multiple species to meet their needs.
   - That newly introduced species can affect the balance of interactions in a system (e.g., a new animal that has no predators consumes much of another organism's food within the ecosystem).
   - That changing an aspect (e.g., organisms or environment) of the ecosystem will affect other aspects of the ecosystem.

Guided Questions

- How do you develop a model to describe the movement of matter within an ecosystem and the relationship between the components of the ecosystem?

Catholic Identity Connections

- This standard looks at how matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. We might use this as an opportunity to think about the Eucharist and transubstantiation in which bread and wine are transformed into the body and blood of Jesus; earthly food becomes bread from heaven. [SC]
- All of creation is interconnected and participates in the web of life, in the unity of the Holy Spirit. Theologian Rev. Thomas Berry taught that creation is a communion of subjects, not a collection of objects. We can relate this to the Body of Christ.
- Systems include organisms, ecosystems, and the Earth. Please revisit the introduction to Catholic Identity. See the section on systems/relational thinking.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
- Share concern and care for the environment as a part of God's creation. [CS S,K6 DS2]

Scripture [S]

- "As a body is one though it has many parts, and all the parts of the body, though many, are one body, so also Christ." (1 Corinthians 12:12)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs in Fifth Grade

5.PS1.A; 5.ESS2.A

Articulation to DCIs across Grade-Levels

2.PS1.A; 2.LS4.D; 4.ESS2.E; MS.PS3.D; MS.LS1.C; MS.LS2.A; MS.LS2.B

5-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

5-ESS1-1 Support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth.

Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect brightness (such as stellar masses, ages, and stages).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world. • Support an argument with evidence, data, or a model.	**ESS1.A The Universe and Its Stars** • The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth.	**Scale, Proportion, and Quantity** • Natural objects exist from the very small to the immensely large.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Supported claims

a. Students identify a given claim to be supported about a given phenomenon. The claim includes the idea that the apparent brightness of the sun and stars is due to their relative distances from Earth.

2. Identifying scientific evidence

a. Students describe the evidence, data, and/or models that support the claim, including:
   - The sun and other stars are natural bodies in the sky that give off their own light.
   - The apparent brightness of a variety of stars, including the sun.
   - A luminous object close to a person appears much brighter and larger than a similar object that is very far away from a person (e.g., nearby streetlights appear bigger and brighter than distant streetlights).
   - The relative distance of the sun and stars from Earth (e.g., although the sun and other stars are all far from the Earth, the stars are very much farther away; the sun is much closer to Earth than other stars).

3. Evaluating and critiquing evidence

a. Students evaluate the evidence to determine whether it is relevant to supporting the claim, and sufficient to describe the relationship between apparent size and apparent brightness of the sun and other stars and their relative distances from Earth.
b. Students determine whether additional evidence is needed to support the claim.

4. Reasoning and synthesis

a. Students use reasoning to connect the relevant and appropriate evidence to the claim with argumentation. Students describe a chain of reasoning that includes:
   - Because stars are defined as natural bodies that give off their own light, the sun is a star.
   - The sun is many times larger than Earth but appears small because it is very far away.
   - Even though the sun is very far from Earth, it is much closer than other stars.
   - Because the sun is closer to Earth than any other star, it appears much larger and brighter than any other star in the sky.
   - Because objects appear smaller and dimmer the farther they are from the viewer, other stars, although immensely large compared to Earth, seem much smaller and dimmer because they are so far away.
   - Although stars are immensely large compared to Earth, they appear small and dim because they are so far away.
   - Similar stars vary in apparent brightness, indicating that they vary in distance from Earth.

Guided Questions

- How do you support an argument that the apparent brightness of the sun and stars is due to their relative distances from the Earth?

Catholic Identity Connections

- Jesus is the Light of the World. As we draw closer to him, the light of Christ appears to grow larger and brighter. Like Jesus, we are called to be God's light in the world. May our light grow ever larger and brighter for all to see.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

RI.5.8 Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

5.NBT.2 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

MS.ESS1.A; MS.ESS1.B

5-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.

Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.

Assessment Boundary: Assessment does not include causes of seasons.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in graphical displays (bar graphs, pictographs, and/or pie charts) to reveal patterns that indicate relationships.	**ESS1.B Earth and the Solar System** • The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.	**Patterns** • Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Organizing data

a. Using graphical displays (e.g., bar graphs, pictographs), students organize data pertaining to daily and seasonal changes caused by the Earth's rotation and orbit around the sun. Students organize data that include:
   - The length and direction of shadows observed several times during one day.
   - The duration of daylight throughout the year, as determined by sunrise and sunset times.
   - Presence or absence of selected stars and/or groups of stars that are visible in the night sky at different times of the year.

2. Identifying relationships

a. Students use the organized data to find and describe relationships within the datasets, including:
   - The apparent motion of the sun from east to west results in patterns of changes in length and direction of shadows throughout a day as Earth rotates on its axis.
   - The length of the day gradually changes throughout the year as Earth orbits the sun, with longer days in the summer and shorter days in the winter.
   - Some stars and/or groups of stars (i.e., constellations) can be seen in the sky all year, while others appear only at certain times of the year.

b. Students use the organized data to find and describe relationships among the datasets, including:
   - Similarities and differences in the timing of observable changes in shadows, daylight, and the appearance of stars show that events occur at different rates (e.g., Earth rotates on its axis once a day, while its orbit around the sun takes a full year).

Guided Questions

- How do you represent in a graphical display the observable changes due to Earth's rotation and orbit around the sun?
- Why are we only able to see some stars in the night sky during particular seasons?

Catholic Identity Connections

- Just as there are patterns in nature, there are also patterns in our spiritual lives. We might encourage our students to keep a journal so that they can discover the patterns of their spiritual lives – shadows of doubt, sadness or despair that lengthen at certain times; the days and nights of our relationship with God; our positions in relation to others in our lives. We might also reflect upon the liturgical year to find the patterns of light and dark that emerge.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Describe God's relationship with humans and nature. [CS S.K6 IS6]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Scripture [S]

- "There is an appointed time for everything, and a time for every affair under the heavens.
  A time to give birth, and a time to die; a time to plant, and a time to uproot the plant.
  A time to kill, and a time to heal; a time to tear down, and a time to build.
  A time to weep, and a time to laugh; a time to mourn, and a time to dance.
  A time to scatter stones, and a time to gather them; a time to embrace, and a time to be far from embraces.
  A time to seek, and a time to lose; a time to keep, and a time to cast away.
  A time to rend, and a time to sew; a time to be silent, and a time to speak.
  A time to love, and a time to hate; a time of war, and a time of peace." (Ecclesiastes 3:1-8)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

5.G.2 Represent real-world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

1.ESS1.A; 1.ESS1.B; 3.PS2.A; MS.ESS1.A; MS.ESS1.B

5-ESS2 Earth's Systems

Students who demonstrate understanding can:

5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Clarification Statement: Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, biosphere, hydrosphere, and atmosphere are each a system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model using an example to describe a scientific principle.	**ESS2.A Earth Materials and Systems** • Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the biosphere (living things, including humans), the hydrosphere (water and ice), and the atmosphere (air). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.	**Systems and System Models** • A system can be described in terms of its components and their interactions.

Examples of Observable Evidence of Student Performance by the End of Fifth Grade

1. Components of the model

a. Students develop a model, using a specific given example of a phenomenon, to describe ways that the geosphere, biosphere, hydrosphere, and/or atmosphere interact. In their model, students identify the relevant components of their example, including the features of two of the following systems that are relevant for the given example:
   - Geosphere (i.e., solid and molten rock, soil, sediment, continents, mountains).
   - Biosphere (i.e., plants, animals [including humans]).
   - Hydrosphere (i.e., water and ice in the form of rivers, lakes, and glaciers).
   - Atmosphere (i.e., wind, oxygen).

2. Relationships

a. Students identify and describe relationships (interactions) within and between parts of the Earth systems identified in the model that are relevant to the example (e.g., the atmosphere and the hydrosphere interact by exchanging water through evaporation and precipitation; the hydrosphere and atmosphere interact through air temperature changes, which lead to the formation or melting of ice).

3. Connections

a. Students use the model to describe a variety of ways in which the parts of two major Earth systems in the specific given example interact to affect the Earth's surface materials and processes in that context. Students use models to describe how parts of an individual Earth system:
   - Work together to affect the functioning of that Earth system.
   - Contribute to the functioning of the other relevant Earth systems.

Guided Questions

- How do you develop a model to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact?

Catholic Identity Connections

- This standard looks at how matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. We might use this as an opportunity to think about the Eucharist and transubstantiation in which bread and wine are transformed into the body and blood of Jesus; earthly food becomes bread from heaven.
- It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- The clarifying statement for this standard connects to care of God's creation. Care for God's creation is the 7th theme of Catholic Social Teaching [CST].
- All of creation is interconnected and participates in the web of life, in the unity of the Holy Spirit.
- The geosphere, biosphere, hydrosphere and atmosphere are all systems. Please revisit the introduction to Catholic Identity. See the section on systems/relational thinking.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. (CS S.K6 IS5)
- Describe God's relationship with humans and nature. [CS S.K6 IS6]
- Share concern and care for the environment as a part of God's creation. [CS S,K6 DS2]
- Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that people must cooperate with God's plan for himself and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Scripture [S]

- "We know that all things work for good for those who love God, who are called according to his purpose." (Romans 8:28)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

5.G.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

2.ESS2.A; 3.ESS2.D; 4.ESS2.A; MS.ESS2.A; MS.ESS2.C; MS.ESS2.D

<table>
<tr><th colspan="3">5-ESS2 Earth's Systems</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
5-ESS2-2 Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Using Mathematics and Computational Thinking
Mathematical and computational thinking in 3-5 builds on K-2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions.
• Describe and graph quantities such as area and volume to address scientific questions.</td><td>ESS2.C The Roles of Water in Earth's Surface Processes
• Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in the streams, lakes, wetlands, and the atmosphere.</td><td>Scale, Proportion, and Quantity
• Standard units are used to measure and describe physical quantities such as weight and volume.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Fifth Grade</th></tr>
<tr><td colspan="3">1. Representation</td></tr>
<tr><td colspan="3">a. Students graph the given data (using standard units) about the amount of salt water and the amount of fresh water in each of the following reservoirs, as well as in all the reservoirs combined, to address a scientific question:
• Oceans.
• Lakes.
• Rivers.
• Glaciers.
• Ground water.
• Polar ice caps.</td></tr>
<tr><td colspan="3">2. Mathematical/computational analysis</td></tr>
<tr><td colspan="3">a. Students use the graphs of the relative amounts of total salt water and total fresh water in each of the reservoirs to describe that:
• The majority of water on Earth is found in the oceans.
• Most of the Earth's fresh water is found in glaciers or underground.
• A small fraction of fresh water is found in lakes, rivers, wetlands, and the atmosphere.</td></tr>
<tr><th colspan="3">Guided Questions</th></tr>
<tr><td colspan="3">• How do you describe and graph the amounts of salt water and fresh water in reservoirs to provide evidence about the distribution of water on Earth?</td></tr>
</table>

Catholic Identity Connections
• Fresh water is a precious resource that is necessary for life. It is precious to our sacramental lives as well. We are grateful for this God given gift, especially in light of the fact that it is not readily available to all. The poor suffer the most in terms of the availability of fresh water. • Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3] • Give examples of the beauty evident in God's creation. [CS S.K6 IS4] • Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1] • Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5] • Describe God's relationship with humans and nature. [CS S.K6 IS6] • Share concern and care for the environment as a part of God's creation. [CS S,K6 DS2]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RI.5.7** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. **W.5.8** Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. **SL.5.5** Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. **Mathematics** **MP.2** Reason abstractly and quantitatively. **MP.4** Model with mathematics.
Connections to Other DCIs in Fifth Grade
N/A
Articulation to DCIs across Grade-Levels
2.ESS2.C; MS.ESS2.C; MS.ESS3.A

<table>
<tr><th colspan="3">5-ESS3 Earth and Human Activity</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 3-5 builds on K-2 experiences and progresses to evaluating the merit and accuracy of ideas and methods.
• Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.</td><td>**ESS3.C Human Impacts on Earth Systems**
• Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.</td><td>**Systems and System Models**
• A system can be described in terms of its components and their interactions.

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World
• Science findings are limited to questions that can be answered with empirical evidence.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Fifth Grade</th></tr>
<tr><td colspan="3">**1. Obtaining information**</td></tr>
<tr><td colspan="3">a. Students obtain information from books and other reliable media about:
• How a given human activity (e.g., in agriculture, industry, everyday life) affects the Earth's resources and environments.
• How a given community uses scientific ideas to protect a given natural resource and the environment in which the resource is found.</td></tr>
<tr><td colspan="3">**2. Evaluating information**</td></tr>
<tr><td colspan="3">a. Students combine information from two or more sources to provide and describe evidence about:
• The positive and negative effects on the environment as a result of human activities.
• How individual communities can use scientific ideas and a scientific understanding of interactions between components of environmental systems to protect a natural resource and the environment in which the resource is found.</td></tr>
<tr><th colspan="3">Guided Questions</th></tr>
<tr><td colspan="3">• Using books and reliable media, how do you explain how communities use scientific ideas to protect Earth's resources and environment?
• How do you explain positive and negative effects of human activity on the environment?</td></tr>
</table>

Catholic Identity Connections

- Care for God's creation is the 7th theme of Catholic Social Teaching [CST]. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- Describe God's relationship with humans and nature. [CS S.K6 IS6]
- Share concern and care for the environment as a part of God's creation. [CS S.K6 DS2]
- Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that people must cooperate with God's plan for himself and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]
- Care of God's creation is directly related to the life and dignity of the human person, for what we do to the web of creation, we do to ourselves. We cannot have healthy humans on an unhealthy planet. [CST]
- Exhibit care and concern at all stages of life for each human person as an image and likeness of God. [CS S.K6 GS1]
- Value the human body as the temple of the Holy Spirit. [CS S.K6 GS3]

Saints [SA]

- St. Francis of Assisi, patron Saint of Ecology

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

W.5.8 Recall relevant information from experiences or legally and ethically gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs in Fifth Grade

N/A

Articulation to DCIs across Grade-Levels

MS.ESS3.A; MS.ESS3.C; MS.ESS3.D

Grades 6-8 Engineering Design

MS-ETS1 Engineering Design

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Catholic Identity

- Noah was given precise directions to build a boat to withstand the flood (Genesis 6:14-16). This story from the Bible includes valuable data – the kind that is needed for engineering. [S]
- Building the Ark of the Covenant (Exodus 37, 38). [S]
- Simon builds a pyramid for the remains of his brother, Jonathan (1 Maccabees 13:25–30). [S]
- The skilled master worker lays the foundation and others build upon. Jesus is the foundation of Christian life (1 Corinthians 3:9-15). [S]
- The house of God is built upon the foundation of the apostles and prophets, with Jesus as the cornerstone (Ephesians 2:19-22). [S]
- Engineering standards can be connected to the themes of Catholic Social Teaching, depending upon the problem being solved.
- Excerpts from "Engineering as a Calling" (http://www.cis.org.uk/upload/Resources/Students/Engineering_text_only.pdf):
  "As the former US President and mining engineer Herbert Hoover wrote, '[Engineering] is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes… Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege.'

  Hoover's quote provides a good definition of what an engineer is, but the Christian engineer's highest priority and primary motivation is to glorify God. A Christian engineer is someone who uses their God given gifts of specialist technical knowledge and practical abilities to transform creation into an image of what the new creation will be like, so that God is glorified and society is improved (Matthew 5:16, Jeremiah 29:7).

  Many of the technological challenges described in Scripture are on very large scales: Noah's ark, building the temple, reconstruction of the walls of Jerusalem and so on. However, in all these cases the emphasis was on the heart of the individual. Local skill and labor was used, particularly in rebuilding the walls of Jerusalem (Nehemiah 3). In the construction of the tabernacle, specific tasks were undertaken by Spirit-filled craftsmen (Exodus 31:1-11). The status of craftsmen depended entirely on their God-given talents and to what use they put them to. Conversely, craftsmen who make idols are described as 'nothing but men' who 'will be brought down to terror and infamy.' (Isaiah 44:11).

  When Paul visited Athens (Acts 17:16-34) it was among the most advanced cities at the time. Even today the ruins remain a testament to the Athenians' skill. In his commentary on Acts, John Stott says that Paul "might have been spellbound by the sheer splendor of the city's architecture, history and wisdom." However Paul saw past their works to their hearts and recognized that they did not glorify God. Paul placed particular emphasis and value on working with the hands (1 Corinthians 4:12, Ephesians 4:28, 1 Thessalonians 4:11) and demonstrated his flexibility in supporting his preaching ministry with practical work including tent making as the need arose.

'… But what of deeds without faith – a category which could incorporate much of modern engineering?' In 1 Corinthians 13: 1-13, we read that even great works of charity are meaningless without Faith, Hope and Love. The greatest technological engineering project will not succeed without a complete appreciation of the social purpose and the spiritual dimension. The Tower of Babel (Genesis 11) gives a strong case study of the folly of Christians in Science (www.cis.org.uk) embarking on a civil engineering project with cutting-edge technologies whilst ignoring God "Come, let us build ourselves a city, with a tower that reaches to the heavens, so that we may make a name for ourselves'. (Genesis 11:4b)." [S]

Scripture [S]

- "Unless the Lord builds the house, those who build it labor in vain." (Psalm 127:1)
- "Everyone then who hears these words of mine and does them will be like a wise man who built his house on the rock. And the rain fell, and the floods came, and the winds blew and beat on that house, but it did not fall, because it had been founded on the rock. And everyone who hears these words of mine and does not do them will be like a foolish man who built his house on the sand. And the rain fell, and the floods came, and the winds blew and beat against that house, and it fell, and great was the fall of it." (Matthew 7:24-27)
- "Everyone who comes to me and hears my words and does them, I will show you what he is like: he is like a man building a house, who dug deep and laid the foundation on the rock. And when a flood arose, the stream broke against that house and could not shake it, because it had been well built. But the one who hears and does not do them is like a man who built a house on the ground without a foundation. When the stream broke against it, immediately it fell, and the ruin of that house was great." (Luke 6:46-49)
- "For which of you, desiring to build a tower, does not first sit down and count the cost, whether he has enough to complete it?" (Luke 14:28)
- "He is before all things, and in him all things hold together." (Colossians 1:17)
- "As you come to him, a living stone rejected by men but in the sight of God chosen and precious, you yourselves like living stones are being built up as a spiritual house, to be a holy priesthood, to offer spiritual sacrifices acceptable to God through Jesus Christ. For it stands in Scripture: 'Behold, I am laying in Zion a stone, a cornerstone chosen and precious, and whoever believes in him will not be put to shame.' So the honor is for you who believe, but for those who do not believe, 'The stone that the builders rejected has become the cornerstone,' and 'A stone of stumbling, and a rock of offense.' They stumble because they disobey the word, as they were destined to do." (1 Peter 2:4-8)
- "For which of you, desiring to build a tower, does not first sit down and count the cost, whether he has enough to complete it?" (Luke 14:28)

Catholic/Christian Scientists

- Johannes Gutenberg (Inventor of the printing press)

Saints [SA]

- St. Patrick, patron saint of engineers
- St. Isadore of Seville, patron saint of computer scientists and the Internet

MS-ETS1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 6-8 builds on K-5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.	**ETS1.A Defining and Delimiting Engineering Problems** • The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.	**Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. • The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Identifying the problem to be solved

a. Students describe a problem that can be solved through the development of an object, tool, process, or system

2. Defining the process or system boundaries and the components of the process or system

a. Students identify the system in which the problem is embedded, including the major components and relationships in the system and its boundaries, to clarify what is and is not part of the problem. In their definition of the system, students include:
- Which individuals or groups need this problem to be solved.
- The needs that must be met by solving the problem.
- Scientific issues that are relevant to the problem.
- Potential societal and environmental impacts of solutions.
- The relative importance of the various issues and components of the process or system.

3. Defining criteria and constraints

a. Students define criteria that must be taken into account in the solution that:
- Meet the needs of the individuals or groups who may be affected by the problem (including defining who will be the target of the solution).
- Enable comparisons among different solutions, including quantitative considerations when appropriate.

b. Students define constraints that must be taken into account in the solution, including:
- Time, materials, and costs.
- Scientific or other issues that are relevant to the problem.
- Needs and desires of the individuals or groups involved that may limit acceptable solutions.
- Safety considerations.
- Potential effect(s) on other individuals or groups.
- Potential negative environmental effects of possible solutions or failure to solve the problem.

Guided Questions

- What factors affect the design process?

Catholic Identity Connections

- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]
- The standard above can be aligned with Catholic Social Teaching. [CST]
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9]
- Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that people must cooperate with God's plan for all and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Catholic/Christian Scientists

- Electronics
  - Andre-Marie Ampere
  - Antoine Cesar Becquerel
  - Guglielmo Marconi
  - Francesco Lana de Terzi
  - AlessandroVolta
- Mathematics
  - Rene Descartes
  - Fibonacci
  - Charles Hermite

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics

MP.2 Reason abstractly and quantitatively.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Connections to Other DCIs in Grades 6-8

Connections to MS-ETS1.A: Defining and Delimiting Engineering Problems include: Physical Science: MS-PS3-3
Connections to MS-ETS1.B: Developing Possible Solutions Problems include: Physical Science: MS-PS1-6, MS-PS3-3, Life Science: MS-LS2-5
Connections to MS-ETS1.C: Optimizing the Design Solution include: Physical Science: MS-PS1-6

Articulation to DCIs across Grade-Levels

3-5.ETS1.A; 3-5.ETS1.C; HS.ETS1.A; HS.ETS1.B

MS-ETS1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.	

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Identifying the given design solution and associated claims and evidence

a. Students identify the given supported design solution.
b. Students identify scientific knowledge related to the problem and each proposed solution.
c. Students identify how each solution would solve the problem.

2. Identifying additional evidence

a. Students identify and describe additional evidence necessary for their evaluation, including:
   - Knowledge of how similar problems have been solved in the past.
   - Evidence of possible societal and environmental impacts of each proposed solution.

b. Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.

3. Evaluating and critiquing evidence

a. Students use a systematic method (e.g., a decision matrix) to identify the strengths and weaknesses of each solution. In their evaluation, students:
   - Evaluate each solution against each criterion and constraint.
   - Compare solutions based on the results of their performance against the defined criteria and constraints.

b. Students use the evidence and reasoning to make a claim about the relative effectiveness of each proposed solution based on the strengths and weaknesses of each.

Guided Questions

- How are potential design processes evaluated?
- How are differing possible solutions evaluated to determine the best possible outcome?

Catholic Identity Connections

- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]
- The standard above can be aligned with Catholic Social Teaching. [CST]
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9]
- Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that people must cooperate with God's plan for all and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

MP.2	Reason abstractly and quantitatively.
7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Connections to Other DCIs in Grades 6-8

N/A

Articulation to DCIs across Grade-Levels

3-5.ETS1.A; 3-5.ETS1.B; 3-5.ETS1.C; HS.ETS1.A; HS.ETS1.B

MS-ETS1 Engineering Design		
Students who demonstrate understanding can: **MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ETS1.B: Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS1.C: Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.	

Examples of Observable Evidence of Student Performance by the End of Eighth Grade
1. Organizing data
a. Students organize given data (e.g., via tables, charts, or graphs) from tests intended to determine the effectiveness of three or more alternative solutions to a problem.
2. Identifying relationships
a. Students use appropriate analysis techniques (e.g., qualitative or quantitative analysis; basic statistical techniques of data and error analysis) to analyze the data and identify relationships within the datasets, including relationships between the design solutions and the given criteria and constraints.
3. Interpreting data
a. Students use the analyzed data to identify evidence of similarities and differences in features of the solutions. b. Based on the analyzed data, students make a claim for which characteristics of each design best meet the given criteria and constraints. c. Students use the analyzed data to identify the best features in each design that can be compiled into a new (improved) redesigned solution.

Guided Questions

- How can data from a test be organized, analyzed, and interpreted?
- How can multiple data sets be used to redesign a better solution?

Catholic Identity Connections

- Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]
- The standard above can be aligned with Catholic Social Teaching. [CST]
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9]
- Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that people must cooperate with God's plan for all and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Mathematics

MP.2	Reason abstractly and quantitatively.
7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

Connections to Other DCIs in Grades 6-8

N/A

Articulation to DCIs across Grade-Levels

3-5.ETS1.A ; 3-5.ETS1.B; 3-5.ETS1.C ; HS.ETS1.B; HS.ETS1.C

MS-ETS1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs.	**ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. • Models of all kinds are important for testing solutions. **ETS1.C: Optimizing the Design Solution** • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Components of the model

a. Students develop a model in which they identify the components relevant to testing ideas about the designed system, including:
   - The given problem being solved, including criteria and constraints.
   - The components of the given proposed solution (e.g., object, tools, or process), including inputs and outputs of the designed system.

2. Relationships

a. Students identify and describe the relationships between components, including:
   - The relationships between each component of the proposed solution and the functionality of the solution.
   - The relationship between the problem being solved and the proposed solution.
   - The relationship between each of the components of the given proposed solution and the problem being solved.
   - The relationship between the data generated by the model and the functioning of the proposed solution.

3. Connections

a. Students use the model to generate data representing the functioning of the given proposed solution and each of its iterations as components of the model are modified.
b. Students identify the limitations of the model with regards to representing the proposed solution.
c. Students describe how the data generated by the model, along with criteria and constraints that the proposed solution must meet, can be used to optimize the design solution through iterative testing and modification.

Guided Questions	
• How can models be used to demonstrate solutions and gather data?	
Catholic Identity Connections	
• Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7] • The standard above can be aligned with Catholic Social Teaching. [CST] • Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. [CS S.K6 IS9] • Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that people must cooperate with God's plan for all and for nature. [CS S.K6 DS3] • Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]	
Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
Mathematics	
MP.2	Reason abstractly and quantitatively.
7.SP	Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.
Connections to Other DCIs in Grades 6-8	
N/A	
Articulation to DCIs across Grade-Levels	
3-5.ETS1.B; 3-5.ETS1.C ; HS.ETS1.B; HS.ETS1.C	

Sixth Grade Standards

6-ESS1 Earth's Place in the Universe

6-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
6-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
6-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.
6-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6- billion-year-old history.

Catholic Identity

- Biblical star and constellation names:
  - Kimah, the Pleiades
  - The Kesil, Orion
  - Ash, or Ayish, the Hyades
  - Mezarim, the Bears (Great and Little)
  - Mazzaroth, Venus (Lucifer and Hesperus)
  - Hadre theman — "the chambers of the south" — Canopus, the Southern Cross, and a Centauri
  - Nachash, Draco

  For more on Astronomy in the Bible, see: http://www.newadvent.org/cathen/02029a.htm

Catholic/Christian Scientists

- Astronomy
  - Nicolaus Copernicus (astronomer)
  - G.G. Coriolis Galileo Galilei (astronomer)
  - Giovanni Domenico Cassini (first to observe four of Saturn's moons and the co-discoverer of the Great Red Spot on Jupiter)
  - Christopher Clavius (Jesuit, the Gregorian calendar)
  - Nicolas Louis de Lacaille (cataloged stars, nebulous objects, and constellations)
  - Pierre-Simon Laplace (the "Newton of France")
  - Paolo dal Pozzo Toscanelli (astronomer and cosmographer)
  - Eduard Heis (contributed the first true delineation of the Milky Way)
  - Gaspard-Gustave Coriolis (the Corialis effect)
  - Léon Foucault (the Foucault pendulum)
  - Daniello Bartoli, Jean-Baptiste Biot
  - (There are many more Catholic astronomers to research.)

- Geology
    - Nicolas Steno (stratigraphy)
- Paleontology/Archeology
    - Gaspard-Gustave Coriolis
    - Leon Foucault
    - Abraham Orteliu
    - Teilhard de Chardin
- Meteorology
    - Theodoric of Freiberg, Evangelista Torricelli

Saints [SA]

- St. Dominic, patron saint of astronomers
- St. Barbara, patron saint of geology

6-ESS2 Earth's Systems

6-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
6-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
6-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
6-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
6-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
6-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determines regional climates.

Catholic/Christian Scientists

- Geology
    - Nicolas Steno (stratigraphy)
    - Georgius Agricola (mineralogy)
    - Jean Baptiste Julien d'Omalius d'Halloy (modern geology)
    - René Just Haüy (crystallography)
    - Abraham Ortelius (created the first modern atlas and theorized on continental drift)
    - Wilhelm Heinrich Waagen (geologist and paleontologist)
    - Johann Joachim Winckelmann (scientific archaeology)
    - Teilhard de Chardin (paleontology)

- Paleontology/Archeology
    - Gaspard-Gustave Coriolis
    - Leon Foucault
    - Abraham Ortelius
    - Teilhard de Chardin
- Meteorology
    - Theodoric of Freiberg
    - Evangelista Torricelli

Saints [SA]

- St. Barbara, patron saint of geology
- St. Clare of Assisi, patron saint of good weather
- St. Eurosia, patron saint against bad weather

6-ESS3 Earth and Human Activity

6-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

6-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

6-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing human impact on the environment.

6-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

6-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Scripture [S]

- "The earth is the LORD's and all it holds, the world and those who dwell in it." (Psalm 24:1)
- "How varied are your works, Lord!
  In wisdom you have made them all; the earth is full of your creatures.
  There is the sea, great and wide!
  It teems with countless beings, living things both large and small.
  There ships ply their course and Leviathan, whom you formed to play with.
  All of these look to you to give them food in due time.
  When you give it to them, they gather; when you open your hand, they are well filled.
  When you hide your face, they panic.
  Take away their breath, they perish and return to the dust.
  Send forth your spirit, they are created and you renew the face of the earth." (Psalm 104:24-30)

Catholic/Christian Scientists

- Rachel Carson
- Sr. Paula Gonzales
- Fr. Thomas Berry (Passionist priest – religion, ecology, cultural history)

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

6-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

6-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

Clarification Statement: Examples of models can be physical, graphical, or conceptual.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Develop and use a model to describe phenomena.	**ESS1.A The Universe and Its Stars** • Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B Earth and the Solar System** • This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of the tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** • Patterns can be used to identify cause and effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Components of the model

a. To make sense of a given phenomenon, students develop a model (e.g., physical, conceptual, graphical) of the Earth-moon-sun system in which they identify the relevant components, including:
   - Earth, including the tilt of its axis of rotation
   - Sun
   - Moon
   - Solar energy

b. Students indicate the accuracy of size and distance (scale) relationships within the model, including any scale limitations within the model.

2. Relationships

a. In their model, students describe the relationships between components, including:
   - Earth rotates on its tilted axis once an Earth day.
   - The moon rotates on its axis approximately once a month.
   - Relationships between Earth and the moon:
     - The moon orbits Earth approximately once a month.
     - The moon rotates on its axis at the same rate at which it orbits Earth so that the side of the moon that faces Earth remains the same as it orbits.
     - The moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the sun.
   - Relationships between the Earth-moon system and the sun:
     - Earth-moon system orbits the sun once an Earth year.
     - Solar energy travels in a straight line from the sun to Earth and the moon so that the side of Earth or the moon that faces the sun is illuminated.
     - Solar energy reflects off of the side of the moon that faces the sun and can travel to Earth.
     - The distance between Earth and the sun stays relatively constant throughout the Earth's orbit.
     - Solar energy travels in a straight line from the sun and hits different parts of the curved Earth at different angles - more directly at the equator and less directly at the poles.

3. Connections

a. Students use patterns observed from their model to provide causal accounts for events, including:
- Moon phases
    - Solar energy coming from the sun bounces off of the moon and is viewed on Earth as the bright part of the moon.
    - The visible proportion of the illuminated part of the moon (as viewed from Earth) changes over the course of a month as the location of the moon relative to Earth and the sun changes.
    - The moon appears to become more fully illuminated until "full" and then less fully illuminated until dark, or "new", in a pattern of change that corresponds to what proportion of the illuminated part of the moon is visible from Earth.
- Eclipses:
    - Solar energy is prevented from reaching the Earth during a solar eclipse because the moon is located between the sun and Earth.
    - Solar energy is prevented from reaching the moon (and thus reflecting off of the moon to Earth) during a lunar eclipse because Earth is located between the sun and moon.
    - Because the moon's orbital plane is tilted with respect to the plane of the Earth's orbit around the sun, for a majority of time during an Earth month, the moon is not in a position to block solar energy from reaching Earth, and Earth is not in a position to block solar energy from reaching the moon.
- Seasons:
    - Because the Earth's axis is tilted, the most direct and intense solar energy occurs over the summer months, and the least direct and intense solar energy occurs over the winter months.
    - The change in season at a given place on Earth is directly related to the orientation of the tilted Earth and the position of Earth in its orbit around the sun because of the change in the directness and intensity of the solar energy at that place over the course of the year.
        - Summer occurs in the Northern Hemisphere at times in the Earth's orbit when the northern axis of Earth is tilted toward the sun. Summer occurs in the Southern Hemisphere at times in the Earth's orbit when the southern axis of Earth is tilted toward the sun.
        - Winter occurs in the Northern Hemisphere at times in the Earth's orbit when the northern axis of Earth is tilted away from the sun. Winter occurs in the Southern Hemisphere at times in the Earth's orbit when the southern axis of Earth is tilted away from the sun.

b. Students use their model to predict:
- The phase of the moon when given the relative locations of the Earth, sun, and moon.
- The relative positions of the Earth, sun, and moon when given a moon phase.
- Whether an eclipse will occur, given the relative locations of the Earth, sun, and moon and a position on Earth from which the moon or sun can be viewed (depending on the type of eclipse).
- The relative positions of the Earth, sun, and moon, given a type of eclipse and a position on Earth from which the moon/sun can be viewed.
- The season on Earth, given the relative positions of Earth and the sun (including the orientation of the Earth's axis) and a position on Earth.
- The relative positions of Earth and the sun when given a season and a relative position (e.g., far north, far south, equatorial) on Earth.

Guided Questions

- How do the relative positions of the sun, Earth, and moon to each other affect their physical phenomena (i.e., moon phases, eclipses, light, and seasons)?

Catholic Identity Connections

- God is the creator of the universe including the Earth, sun, and moon systems which allow for life. [S] [T]
- The liturgical year of the Catholic Church is aligned with the Earth-sun-moon system. Easter is the first Sunday after the first full moon after the Spring equinox.
- *All creation is a system of interrelated parts. All of creation works together as one sacred whole. Humans are a part of this system* (Pope Francis, ***Laudato Si'***). [M]
- The Trinity - Our God is a relational God, creator of a relationship universe. [S] [T]
- The Catholic sacraments are based on relationships (Bernand Cook). [ST]
- The Catholic liturgical year is based upon the relationships and patterns of the sun, Earth and moon. [T]
- Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS S.K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Mathematics

MP.4 Model with mathematics.

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

7.RP.2 Recognize and represent proportional relationships between quantities.

Connections to Other DCIs in Sixth Grade

MS.PS2.A; MS.PS2.B

Articulation to DCIs across Grade-Bands

3.PS2.A; 5.PS2.B; 5.ESS1.B

6-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

6-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).

Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**ESS1.A The Universe and Its Stars** • Earth and its solar system are part of the Milky Way galaxy, which is one of the many galaxies in the universe. **ESS1.B Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. • The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	**Systems and System Models** • Models can be used to represent systems and their interactions. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Components of the model

a. To make sense of a given phenomenon, students develop a model in which they identify the relevant components of the system, including:
   - Gravity.
   - The solar system as a collection of bodies, including the sun, planets, moons, and asteroids.
   - The Milky Way galaxy as a collection of stars (e.g., the sun) and their associated systems of objects.
   - Other galaxies in the universe.

b. Students indicate the relative spatial scales of solar systems and galaxies in the model.

2. Relationships

a. Students describe the relationships and interactions between components of the solar and galaxy systems, including:
   - Gravity as an attractive force between solar system and galaxy objects that:
     - Increases with the mass of the interacting object's increases.
     - Decreases as the distances between objects increases.
   - The orbital motion of objects in our solar system (e.g., moons orbit around planets, all objects within the solar system orbit the sun).
   - The orbital motion, in the form of a disk, of vast numbers of stars around the center of the Milky Way.
   - That our solar system is one of many systems orbiting the center of the larger system of the Milky Way galaxy.
   - The Milky Way is one of many galaxy systems in the universe.

3. Connections

a. Students use the model to describe that gravity is a predominantly inward-pulling force that can keep smaller/less massive objects in orbit around larger/more massive objects.

b. Students use the model to describe that gravity causes a pattern of smaller/less massive objects orbiting around larger/more massive objects at all system scales in the universe, including that:
   - Gravitational forces from planets cause smaller objects (e.g., moons) to orbit around the planets.
   - The gravitational force of the sun causes the planets and other bodies to orbit around it, holding the solar system together.
   - The gravitational forces from the center of the Milky Way cause stars and stellar systems to orbit around the center of the galaxy.
   - The hierarchy pattern of orbiting systems in the solar system was established early in its history as the disk of dust and gas was driven by gravitational forces to form moon-planet and planet-sun orbiting systems.

c. Students use the model to describe that objects too far away from the sun do not orbit it because the sun's gravitational force on those objects is too weak to pull them into orbit.

d. Students use the model to describe what a given phenomenon might look like without gravity (e.g., smaller planets would move in straight paths through space, rather than orbiting a more massive body).

Guided Questions

- How can the position and mass of a solar body affect the gravity on that body?
- How does gravity affect orbital motion within small or large systems?

Diocese of Owensboro Science Standards
Grade 6

Catholic Identity Connections

- *All creation is a system of interrelated parts. All of creation works together as one sacred whole. Humans are a part of this system (Pope Francis,* ***Laudato Si'****).* [M]
- The Trinity - Our God is a relational God, creator of a relational universe. [S] [T]
- The Catholic sacraments are based on relationships (Bernand Cook). [ST]
- God is the attractive force at the center of all creation and pulls everything toward himself; all of creation groans for completion in Christ (Rom 8:22). [S] [T]
- Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS S.K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Scripture [S]

- Gravitational properties of constellations- "Have you tied cords to the Pleiades, or loosened the bonds of Orion?" (Job 38:31)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5	Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Mathematics

MP.4	Model with mathematics.
6.RP.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
7.RP.2	Recognize and represent proportional relationships between quantities.
6.EE.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.
7.EE.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Connections to Other DCIs in Sixth Grade

MS.PS2.A; MS.PS2.B

Articulation to DCIs across Grade-Bands

3.PS2.A; 5.PS2.B; 5.ESS1.B

6-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

6-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.

Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.

Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS1.B Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Organizing data

a. Students organize given data on solar system objects (e.g., surface features, object layers, orbital radii) from various Earth- and space-based instruments to allow for analysis and interpretation (e.g., transforming tabular data into pictures, diagrams, graphs, or physical models that illustrate changes in scale).
b. Students describe that different representations illustrate different characteristics of objects in the solar system, including differences in scale.

2. Identifying relationships

a. Students use quantitative analyses to describe similarities and differences among solar system objects by describing patterns of features of those objects at different scales, including:
   - Distance from the sun.
   - Diameter.
   - Surface features (e.g., sizes of volcanoes).
   - Structure.
   - Composition (e.g., ice versus rock versus gas).
b. Students identify advances in solar system science made possible by improved engineering (e.g., knowledge of the evolution of the solar system from lunar exploration and space probes) and new developments in engineering made possible by advances in science (e.g., space-based telescopes from advances in optics and aerospace engineering).

3. Interpreting data

a. Students use the patterns they find in multiple types of data at varying scales to draw conclusions about the identifying characteristics of different categories of solar system objects (e.g., planets, meteors, asteroids, comets) based on their features, composition, and locations within the solar system (e.g., most asteroids are rocky bodies between Mars and Jupiter, while most comets reside in orbits farther from the sun and are composed mostly of ice).
b. Students use patterns in data as evidence to describe that two objects may be similar when viewed at one scale (e.g., types of surface features) but may appear to be quite different when viewed at a different scale (e.g., diameter or number of natural satellites).
c. Students use the organization of data to facilitate drawing conclusions about the patterns of scale properties at more than one scale, such as those that are too large or too small to directly observe.

Guided Questions

- How is technology used to gather information about solar bodies in relation to the Earth and its physical/chemical features?
- What technology can be used in space exploration to gather information?

Catholic Identity Connections

- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics
MP.2 Reason abstractly and quantitatively.
6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
7.RP.2 Recognize and represent proportional relationships between quantities.

Connections to Other DCIs in Sixth Grade

MS.ESS2.A

Articulation to DCIs across Grade-Bands

5.ESS1.B

6-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

6-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.

Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS1.C The History of Planet Earth** • The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including how events in the Earth's 4.6-billion-year-old history are organized relative to one another using the geologic time scale.

b. Students use evidence and reasoning to construct an explanation. In their explanation, students describe how the relative order of events is determined on the geologic time scale using:
   - Rock strata and relative ages of rock units (e.g., patterns of layering).
   - Major events in the Earth's history and/or specific changes in fossils over time (e.g., formation of mountain chains, formation of ocean basins, volcanic eruptions, glaciations, asteroid impacts, extinctions of groups of organisms).

2. Evidence

a. Students identify and describe the evidence necessary for constructing the explanation, including:
   - Types and order of rock strata.
   - The fossil record.
   - Identification of and evidence for major event(s) in the Earth's history (e.g., volcanic eruptions, asteroid impacts).
   - Use of data from relative and absolute dating.

3. Reasoning

a. Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for how the geologic time scale is used to construct a timeline of the Earth's history. Students describe the following chain of reasoning for their explanation:

- Unless they have been disturbed by subsequent activity, newer rock layers sit on top of older rock layers, allowing for a relative ordering in time of the formation of the layers (i.e., older sedimentary rocks lie beneath younger sedimentary rocks).
- Any rocks or features that cut existing rock strata are younger than the rock strata that they cut (e.g., a younger fault cutting across older, existing rock strata).
- The fossil record can provide relative dates based on the appearance or disappearance of organisms (e.g., fossil layers that contain only extinct animal groups are usually older than fossil layers that contain animal groups that are still alive today, and layers with only microbial fossils are typical of the earliest evidence of life).
- Specific major events (e.g., extensive lava flows, volcanic eruptions, asteroid impacts) can be used to indicate periods of time that occurred before a given event from periods that occurred after it.
- Using a combination of the order of rock layers, the fossil record, and evidence of major geologic events, the relative time ordering of events can be constructed as a model for Earth's history, even though the timescales involved are immensely vaster that the lifetimes of humans or the entire history of humanity.

Guided Questions

- How do you determine the age of rock strata?
- What does the age of rock strata reveal about Earth's history?

Catholic Identity Connections

- The universe was created by God in stages that built upon one another over a period of time. God continues to create in the world.
- See the writings of Illia Delio, OSF on evolution and Christianity.
- Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. [CS S.K6 IS1]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Mathematics

6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Connections to Other DCIs in Sixth Grade

MS.LS4.A; MS.LS4.C

Articulation to DCIs across Grade-Bands

3.LS4.A; 3.LS4.C; 4.ESS1.C

6-ESS2 Earth's Systems

Students who demonstrate understanding can:

6-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.

Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials (e.g., rock cycle).

Assessment Boundary: Assessment does not include the identification and naming of minerals.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**ESS2.A Earth's Materials and Systems** • All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and the Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Components of the model

a. To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
- General types of Earth materials that can be found in different locations, including:
    - Those located at the surface (exterior) and/or in the interior.
- Those that exist(ed) before and/or after chemical and/or physical changes that occur during Earth processes (e.g., melting, sedimentation, weathering).
    - Energy from the sun.
    - Energy from the Earth's hot interior.
    - Relevant Earth processes.
    - The temporal and spatial scales for the system.

2. Relationships

a. In the model, students describe relationships between components, including:
- Different Earth processes (e.g., melting, sedimentation, crystallization) drive matter cycling (i.e., from one type of Earth material to another) through observable chemical and physical changes.
- The movement of energy that originates from the Earth's hot interior and causes the cycling of matter through the Earth processes of melting, crystallization, and deformation.
- Energy flows from the sun cause matter cycling via processes that produce weathering, erosion, and sedimentation (e.g., wind, rain).
- The temporal and spatial scales which the relevant Earth processes operate.

3. Connections

a. Students use the model to describe (based on evidence for changes over time and processes at different scales) that energy from the Earth's interior and the sun drive Earth processes that together cause matter cycling through different forms of Earth materials.

b. Students use the model to account for interactions between different Earth processes, including:
   - The Earth's internal heat energy drives processes such as melting, crystallization, and deformation that change the atomic arrangement of elements in rocks and that move and push rock material to the Earth's surface where it is subject to surface processes like weathering and erosion.
   - Energy from the sun drives the movement of wind and water that causes the erosion, movement, and sedimentation of weathered Earth materials.
   - Given the right setting, any rock on Earth can be changed into a new type of rock by processes driven by the Earth's internal energy or by energy from the sun.

c. Students describe that these changes are consistently occurring but that landforms appear stable to humans because they are changing on time scales much longer than human lifetimes.

Guided Questions

- How does energy change Earth's materials?
- How does energy drive the processes that change Earth's materials?

Catholic Identity Connections

- God is the creator of all geological processes.
- *All creation is a system of interrelated parts. All of creation works together as one sacred whole* (Pope Francis, ***Laudato Si'***). [M]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Connections to Other DCIs in Sixth Grade

MS.PS3.B; MS.LS2.B; MS.LS2.C; MS.ESS1.B; MS.ESS3.C

Articulation to DCIs across Grade-Bands

4.PS3.B; 4.ESS2.A; 5.ESS2.A

6.ESS2 Earth's Systems

Students who demonstrate understanding can:

6-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.	**ESS2.A Earth's Materials and Systems** • The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. **ESS2.C The Roles of Water in Earth's Surface Processes** • Water's movements - both on the land and underground - cause weathering and erosion, which change the land's surface features and create underground formations.	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates a given phenomenon to a scientific idea, including that geoscience processes have changed the Earth's surface at varying time and spatial scales.
b. Students use evidence and reasoning to construct an explanation for the given phenomenon, which involves changes at Earth's surface.

2. Evidence

a. Students identify and describe the evidence necessary for constructing an explanation, including:
   - The slow- and large-scale motion of the Earth's plates and the results of that motion.
   - Surface weathering, erosion, movement, and the deposition of sediment ranging from large to microscopic scales (e.g., sediment consisting of boulders and microscopic grains of sand, raindrops dissolving microscopic amounts of minerals).
   - Rapid catastrophic events (e.g., earthquakes, volcanoes, meteor impacts).

b. Students identify the corresponding timescales for each identified geoscience process.

c. Students use multiple valid and reliable sources, which may include students' own investigations, evidence from data, and observations from conceptual models used to represent changes that occur on very large or small spatial and/or temporal scales (e.g., stream tables to illustrate erosion and deposition, maps and models to show the motion of the tectonic plates).

3. Reasoning

a. Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for how geoscience processes have changed the Earth's surface at a variety of temporal and spatial scales. Students describe the following chain of reasoning for their explanation:

- The motion of the Earth's plates produces changes on a planetary scale over a range of time periods from millions to billions of years. Evidence for the motion of plates can explain large-scale features of the Earth's surface (e.g., mountains, distribution of continents) and how they change.
- Surface processes such as erosion, movement, weathering, and the deposition of sediment can modify surface features, such as mountains, or create new features, such as canyons. These processes can occur at spatial scales ranging from large to microscopic over time periods ranging from years to hundreds of millions of years.
- Catastrophic changes can modify or create surface features over a very short period of time compared to other geoscience processes, and the results of those catastrophic changes are subject to further changes over time by processes that act on longer time scales (e.g., erosion of a meteor crater).
- A given surface feature is the result of a broad range of geoscience processes occurring at different temporal and spatial scales.
- Surface features will continue to change in the future as geoscience processes continue to occur.

Guided Questions

- What processes can explain the changing of the Earth's surface?
- How do catastrophic events help shape/change Earth's constant processes?

Catholic Identity Connections

- Our spiritual growth is often slow and steady, but sometimes it is punctuated by catastrophic events through which we experience the inbreaking of God’s presence and grace in particularly powerful ways.
- *All creation is a system of interrelated parts. All of creation works together as one sacred whole* (Pope Francis, ***Laudato Si’***). [M]
- Describe the relationships, elements, underlying order, harmony, and meaning in God’s creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God’s love and goodness and, therefore, is “sacramental” in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God’s creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **SL.8.5** Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. **Mathematics** **MP.2** Reason abstractly and quantitatively. **6.NS.5** Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. **6.EE.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. **7.EE.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Connections to Other DCIs in Sixth Grade
MS.PS1.B; MS.LS2.B
Articulation to DCIs across Grade-Bands
4.ESS1.C; 4.ESS2.A; 4.ESS2.E; 5.ESS2.A

6-ESS2 Earth's Systems

Students who demonstrate understanding can:

6-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).

Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. **Connections to Nature of Science** **Scientific Knowledge Is Open to Revision in Light of New Evidence** • Science findings are frequently revised and/or reinterpreted based on new evidence.	**ESS2.B Plate Tectonics and Large-Scale System Interactions** • Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. **ESS2.C The Roles of Water in Earth's Surface Processes** • Water's movements - both on the land and underground - cause weathering and erosion, which change the land's surface features and create underground formations.	**Patterns** • Patterns in rates of change and other numerical relationships can provide information about natural systems.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Organizing data

a. Students organize data that represent the distribution of fossils and rocks, continental shapes, seafloor structures, and/or age of oceanic crust.
b. Students describe what each dataset represents.
c. Students organize the given data in a way that facilitates analysis and interpretation.

2. Identifying relationships

a. Students analyze the data to identify relationships (including relationships that can be used to infer numerical rates of change, such as patterns of age of seafloor) in the datasets about Earth features.

3. Interpreting data

a. Students use the analyzed data to provide evidence for past plate motion. Students describe:
   - Regions of different continents that share similar fossils and similar rocks suggest that, in the geologic past, those sections of continent were once attached and have since separated.
   - The shapes of continents, which roughly fit together (like pieces of a jigsaw puzzle) suggest that those land masses were once joined and have since separated.
   - The separation of continents by the sequential formation of new seafloor at the center of the ocean is inferred by age patterns in oceanic crust that increase in age from the center of the ocean to the edges of the ocean.
   - The distribution of seafloor structures (e.g., volcanic ridges at the centers of oceans, trenches at the edges of continents) combined with the patterns of ages of rocks of the seafloor (youngest ages at the ridge, oldest ages at the trenches) supports the interpretation that new crust forms at the ridges and then moves away from the ridges as new crust continues to form and that the oldest crust is being destroyed at seafloor trenches.

Guided Questions

- What are the pieces of evidence that show that Earth's plates are in constant motion?

Catholic Identity Connections

- God's love is a sign of trust in all creation.
- *All creation is a system of interrelated parts. All creation works together as one sacred whole* (Pope Francis, ***Laudato Si'***). [M]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Mathematics

MP.2 Reason abstractly and quantitatively.

6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Connections to Other DCIs in Sixth Grade

MS.LS4.A

Articulation to DCIs across Grade-Bands

3.LS4.A; 3.ESS3.B; 4.ESS1.C; 4.ESS2.B; 4.ESS3.B

6-ESS2 Earth's Systems

Students who demonstrate understanding can:

6-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	**ESS2.C The Roles of Water in Earth's Surface Processes** • Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, crystallization, and precipitation as well as downhill flows on land. • Global movements of water and its changes in form are propelled by sunlight and gravity.	**Energy and Matter** • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Components of the model

a. To make sense of a phenomenon, students develop a model in which they identify the relevant components:
- Water (liquid, solid, and in the atmosphere).
- Energy in the form of sunlight.
- Gravity.
- Atmosphere.
- Landforms.
- Plants and other living things.

2. Relationships

a. In their model, students describe relevant relationships between components, including:
- Energy transfer from the sun warms water on Earth, which can evaporate into the atmosphere.
- Water vapor in the atmosphere forms clouds, which can cool and condense to produce precipitation that falls to the surface of Earth.
- Gravity causes water on land to move downhill (e.g., rivers and glaciers) and much of it eventually flows into oceans.
- Some liquid and solid water remains on land in the form of bodies of water and ice sheets.
- Some water remains in the tissues of plants and other living organisms, and this water is released when the tissues decompose.

3. Connections

a. Students use the model to account for both energy from light and the force of gravity driving water cycling between oceans, the atmosphere, and land, including that:
   - Energy from the sun drives the movement of water from the Earth (e.g., oceans, landforms, plants) into the atmosphere through transpiration and evaporation.
   - Water vapor in the atmosphere can cool and condense to form rain or crystallize to form snow or ice, which returns to Earth when pulled down by gravity.
   - Some rain falls back into the ocean, and some rain falls on land. Water that falls on land can:
     - Be pulled down by gravity to form surface waters such as rivers, which join together and generally flow back into the ocean.
     - Evaporate back into the atmosphere.
     - Be taken up by plants, which release it through transpiration and also eventually through decomposition.
     - Be taken up by animals, which release it through respiration and also eventually through decomposition.
     - Freeze (crystallize) and/or collect in frozen form, in some cases forming glaciers or ice sheets.
     - Be stored on land in bodies of water or below ground in aquifers.

b. Students use the model to describe that the transfer of energy between water and its environment drives the phase changes that drive water cycling through evaporation, transpiration, condensation, crystallization, and precipitation.

c. Students use the model to describe how gravity interacts with water in different phases and locations to drive water cycling between the Earth's surface and the atmosphere.

Guided Questions

- What are the driving forces of the hydrologic cycle?
- How does the energy of the sun affect biological/physical relationships on Earth?

Catholic Identity Connections

- *All of creation is interdependent. All of creation is a system of interrelated parts. All of creation works together as one sacred whole. Humans are a part of this system* (Pope Francis, ***Laudato Si'***). [M]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Scripture [S]

- "He holds in check the water drops that filter in rain from his flood, till the clouds flow with them and they rain down on all humankind." (Job 36:27-28)
- "All rivers flow to the sea, yet never does the sea become full. To the place where they flow, the rivers continue to flow." (Ecclesiastes 1:7)

Diocese of Owensboro ELA and Mathematics Standards Connections

N/A

Connections to Other DCIs in Sixth Grade

MS.PS1.A; MS.PS2.B; MS.PS3.A; MS.PS3.D

Articulation to DCIs across Grade-Bands

3.PS2.A; 4.PS3.B; 5.PS2.B; 5.ESS2.C

6.ESS2 Earth's Systems

Students who demonstrate understanding can:

6-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).

Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.	**ESS2.C The Roles of Water in Earth's Surface Processes** • The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. **ESS2.D Weather and Climate** • Because these patterns are so complex, weather can only be predicted probabilistically.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Identifying the phenomenon under investigation

a. From the given investigation plan, students describe the phenomenon under investigation, which includes the relationships between air mass interactions and weather conditions.

b. Students identify the purpose of the investigation, which includes providing evidence to answer questions about how motions and complex interactions of air masses result in changes in weather conditions [note: expectations of students regarding mechanisms are limited to relationships between patterns of activity of air masses and changes in weather].

2. Identifying the evidence to address the purpose of the investigation

a. From a given investigation plan, students describe the data to be collected and the evidence to be derived from the data that would indicate relationships between air mass movement and changes in weather, including:
   - Patterns in weather conditions in a specific area (e.g., temperature, air pressure, humidity, wind speed) over time.
   - The relationship between the distribution and movement of air masses and landforms, ocean temperatures, and currents.
   - The relationship between observed, large-scale weather patterns and the location or movement of air masses, including patterns that develop between air masses (e.g., cold fronts may be characterized by thunderstorms).

b. Students describe how the evidence to be collected will be relevant to determining the relationship between patterns of activity of air masses and changes in weather conditions.
c. Students describe that because weather patterns are so complex and have multiple causes, weather can be predicted only probabilistically.

3. Planning the investigation

a. Students describe the tools and methods used in the investigation, including how they are relevant to the purpose of the investigation.

4. Collecting the data

a. According to the provided investigation plan, students make observations and record data (firsthand and/or from professional weather monitoring services).

Guided Questions

- How do weather factors influence each other to create a climate?
- How is data collected to determine the weather in an area?

Catholic Identity Connections

- In the Catholic tradition we sometimes think of movements of the Holy Spirit in terms of wind (Pentecost). This lesson provides the opportunity to make an analogy with the movements of the Holy Spirit in our lives.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using research terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Mathematics

MP.2 Reason abstractly and quantitatively.

6.NS.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.

Connections to Other DCIs in Sixth Grade

MS.PS1.B; MS.PS2.A; MS.PS3.A; MS.PS3.B

Articulation to DCIs across Grade-Bands

3.ESS2.D; 5.ESS2.A

6-ESS2 Earth's Systems

Students who demonstrate understanding can:

6-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.

Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**ESS2.C The Roles of Water in Earth's Surface Processes** • Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. **ESS2.D Weather and Climate** • Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. • The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.	**Systems and System Models** • Models can be used to represent systems and their interactions - such as inputs, processes, and outputs - and energy, matter, and information flows within systems.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Components of the model

a. To make sense of a phenomenon, students develop a model in which they identify the relevant components of the system, with inputs and outputs, including:
   - The rotating Earth
   - The atmosphere
   - The oceans, including the relative rate of thermal energy transfer of water compared to land or air
   - Continents and the distribution of landforms on the surface of Earth
   - Global distribution of ice
   - Distribution of living things
   - Energy
   - Radiation from the sun as an input
   - Thermal energy that exists in the atmosphere, water, land, and ice (as represented by temperature)

2. Relationships

a. In the model, students identify and describe the relationships between components of the system, including:
• Differences in the distribution of solar energy and temperature changes, including:
  • Higher latitudes receive less solar energy per unit of area than do lower latitudes, resulting in temperature differences based on latitude.
  • Smaller temperature changes tend to occur in oceans than on land in the same amount of time.
  • In general, areas at higher elevations have lower average temperatures than do areas at lower elevations.
  • Features of the Earth's surface, such as the amount of solar energy reflected back into the atmosphere or the absorption of solar energy by living things, affect the amount of solar energy transferred into heat energy.
• Motion of ocean waters and air masses (matter):
  • Fluid matter (i.e., air, water) flows from areas of higher density to areas of lower density (due to temperature or salinity). The density of a fluid can vary for several different reasons (e.g., changes in salinity and temperature of water can each cause changes in density). Differences in salinity and temperature can, therefore, cause fluids to move vertically and, as a result of vertical movement, also horizontally because of density differences.
• Factors affecting the motion of wind and currents:
  • The Earth's rotation causes oceanic and atmospheric flows to curve when viewed from the rotating surface of Earth (Coriolis force).
  • The geological distribution of land limits where ocean currents can flow.
  • Landforms affect atmospheric flows (e.g., mountains deflect wind and/or force it to higher elevation).
• Thermal energy transfer:
  • Thermal energy moves from areas of high temperature to areas of lower temperature either through the movement of matter, via radiation, or via conduction of heat from warmer objects to cooler objects.
  • Absorbing or releasing thermal energy produces a more rapid change in temperature on land compared to in water.
  • Absorbing or releasing thermal energy produces a more rapid change in temperature in the atmosphere compared to either land or in water so the atmosphere is warmed or cooled by being in contact with land or the ocean.

3. Connections

a. Students use the model to describe:
• The general latitudinal pattern in climate (higher average annual temperatures near the equator and lower average annual temperatures at higher latitudes) caused by more direct light (greater energy per unit of area) at the equator (more solar energy) and less direct light at the poles (less solar energy).
• The general latitudinal pattern of drier and wetter climates caused by the shift in the amount of air moisture during precipitation from rising moisture-rich air and the sinking of dry air.
• The pattern of differing climates in continental areas as compared to oceans. Because water can absorb more solar energy for every degree change in temperature compared to land, there is a greater and more rapid temperature change on land than in the ocean. At the centers of landmasses, this leads to conditions typical of continental climate patterns.
• The pattern that climates near large water bodies, such as marine coasts, have comparatively smaller changes in temperature relative to the center of the landmass. Land near the oceans can exchange thermal energy through the air, resulting in smaller changes in temperature. At the edges of landmasses, this leads to marine climates.
• The pattern that climates at higher altitudes have lower temperatures than climates at lower altitudes. Because of the direct relationship between temperatures and pressure, given the same amount of thermal energy, air at lower pressures (higher altitudes) will have lower temperatures than air at higher pressures (lower altitudes).
• Regional patterns of climate (e.g., temperature or moisture) related to a specific pattern of water or air circulation, including the role of the following in contributing to the climate pattern:
  • Air or water moving from areas of high temperature, density, and/or salinity to areas of low temperature, density, and/or salinity.
  • The Earth's rotation, which affects atmospheric and oceanic circulation.
  • The transfer of thermal energy with the movement of matter.
  • The presence of landforms (e.g., the rain shadow effect).

b. Students use the model to describe the role of each of its components in producing a given regional climate.

Guided Questions

- What is the driving force behind atmospheric and oceanic circulation?
- What contributes to the differences in circulation in different regions?

Catholic Identity Connections

- *All of creation is a system of interrelated parts. All of creation works together as one sacred whole* (Pope Francis, ***Laudato Si'***). [M]
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. [CS S.K6 IS3]
- Give examples of the beauty evident in God's creation. [CS S.K6 IS4]
- Display a sense of wonder and delight about the natural universe and its beauty. [CS S.K6 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Connections to Other DCIs in Sixth Grade

MS.PS2.A; MS.PS3.B; MS.PS4.B

Articulation to DCIs across Grade-Bands

3.PS2.A; 3.ESS2.D; 5.ESS2.A

6-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

6-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include, but are not limited to, petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe nature operate today as they did in the past and will continue to do so in the future.	**ESS3.A Natural Resources** • Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement relating a given phenomenon to scientific ideas, including that past and current geoscience processes have caused the uneven distribution of the Earth's resources, including:
   - That the uneven distribution of the Earth's mineral, energy, and groundwater resources are the results of past and current geologic processes.
   - That resources are typically limited and non-renewable due to factors such as the long amounts of time required for some resources to form or the environment in which resources were created forming once or only rarely in the Earth's history.

b. Students use evidence and reasoning to construct a scientific explanation of the phenomenon.

2. Identifying the scientific evidence to construct the explanation

a. Students identify and describe the evidence necessary for constructing an explanation, including:
   - Type and distribution of an example of each type of Earth resource: mineral, energy, and groundwater.
   - Evidence for the past and current geologic processes (e.g., volcanic activity, sedimentary processes) that have resulted in the formation of each of the given resources.
   - The ways in which the extraction of each type of resource by humans changes how much and where more of that resource can be found.

b. Students use multiple valid and reliable sources of evidence.

3. Reasoning

a. Students use reasoning to connect the evidence and support an explanation. Students describe a chain of reasoning that includes:
   - The Earth's resources are formed as a result of past and current geologic processes.
   - The environment or conditions that formed the resources are specific to certain areas and/or times on Earth, thus identifying why those resources are found only in those specific places/periods.
   - As resources are used, they are depleted from the sources until they can be replenished, mainly through geologic processes.
   - Because many resources continue to be formed in the same ways that they were in the past, and because the amount of time required to form most of these resources (e.g., minerals, fossil fuels) is much longer than timescales of human lifetimes, these resources are limited to current and near-future generations. Some resources (e.g., groundwater) can be replenished on human timescales and are limited based on distribution.
   - The extraction and use of resources by humans decreases the amounts of these resources available in some locations and changes the overall distribution of these resources on Earth.

Guided Questions

- What causes the uneven distribution of Earth's resources?
- How do humans impact the amounts of renewable and non-renewable resources available?

Catholic Identity Connections

- Water is sacred. It is an integral aspect of our liturgical and sacramental lives as Catholics.
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- Describe God’s relationship with humans and nature. [CS S.K6 IS6]
- Share concern and care for the environment as a part of God’s creation. [CS S,K6 DS2]
- Accept the premise that nature should not be manipulated simply at peoples’ will or only viewed as a thing to be used, but that people must cooperate with God’s plan for himself and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Connections to Other DCIs in Sixth Grade

MS.PS1.A; MS.PS1.B; MS.ESS2.D

Articulation to DCIs across Grade-Bands

4.PS3.D; 4.ESS3.A

6-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

6-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings.	**ESS3.B Natural Hazards** • Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Organizing data

a. Students organize data that represent the type of natural hazard event and features associated with that type of event, including the location, magnitude, frequency, and any associated precursor event or geologic forces.
b. Students organize data in a way that facilitates analysis and interpretation.
c. Students describe what each dataset represents.

2. Identifying relationships

a. Students analyze data to identify and describe patterns in the datasets, including:
   - The location of natural hazard events relative to geographic and/or geologic features.
   - Frequency of natural hazard events.
   - Severity of natural hazard events.
   - Types of damage caused by natural hazard events.
   - Location or timing of features and phenomena (e.g., aftershocks, flash floods) associated with natural hazard events.

b. Students describe similarities and differences among identified patterns.

3. Interpreting data

a. Students use the analyzed data to describe:
   - Areas that are susceptible to the natural hazard events, including areas designated as at the greatest and least risk for severe events.
   - How frequently areas, including areas experiencing the highest and lowest frequency of events, are at risk.
   - What type of damage each area is at risk of during a given natural hazard event.
   - What features, if any, occur before a given natural hazard event that can be used to predict the occurrence of the natural event and when and where they can be observed.

b. Using the patterns in the data, students make a forecast for the potential of a natural hazard event to affect an area in the future, including information on frequency and/or probability of event occurrence; how severe the event is likely to be; where the event is most likely to cause the most damage; and what events, if any, are likely to precede the event.

c. Students give at least three examples of the technologies that engineers have developed to mitigate the effects of natural hazards (e.g., the design of buildings and bridges to resist earthquakes, warning sirens for tsunamis, storm shelters for tornados, levees along rivers to prevent flooding.

Guided Questions

- How is data collected to predict the risk or impact on an area due to a natural hazard event?

Catholic Identity Connections

- Noah was given precise directions to build a boat to withstand the flood. This story from the Bible includes valuable data – the kind that is needed for engineering (Gen 6:14-16). [S]
- Humans can collect and utilize data to predict some natural hazards, but others cannot be predicted. This brings us back to the knowledge that we are not ultimately in control and, ultimately, we survive through the love, grace and power of God.
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. [CS S.K6 IS2]

Scripture [S]

- After the flood God makes a covenant with Noah, his sons, and all of creation:
  "God said to Noah and to his sons with him: 'See, I am now establishing my covenant with you and your descendants after you and with every living creature that was with you: the birds, the tame animals, and all the wild animals that were with you—all that came out of the ark. I will establish my covenant with you, that never again shall all creatures be destroyed by the waters of a flood; there shall not be another flood to devastate the earth.' God said: 'This is the sign of the covenant that I am making between me and you and every living creature with you for all ages to come: I set my bow in the clouds to serve as a sign of the covenant between me and the earth. When I bring clouds over the earth, and the bow appears in the clouds, I will remember my covenant between me and you and every living creature—every mortal being—so that the waters will never again become a flood to destroy every mortal being. When the bow appears in the clouds, I will see it and remember the everlasting covenant between God and every living creature—every mortal being that is on earth.' God told Noah: 'This is the sign of the covenant I have established between me and every mortal being that is on earth.'" (Genesis 9:8-17)

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **Mathematics** **MP.2** Reason abstractly and quantitatively. **6.EE.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. **7.EE.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Connections to Other DCIs in Sixth Grade
MS.PS3.C
Articulation to DCIs across Grade-Bands
3.ESS3.B; 4.ESS3.B

6-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

6-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific principles to design an object, tool, process, or system.	**ESS3.C Human Impacts on Earth Systems** • Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Relationships can be classified as causal or correlational, and correlation does not necessarily imply causations. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Using scientific knowledge to generate design solutions

a. Given a problem related to human impact on the environment, students use scientific information and principles to generate a design solution that:
   - Addresses the results of the particular human activity.
   - Incorporates technologies that can be used to monitor and minimize negative effects that human activities have on the environment.

b. Students identify relationships between the human activity and the negative environmental impact based on scientific principles, and distinguish between causal and correlational relationships to facilitate the design of the solution.

2. Describing criteria and constraints, including quantification when appropriate

a. Students define and quantify, when appropriate, criteria and constraints for the solution, including:
   - Individual or societal needs and desires.
   - Constraints imposed by economic conditions (e.g., costs of building and maintaining the solution).

3. Evaluating potential solutions

a. Students describe how well the solution meets the criteria and constraints, including monitoring or minimizing a human impact based on the causal relationships between relevant scientific principles about the processes that occur in, as well as among, Earth systems and the human impact on the environment.

b. Students identify limitations of the use of technologies employed by the solution.

Guided Questions
• How do humans impact the Earth's environment?
Catholic Identity Connections
• Care for God’s creation is the 7th theme of Catholic Social Teaching [CST]. It is also an important theme of the writings of the last three Popes, most recently Pope Francis’ ***Laudato Si’***. [MA] • “*Today, however, we have to realize that a true ecological approach always becomes a social approach; it must integrate questions of justice in debates on the environment, so as to hear both the cry of the earth and the cry of the poor*” (Pope Francis, ***Laudato Si’***, para. 49). • Pope Francis on water: “*Other indicators of the present situation have to do with the depletion of natural resources. We all know that it is not possible to sustain the present level of consumption in developed countries and wealthier sectors of society, where the habit of wasting and discarding has reached unprecedented levels. The exploitation of the planet has already exceeded acceptable limits and we still have not solved the problem of poverty*” (Pope Francis, ***Laudato Si’***, para. 27). “*Fresh drinking water is an issue of primary importance, since it is indispensable for human life and for supporting terrestrial and aquatic ecosystems. Sources of fresh water are necessary for health care, agriculture and industry. Water supplies used to be relatively constant, but now in many places demand exceeds the sustainable supply, with dramatic consequences in the short and long term. Large cities dependent on significant supplies of water have experienced periods of shortage, and at critical moments these have not always been administered with sufficient oversight and impartiality. Water poverty especially affects Africa where large sectors of the population have no access to safe drinking water or experience droughts which impede agricultural production. Some countries have areas rich in water while others endure drastic scarcity*” (Pope Francis, ***Laudato Si’***, para. 28). “*One particularly serious problem is the quality of water available to the poor. Every day, unsafe water results in many deaths and the spread of water-related diseases, including those caused by microorganisms and chemical substances. Dysentery and cholera, linked to inadequate hygiene and water supplies, are a significant cause of suffering and of infant mortality. Underground water sources in many places are threatened by the pollution produced in certain mining, farming and industrial activities, especially in countries lacking adequate regulation or controls. It is not only a question of industrial waste. Detergents and chemical products, commonly used in many places of the world, continue to pour into our rivers, lakes and seas*” (Pope Francis, ***Laudato Si’***, para. 29). • Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5] • Describe God’s relationship with humans and nature. [CS S.K6 IS6] • Share concern and care for the environment as a part of God’s creation. [CS S,K6 DS2] • Accept the premise that nature should not be manipulated simply at peoples’ will or only viewed as a thing to be used, but that people must cooperate with God’s plan for himself and for nature. [CS S.K6 DS3]Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4] • Describe how science and technology should always be at the service of humanity and, ultimately, to God, in harmony with His purposes. [CS S.K6 IS7]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **WHST.6-8.8** Gather relevant information from multiple print and digital sources, using research terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. **Mathematics** **6.RP.1** Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. **7.RP.2** Recognize and represent proportional relationships between quantities. **6.EE.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. **7.EE.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Connections to Other DCIs in Sixth Grade
MS.LS2.A; MS.LS2.C; MS.LS4.D
Articulation to DCIs across Grade-Bands
3.LS2.C; 3.LS4.D; 5.ESS3.C

6-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

6-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, minerals, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**ESS3.C Human Impacts on Earth Systems** • Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society makes.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Supported claims

a. Students make a claim, to be supported by evidence, to support or refute an explanation or model for a given phenomenon. Students identify the idea in their claim that increases in the size of the human population and per-capita consumption of natural resources affect Earth systems.

2. Identifying scientific evidence

a. Students identify evidence to support the claim from the given materials, including:
- Changes in the size of human population(s) in a given region or ecosystem over a given timespan.
- Per-capita consumption of resources by humans in a given region or ecosystem over a given timespan.
- Changes in Earth systems in a given region or ecosystem over a given timespan.
- The ways engineered solutions have altered the effects of human activities on Earth's systems.

3. Evaluating and critiquing evidence

a. Students evaluate the evidence for its necessity and sufficiency for supporting the claim.
b. Students determine whether the evidence is sufficient to determine causal relationships between consumption of natural resources and the impact on Earth systems.
c. Students consider alternative interpretations of the evidence and describe why the evidence supports the claim they are making, as opposed to any alternative claims.

4. Reasoning and synthesis

a. Students use reasoning to connect the evidence and support an explanation to the claim. In their arguments, students describe a chain of reasoning that includes:
    - Increases in the size of the human population or in the per-capita consumption of a given population cause increases in the consumption of natural resources.
    - Natural resource consumption causes changes in Earth systems.
    - Because human population growth affects natural resource consumption and natural resource consumption has an effect on Earth systems, changes in human populations have a causal role in changing Earth systems.
    - Engineered solutions alter the effects of human populations on Earth systems by changing the rate of natural resource consumption or mitigating the effects of changes in Earth systems.

Guided Questions

- What is the relationship between human population and the consumption of natural resources?

Catholic Identity Connections

- Care for God's creation is the 7th theme of Catholic Social Teaching [CST]. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Pope Francis on consumption: *"At the same time, Bartholomew has drawn attention to the ethical and spiritual roots of environmental problems, which require that we look for solutions not only in technology but in a change of humanity; otherwise we would be dealing merely with symptoms. He asks us to replace consumption with sacrifice, greed with generosity, wastefulness with a spirit of sharing, an asceticism which 'entails learning to give, and not simply to give up. It is a way of loving, of moving gradually away from what I want to what God's world needs. It is liberation from fear, greed and compulsion'. As Christians, we are also called 'to accept the world as a sacrament of communion, as a way of sharing with God and our neighbors on a global scale. It is our humble conviction that the divine and the human meet in the slightest detail in the seamless garment of God's creation, in the last speck of dust of our planet*'" (Pope Francis, ***Laudato Si'***, para. 9).
  "*But our industrial system, at the end of its cycle of production and consumption, has not developed the capacity to absorb and reuse waste and by-products. We have not yet managed to adopt a circular model of production capable of preserving resources for present and future generations, while limiting as much as possible the use of non-renewable resources, moderating their consumption, maximizing their efficient use, reusing and recycling them. A serious consideration of this issue would be one way of counteracting the throwaway culture which affects the entire planet, but it must be said that only limited progress has been made in this regard*" (Pope Francis, ***Laudato Si'***, para. 22). [M]
- Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5]
- Describe God's relationship with humans and nature. [CS S.K6 IS6]
- Share concern and care for the environment as a part of God's creation. [CS S,K6 DS2]
- Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that we must cooperate with God's plan for us and for nature. [CS S.K6 DS3]
- Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
WHST.6-8.1	Write arguments focused on discipline-specific content.
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research.
Mathematics	
6.RP.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
7.RP.2	Recognize and represent proportional relationships between quantities.
6.EE.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.
7.EE.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Connections to Other DCIs in Sixth Grade	
MS.LS2.A; MS.LS2.C; MS.LS4.D	
Articulation to DCIs across Grade-Bands	
3.LS2.C; 3.LS4.D; 5.ESS3.C	

6-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

6-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rate of human activities. Emphasis is on the major role that human activities play in causing the rise of global features.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions to identify and clarify evidence of an argument.	**ESS3.D Global Climate Change** • Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature. Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities.	**Stability and Change** • Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Examples of Observable Evidence of Student Performance by the End of Sixth Grade

1. Addressing phenomena of the natural world

a. Students examine a given claim and the given supporting evidence as a basis for formulating questions. Students ask questions that would identify and clarify the evidence, including:
   - The relevant ways in which natural processes and/or human activities may have affected the patterns of change in global temperatures over the past century.
   - The influence of natural processes and/or human activities on a gradual or sudden change in global temperatures in natural systems (e.g., glaciers and arctic ice, and plant and animal seasonal movements and life cycle activities).
   - The influence of natural processes and/or human activities on changes in the concentration of carbon dioxide and other greenhouse gases in the atmosphere over the past century.

2. Identifying the scientific nature of the question

a. Students' questions can be answered by examining evidence for:
   - Patterns in data that connect natural processes and human activities to changes in global temperatures over the past century.
   - Patterns in data that connect the changes in natural processes and/or human activities related to greenhouse gas production to changes in the concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

Guided Questions

- What factors contribute to global temperature change?

Diocese of Owensboro Science Standards
Grade 6

Catholic Identity Connections
• Care for God's creation is the 7th theme of Catholic Social Teaching [CST]. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA] • Pope Francis on climate change: "*Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day. Its worst impact will probably be felt by developing countries in coming decades. Many of the poor live in areas particularly affected by phenomena related to warming, and their means of subsistence are largely dependent on natural reserves and ecosystemic services such as agriculture, fishing and forestry. They have no other financial activities or resources which can enable them to adapt to climate change or to face natural disasters, and their access to social services and protection is very limited. For example, changes in climate, to which animals and plants cannot adapt, lead them to migrate; this in turn affects the livelihood of the poor, who are then forced to leave their homes, with great uncertainty for their future and that of their children. There has been a tragic rise in the number of migrants seeking to flee from the growing poverty caused by environmental degradation. They are not recognized by international conventions as refugees; they bear the loss of the lives they have left behind, without enjoying any legal protection whatsoever. Sadly, there is widespread indifference to such suffering, which is even now taking place throughout our world. Our lack of response to these tragedies involving our brothers and sisters points to the loss of that sense of responsibility for our fellow men and women upon which all civil society is founded*" (Pope Francis, ***Laudato Si'***, para. 25). • Explain the processes of conservation, preservation, overconsumption, and stewardship in relation to caring for that which God has given to sustain and delight us. [CS S.K6 IS5] • Describe God's relationship with humans and nature. [CS S.K6 IS6] • Share concern and care for the environment as a part of God's creation. [CS S,K6 DS2] • Accept the premise that nature should not be manipulated simply at peoples' will or only viewed as a thing to be used, but that we must cooperate with God's plan for us and for nature. [CS S.K6 DS3] • Accept that scientific knowledge is a call to serve and not simply a means to gain power, material prosperity, or success. [CS S.K6 DS4]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **WHST.6-8.7** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. **WHST.6-8.8** Gather relevant information from multiple print and digital sources, using research terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. **Mathematics** **MP.2** Reason abstractly and quantitatively. **6.EE.6** Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. **7.EE.4** Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.
Connections to Other DCIs in Sixth Grade
MS.PS3.A
Articulation to DCIs across Grade-Bands
N/A

Seventh Grade Standards

7-LS1 From Molecules to Organisms: Structures and Processes

7-LS1-1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
7-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
7-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
7-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.
7-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
7-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
7-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
7-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Scripture [S]

- The Old Testament contains medical information that was very advanced for its time and predates medical discoveries as recent as 100 years ago. Examples of the medical knowledge of the Israelites include:
    - Sanitary practices in the Bible: Numbers 19:3-22, Leviticus11:1-47; 15:1-33, Deuteronomy 23:12.
    - Bacteria: Leviticus 13:52
    - Laws of quarantine: Leviticus 13, 14, 22, Numbers 19:20
    - The first antiseptic – hyssop: Numbers 19:18, Ps 51:7
    - Fetal alcohol syndrome: Judges 13:3-4
    - Dietary guidelines: Genesis 1:29, Genesis 9:3, Leviticus 11

Catholic/Christian Scientists

- Louis Pasteur (bacteriology)
- Gregor Mendel (genetics through plant research)
- Bartolomeo Eustachi (one of the founders of human anatomy)
- Sr. Paula González (biology)
- Andreas Vesalius (modern human anatomy)
- Theodor Schwann (theory of the cellular structure of animal organisms)
- Jérôme Lejeune (the link of diseases to chromosome abnormalities)

Saints [SA]

- The Virgin Mary, said “yes” to Life
- St. Alexandra, patron saint of humanity
- St. Margaret of Castello, patron saint of pro-life groups
- St. Maximilian Kolbe, patron saint of the pro-life movement

- Our Lady of Lourdes, patron saint of bodily ills
- Our Lady of the Thorns, patron saint of blood donors
- St. Agnes of Rome, patron saint of bodily purity
- St. Agrippina, patron saint of bacterial disease and infection
- St. Godebertha, patron saint against infectious diseases

7-LS2 Ecosystems: Interactions, Energy, and Dynamics

7-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
7-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
7-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
7-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
7-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Catholic Identity

- Pope Francis on loss of biodiversity: *"It is not enough, however, to think of different species merely as potential "resources" to be exploited, while overlooking the fact that they have value in themselves. Each year sees the disappearance of thousands of plant and animal species which we will never know, which our children will never see, because they have been lost forever. The great majority become extinct for reasons related to human activity. Because of us, thousands of species will no longer give glory to God by their very existence, nor convey their message to us. We have no such right*" (Pope Francis, ***Laudato Si'***, para. 33).

  "Greater investment needs to be made in research aimed at understanding more fully the functioning of ecosystems and adequately analyzing the different variables associated with any significant modification of the environment. Because all creatures are connected, each must be cherished with love and respect, for all of us as living creatures are dependent on one another. Each area is responsible for the care of this family. This will require undertaking a careful inventory of the species which it hosts, with a view to developing programs and strategies of protection with particular care for safeguarding species heading towards extinction" (Pope Francis, ***Laudato Si'***, para. 42).

Catholic/Christian Scientists

- Ecology
  - Rachel Carson (marine biologist)
  - Sr. Paula Gonzales (biology, solar energy)
  - Fr. Thomas Berry (religion, ecology, cultural history)

7-LS3 Heredity: Inheritance and Variation of Traits

7-LS3-1 Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.
7-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variations.

Catholic/Christian Scientists

- Life Science
    - Gregor Mendel (genetics through plant research)
    - Bartolomeo Eustachi (one of the founders of human anatomy)
    - Sr. Paula González (biology)
    - Antoine Laurent de Jussieu (natural classification of flowering plants)
    - Jean-Baptiste Lamarck (his theories on evolution preceded those of Darwin)
    - Andreas Vesalius (modern human anatomy)
    - Theodor Schwann (theory of the cellular structure of animal organisms)
    - Jérôme Lejeune (the link of diseases to chromosome abnormalities)
- Botany
    - Carl Linnaeus
    - Stephan Endlicher
    - James Britton
    - Andrea Cesalpino
    - James Britten

Saints [SA]

- The Virgin Mary, said "yes" to Life
- St. Alexandra, patron saint of humanity
- St. Margaret of Castello, patron saint of pro-life groups
- St. Maximilian Kolbe, patron saint of the pro-life movement

7-LS4 Biological Evolution: Unity and Diversity

7-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
7-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
7-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships

not evident in the fully formed anatomy.

7-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

7-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

7-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Catholic Identity

- Pope Francis on evolution: *"Human beings, even if we postulate a process of evolution, also possess a uniqueness which cannot be fully explained by the evolution of other open systems. Each of us has his or her own personal identity and is capable of entering into dialogue with others and with God himself. Our capacity to reason, to develop arguments, to be inventive, to interpret reality and to create art, along with other not yet discovered capacities, are signs of a uniqueness which transcends the spheres of physics and biology. The sheer novelty involved in the emergence of a personal being within a material universe presupposes a direct action of God and a particular call to life and to relationship on the part of a "Thou" who addresses himself to another "thou". The biblical accounts of creation invite us to see each human being as a subject who can never be reduced to the status of an object*" (Pope Francis, ***Laudato Si'***, para. 81).

  "The continued acceleration of changes affecting humanity and the planet is coupled today with a more intensified pace of life and work which might be called 'rapidification'. Although change is part of the working of complex systems, the speed with which human activity has developed contrasts with the naturally slow pace of biological evolution. Moreover, the goals of this rapid and constant change are not necessarily geared to the common good or to integral and sustainable human development" (Pope Francis, ***Laudato Si'***, para. 18).
- Plants in the Bible:
  - http://ww2.odu.edu/~lmusselm/plant/bible/allbibleplantslist.php
  - http://www.newadvent.org/cathen/12149a.htm
  - Below is a list of the flowers dedicated to the Blessed Mother. (https://www.catholicculture.org/culture/library/view.cfm?recnum=5855)
    - White Lily "Annunciation Lily", symbol of Mary's Immaculate Purity.
    - Impatiens "Our Lady's Earrings", symbolical pure adornments of the ears of Mary who heard the word of God and kept it.
    - Violet symbol of Mary's humility "regarded by the Lord".
    - Lady-Slipper "Our Lady's Slipper", symbol of Mary's graceful Visitation trip to visit Elizabeth in the hill country: "All her steps were most beauteous."
    - Thistle-Down another Visitation symbol, from its graceful movement in air currents.
    - Rose symbol of the Blessed Virgin of prophecy, the Rose plant bearing the flower, Christ.
    - Daisy "Mary's Flower of God".
    - Periwinkle "Virgin Flower", emblem of the Blessed Virgin.
    - Columbine symbol of the dove of the Holy Spirit, Mary's overshadowing, indwelling, divine Spouse.
    - Pansy "Trinity Flower", symbol of the Trinity, first revealed to Mary.
    - Strawberry "Fruitful Virgin", in flower and fruit at the same time.

Catholic/Christian Scientists

- Ecology
    - Rachel Carson (marine biologist)
    - Sr. Paula Gonzales (biology, solar energy)
    - Fr. Thomas Berry (Passionist priest – religion, ecology, cultural history)

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

7-LS1	**From Molecules to Organisms: Structures and Processes**	
Students who demonstrate understanding can: **7-LS1-1 Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells.**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation.	**LS1.A Structure and Function** • All living things are made up of cells, which is the smallest unit that can carry on all processes of life. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).	**Scale, Proportion, and Quantity** • Phenomena that can be observed at one scale may not be observable at another scale. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade
1. Identifying the phenomenon under investigation
a. From the given investigation plan, students identify and describe the phenomenon under investigation, which includes the idea that living things are made up of cells and organized into similar groups (i.e., kingdoms). b. Students identify and describe the purpose of the investigation, which includes providing evidence for the ideas that all living things are made of cells (either one cell or many different numbers and types of cells) and that the cell is the smallest unit that can carry on all processes of life.
2. Identifying the evidence to address the purpose of the investigation
a. From the given investigation plan, students describe the data that will be collected and the evidence to be derived from the data, including: • The presence or absence of cells in living and nonliving things. • The presence or absence of any part of a living thing that is not made up of cells. • The presence or absence of cells in a variety of organisms, including unicellular and multicellular organisms. • Different types of cells within one multicellular organism. b. Students describe how the evidence collected will be relevant to the purpose of the investigation.
3. Planning the investigation
a. From the given investigation plan, students describe how the tools and methods included in the experimental design will provide the evidence necessary to address the purpose of the investigation, including that due to their small-scale size, cells are unable to be seen with the unaided eye and require engineered magnification devices to be seen.
b. Students describe how the tools used in the investigation are an example of how science depends on engineering advances.

4. Collecting the data

a. According to the given investigation plan, students collect and record data on the cellular composition of living organisms.
b. Students identify the tools used for observation of different magnifications and describe that different tools are required to observe phenomena related to cells at different scales.
c. Students evaluate the data they collected to determine whether the resulting evidence meets the goals of the investigation, including cellular composition as a distinguishing feature of living things.

Guided Questions

- What is the basic structure of living things?

Catholic Identity Connections

- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

Connections to Other DCIs in Seventh Grade

N/A

Articulation to DCIs across Grade-Bands

N/A

7-LS1 From Molecules to Organisms: Structures and Processes		
Students who demonstrate understanding can: **7-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.** **a. Explain and illustrate the steps involved in mitosis.** **b. Explain and illustrate the steps involved in meiosis.** Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**LS1.A Structure and Function** • Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	**Structure and Function** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Components of the model

a. To make sense of a phenomenon, students develop a model in which they identify the parts (i.e., components; e.g., nucleus, chloroplasts, cell wall, mitochondria, cell membrane, the function of a cell as a whole) of cells relevant for the given phenomenon.

2. Relationships

a. In the model, students describe the relationships between components, including:
   - The particular functions of parts of cells in terms of their contributions to overall cellular functions (e.g., chloroplasts' involvement in photosynthesis and energy production, mitochondria's involvement in cellular respiration).
   - The structure of the cell membrane or cell wall and its relationship to the function of the organelles and the whole cell.

3. Connections

a. Students use the model to describe a causal account for the phenomenon, including how different parts of a cell contribute to how the cell functions as a whole, both separately and together with other structures. Students include how components, separately and together, contribute to:
   - Maintaining a cell's internal processes, for which it needs energy.
   - Maintaining the structure of the cell and controlling what enters and leaves the cell.
   - Functioning together as parts of a system that determines cellular function.

b. Students use the model to identify key differences between plant and animal cells based on structure and function, including:
   - Plant cells have a cell wall in addition to a cell membrane, whereas animal cells have only a cell membrane. Plants use cell walls to provide structure to the plant.
   - Plant cells contain organelles called chloroplasts, while animal cells do not. Chloroplasts allow plants to make the food they need to live using photosynthesis.

Guided Questions

- How do the individual components of a cell function and interact?

Catholic Identity Connections

- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Mathematics

6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

Connections to Other DCIs in Seventh Grade

MS.LS3.A

Articulation to DCIs across Grade-Bands

4.LS1.A

7-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

7-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon.	**LS1.A Structure and Function** • In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.	**Systems and System Models** • Systems may interact with other systems; they may have subsystems and be a part of larger complex systems.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. **Supported claims**
   a. Students make a claim to be supported, related to a given explanation or model of a phenomenon. In the claim, students include the idea that the body is a system of interacting subsystems composed of groups of cells.
2. **Identifying scientific evidence**
   a. Students identify and describe the given evidence that supports the claim (e.g., evidence from data and scientific literature), including evidence that:
      - Specialized groups of cells work together to form tissues (e.g., evidence from data about the kinds of cells found in different tissues, such as nervous, muscular, and epithelial, and their functions).
      - Specialized tissues comprise each organ, enabling the specific organ functions to be carried out (e.g., the heart contains muscle, connective, and epithelial tissues that allow the heart to receive and pump blood).
      - Different organs can work together as subsystems to form organ systems that carry out complex functions (e.g., the heart and blood vessels work together as the circulatory system to transport blood and materials throughout the body).
      - The body contains organs and organ systems that interact with each other to carry out all necessary functions for survival and growth of the organism (e.g., the digestive, respiratory, and circulatory systems are involved in the breakdown and transport of food and the transport of oxygen throughout the body to cells, where the molecules can be used for energy, growth, and repair).
3. **Evaluating and critiquing the evidence**
   a. Students evaluate the evidence and identify the strengths and weaknesses of the evidence, including:
      - Types of sources.
      - Sufficiency, including validity and reliability, of the evidence to make and defend the claim.
      - Any alternative interpretations of the evidence and why the evidence supports the student's claim, as opposed to any other claims.

4. Reasoning and synthesis

a. Students use reasoning to connect the appropriate evidence to the claim. Students describe the following chain of reasoning in their argumentation:
  - Every scale (e.g., cells, tissues, organs, organ systems) of body function is composed of systems of interacting components.
  - Organs are composed of interacting tissues. Each tissue is made up of specialized cells. These interactions at the cellular and tissue levels enable the organs to carry out specific functions.
  - A body is a system of specialized organs that interact with each other and their subsystems to carry out the functions necessary for life.

b. Students use oral or written arguments to support or refute an explanation or model of a phenomenon.

Guided Questions

- What is the interaction of cells or groups of cells within a system or sub-system?
- How are cells organized into tissues, organs, and organ systems to form the organism?

Catholic Identity Connections

- Theme 1 of Catholic Social Teaching – Life and Dignity of the Human Person
- Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
- Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Saints [SA]

- The Virgin Mary, said "yes" to Life
- St. Alexandra, patron saint of humanity
- St. Margaret of Castello, patron saint of pro-life groups
- St. Maximilian Kolbe, patron saint of the pro-life movement
- St. Agnes of Rome, patron saint of bodily purity

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RI.6.8 Delineate and evaluate the argument and specify claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

WHST.6-8.1 Write arguments focused on discipline-specific content.

Mathematics

6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

Connections to Other DCIs in Seventh Grade

N/A

Articulation to DCIs across Grade-Bands

N/A

7-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

7-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**LS1.B Growth and Development of Organisms** • Animals engage in characteristic behaviors that increase the odds of reproduction. • Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described by using probability.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Supported claims

a. Students make a claim to support a given explanation of a phenomenon. In their claim, students include the idea that characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.

2. Identifying scientific evidence

a. Students identify the given evidence that supports the claim (e.g., evidence from data and scientific literature), including:
- Characteristic animal behaviors that increase the probability of reproduction.
- Specialized plant and animal structures that increase the probability of reproduction.
- Cause and effect relationships between the:
  - Specialized plant structures and probability of successful reproduction of plants that have those structures.
  - Animal behaviors and the probability of successful reproduction of animals that exhibit those behaviors.
  - Plant reproduction and the animal behaviors related to plant reproduction.

3. Evaluating and critiquing the evidence

a. Students evaluate the evidence and identify the strengths and weaknesses of the evidence used to support the claim, including:
- Validity and reliability of sources.
- Sufficiency - including relevance, validity, and reliability - of the evidence to make and defend the claim.
- Alternative interpretations of the evidence and why the evidence supports the student's claim, as opposed to any other claims.

4. Reasoning and synthesis

a. Students use reasoning to connect the appropriate evidence to the claim, using oral or written arguments. Students describe the following chain of reasoning in their argumentation:
   - Many characteristic animal behaviors affect the likelihood of successful reproduction.
   - Many specialized plant structures affect the likelihood of successful reproduction.
   - Sometimes, animal behavior plays a role in the likelihood of successful reproduction in plants.
   - Because successful reproduction has several causes and contributing factors, the cause and effect relationships between any of these characteristics, separately or together, and reproductive likelihood can be accurately reflected only in terms of probability.

Guided Questions

- How does the structure of plants contribute to reproduction?
- How do animal behaviors contribute to reproduction?

Catholic Identity Connections

- This standard can be approached in various ways, due to its emphasis on the scientific method as well as on the science content itself. The study of reproduction can easily be connected with the first theme of Catholic Social Teaching [CST] – Life and Dignity of the Human Person, as follows:
  - Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
  - Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
  - Demonstrate an understanding of the moral issues involving in vitro fertilization, human cloning, human genetic manipulation, and human experimentation and what the Church teaches regarding work in these areas. [CS S.712 IS17]
- Life Science
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out this role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
  - Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
  - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
  - Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
- The Scientific Method
  - Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
  - Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RI.6.8	Delineate and evaluate the argument and specify claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.
WHST.6-8.1	Write arguments focused on discipline-specific content.
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
Mathematics	
6.SP.2	Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.
6.SP.4	Display numerical data in plots on a number line, including dot plots, histograms, and box plots (e.g., box-and-whisker plot).
Connections to Other DCIs in Seventh Grade	
MS.LS2.A	
Articulation to DCIs across Grade-Bands	
3.LS1.B	

7-LS1 From Molecules to Organisms: Structures and Processes		
Students who demonstrate understanding can: **7-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.** Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.B Growth and Development of Organisms** • Genetic factors as well as local conditions affect the growth of the adult plant.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described by using probability.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade
1. Articulating the explanation of phenomena
a. Students articulate a statement that relates the given phenomenon to a scientific idea, including the idea that both environmental and genetic factors influence the growth of organisms. b. Students use evidence and reasoning to construct a scientific explanation for the given phenomenon.
2. Evidence
a. Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including: • Environmental factors (e.g., availability of light, space, water, size of habitat) and that they can influence growth. • Genetic factors (e.g., specific breeds of plants and animals and their typical sizes) and that they can influence growth. • Changes in growth of organisms as specific environmental and genetic factors change. b. Students use multiple valid and reliable sources of evidence to construct the explanation.

3. Reasoning

a. Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for a phenomenon involving genetic and environmental influences on organism growth. Students describe their chain of reasoning that includes:
   - Organism growth is influenced by multiple environmental (e.g., drought, changes in food availability) and genetic (e.g., specific breed) factors.
   - Because both environmental and genetic factors can influence organisms simultaneously, organism growth is the result of environmental and genetic factors working together (e.g., water availability influences how tall dwarf fruit trees will grow).
   - Because organism growth can have several genetic and environmental causes, the contributions of specific causes or factors to organism growth can be described only using probability (e.g., not every fish in a large pond grows to the same size).

Guided Questions

- How do environmental and genetic factors influence the growth of organisms?

Catholic Identity Connections

- This standard might be extended to understanding evolution, drawing upon the following:
  - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out this role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
- Connections may also be made with the sixth theme of Catholic Social Teaching -- Option for the Poor and Vulnerable: A basic moral test is how our most vulnerable members are faring. This is directly related to drought, changes in food availability, etc. The poor suffer most from environmental degradation. [CST]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.2 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not.

WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

Mathematics

6.SP.2 Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

6.SP.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots (e.g., box-and-whisker plot).

Connections to Other DCIs in Seventh Grade

MS.LS2.A

Articulation to DCIs across Grade-Bands

3.LS1.B; 3.LS3.A

<table>
<tr><th colspan="3">7-LS1 From Molecules to Organisms: Structures and Processes</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
7-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
• Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Connections to Nature of Science

Scientific Knowledge Is Based on Empirical Evidence
• Science knowledge is based upon logical connections between evidence and explanations.</td><td>LS1.C Organization for Matter and Energy Flow in Organization
• Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

PS3.D Energy in Chemical Processes and Everyday Life
• The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (secondary emphasis)</td><td>Energy and Matter
• Within a natural system, the transfer of energy drives the motion and/or cycling of matter.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Seventh Grade</th></tr>
<tr><td colspan="3">1. Articulating the explanation of phenomena
a. Students articulate a statement that relates the given phenomenon to a scientific idea, including the idea that photosynthesis results in the cycling of matter and energy into and out of organisms.
b. Students use evidence and reasoning to construct a scientific explanation for the given phenomenon.</td></tr>
</table>

2. Evidence

a. Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including that:
   - Plants, algae, and photosynthetic microorganisms require energy (in the form of sunlight) and must take in carbon dioxide and water to survive.
   - Energy from sunlight is used to combine simple nonfood molecules (e.g., carbon dioxide and water) into food molecules (e.g., sugar) and oxygen, which can be used immediately or stored by the plant.
   - Animals take in food and oxygen to provide energy and materials for growth and survival.
   - Some animals eat plants, algae, and photosynthetic microorganisms, and some animals eat other animals, which have themselves eaten photosynthetic organisms.

b. Students use multiple valid and reliable sources of evidence.

3. Reasoning

a. Students use reasoning, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to connect the evidence and support an explanation for energy and matter cycling during photosynthesis. Students describe a chain of reasoning for their explanation that includes:
   - Plants, algae, and photosynthetic microorganisms take in matter (in the form of carbon dioxide and water) and use the energy from the sun to produce carbon-based organic molecules (food), which they can use immediately or store, and release oxygen into the environment through photosynthesis.
   - Plants use the food they have made for energy, growth, and other necessary functions (e.g., repair, seed production).
   - Animals depend on matter from plants for growth and survival, including:
     - Eating photosynthetic organisms (or other organisms that have eaten photosynthetic organisms), thus acquiring the matter they contain, the production of which was driven by photosynthesis.
   - Because animals acquire their food from photosynthetic organisms (or from other animals that have eaten those organisms) and their oxygen from the products of photosynthesis, all food and most of the oxygen animals use for life processes are the results of energy from the sun driving matter flows through the process of photosynthesis.
   - The process of photosynthesis has an important role in energy and matter cycling within plants (i.e., the conversion of carbon dioxide and water into complex carbon- based molecules (sugars) and oxygen, the contribution of sugars to plant growth and internal processes) as well as from plants to other organisms.

Guided Questions

- What is the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms?

Catholic Identity Connections

- This standard also connects to care for God’s creation: [ST]
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
  - Describe humanity’s natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. **RST.6-8.2** Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. **WHST.6-8.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes. **WHST.6-8.8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. **Mathematics** **6.EE.9** Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.
Connections to Other DCIs in Seventh Grade
MS.PS1.B; MS.ESS2.A
Articulation to DCIs across Grade-Bands
5.PS3.D; 5.LS1.C; 5.LS2.A

7-LS1	**From Molecules to Organisms: Structures and Processes**
Students who demonstrate understanding can:	
7-LS1-7	**Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.**

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	**LS1.C Organization for Matter and Energy Flow in Organisms** • Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. **PS3.D Energy in Chemical Processes and Everyday Life** • Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. *(secondary emphasis)*	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Components of the model

a. To make sense of a phenomenon, students develop a model in which they identify the relevant components for describing how food molecules are rearranged as matter moves through an organism, including:
   - Molecules of food, which are complex carbon-containing molecules.
   - Oxygen.
   - Energy that is released or absorbed during chemical reactions between food and oxygen.
   - New types of molecules produced through chemical reactions involving food.

2. Relationships

a. In the model, students identify and describe the relationships between components, including:
   - During cellular respiration, molecules of food undergo chemical reactions with oxygen, releasing stored energy.
   - The atoms in food are rearranged through chemical reactions to form new molecules.

3. Connections

a. Students use the model to describe:
   - The number of each type of atom being the same before and after chemical reactions, indicating that the matter ingested as food is conserved as it moves through an organism to support growth.
   - That all matter (atoms) used by the organism for growth comes from the products of the chemical reactions involving the matter taken in by the organism.
   - Food molecules taken in by the organism are broken down and can then be rearranged to become the molecules that comprise the organism (e.g., the proteins and other molecules in a hamburger can be broken down and used to make a variety of tissues in humans).
   - As food molecules are rearranged, energy is released and can be used to support other processes within the organism.

Guided Questions

- How do cells release energy from food?
- How do cells transport materials?

Catholic Identity Connections

- This standard can be related to the first theme of Catholic Social Teaching – Life and Dignity of the Human Person, when we consider the quality of food that we ingest:
  - Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
  - Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
- It also relates to the church's teachings on creation. It can be related to care of plants, animals and ecosystems.
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
  - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]

Saints [SA]

- The Virgin Mary, said "yes" to Life
- St. Alexandra, patron saint of humanity
- St. Margaret of Castello, patron saint of pro-life groups
- St. Maximilian Kolbe, patron saint of the pro-life movement
- St. Agnes of Rome, patron saint of bodily purity

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Connections to Other DCIs in Seventh Grade

MS.PS1.B

Articulation to DCIs across Grade-Bands

5.PS3.D; 5.LS1.C; 5.LS2.B

7-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

7-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**LS1.D Information Processing** • Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural systems.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Obtaining information

a. Students gather and synthesize information from at least two sources (e.g., text, media, visual displays, data) about a phenomenon that includes the relationship between sensory receptors and the storage of sensory information by organisms. Students gather information about:
   - Different types of sensory receptors and the types of inputs to which they respond (e.g., electromagnetic, mechanical, chemical stimuli).
   - Sensory information transmission along nerve cells from receptors to the brain.
   - Sensory information processing by the brain as:
     - Memories (i.e., stored information).
     - Immediate behavioral responses (i.e., immediate use).

b. Students gather sufficient information to provide evidence that illustrates the causal relationships between information received by sensory receptors and behavior, both immediate and over longer time scales (e.g., a loud noise processed via auditory receptors may cause an animal to startle immediately or may be encoded as a memory, which can later be used to help the animal react appropriately in similar situations).

2. Evaluating information

a. Students evaluate the information based on:
   - The credibility, accuracy, and possible bias of each publication and the methods used to generate and collect the evidence.
   - The ability of the information to provide evidence that supports or does not support the idea that sensory receptors send signals to the brain, resulting in immediate behavioral changes or stored memories.
   - Whether the information is sufficient to allow prediction of the response of an organism to different stimuli based on cause and effect relationships between the responses of sensory receptors and behavioral responses.

Guided Questions

- What factors affect animal behavior?

Catholic Identity Connections

- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Evaluate the relationship between God, man, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6)
- Describe humanity's natural situation in, and dependence upon, physical reality and how man carries out his role as a cooperator with God in the work of creation. [CS S.712 IS7)
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1)
- Memory is an important part of our liturgical lives.
- The Eucharistic Prayers of the Catholic Church contain an anamnesis (from the Greek word meaning "recollection") which follows the consecration. The USCCB writes, "The anamnesis, by which the Church, fulfilling the command that she received from Christ the Lord through the Apostles, celebrates the memorial of Christ, recalling especially His blessed Passion, glorious Resurrection, and Ascension into heaven." This is the high point of the Mass, as we remember "the mystery of faith" and enter into liturgical time in which this mystery occurs in the present. [SC]

  Priest: The mystery of faith:
  People: A - We proclaim your Death, O Lord, and profess your Resurrection until you come again.
  or B - When we eat this Bread and drink this Cup, we proclaim your death, O Lord, until you come again.
  or C - Save us, Savior of the world, for by your Cross and Resurrection you have set us free.

Scripture [S]

- "Then he took the bread, said the blessing, broke it, and gave it to them, saying, "This is my body, which will be given for you; do this in memory of me." (Luke 22:19)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Connections to Other DCIs in Seventh Grade

N/A

Articulation to DCIs across Grade-Bands

4.LS1.D

7-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

7-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing and interpreting data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena.	**LS2.A Interdependent Relationships in Ecosystems** • Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. • In an ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. • Growth of organisms and population increases are limited by access to resources.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Organizing data

a. Students organize the given data (e.g., using tables, graphs, and charts) to allow for analysis and interpretation of relationships between resource availability and organisms in an ecosystem, including:
   - Populations (e.g., sizes, reproduction rates, growth information) of organisms as a function of resource availability.
   - Growth of individual organisms as a function of resource availability.

2. Identifying relationships

a. Students analyze the organized data to determine the relationships between the size of a population, the growth and survival of individual organisms, and resource availability.

b. Students determine whether the relationships provide evidence of a causal link between these factors.

3. Interpreting data

a. Students analyze and interpret the organized data to make predictions based on evidence of causal relationships between resource availability, organisms, and organism populations. Students make relevant predictions, including:
   - Changes in the amount and availability of a given resource (e.g., less food) may result in changes in the population of an organism (e.g., less food results in fewer organisms).
   - Changes in the amount or availability of a resource (e.g., more food) may result in changes in the growth of individual organisms (e.g., more food results in faster growth).
   - Resource availability drives competition among organisms, both within a population as well as between populations.
   - Resource availability may have effects on a population's rate of reproduction.

Guided Questions

- What are the effects of resource availability on organisms in an ecosystem?

Catholic Identity Connections

- This standard relates to Catholic Social Teaching. [CST]
  - Theme 4 – Option for the Poor and Vulnerable - A basic moral test is how our most vulnerable members are faring.
  - Theme 6 – Solidarity - We are one human family whatever our national, racial, ethnic, economic, and ideological differences. We are our brothers and sisters keepers, wherever they may be. Loving our neighbor has global dimensions in a shrinking world.
  - Theme 7 – Care of God’s Creation - We show our respect for the Creator by our stewardship of creation. Care for the earth is not just an Earth Day slogan, it is a requirement of our faith. We are called to protect people and the planet, living our faith in relationship with all of God’s creation. This environmental challenge has fundamental moral and ethical dimensions that cannot be ignored.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Connections to Other DCIs in Seventh Grade

MS.ESS3.A; MS.ESS3.C

Articulation to DCIs across Grade-Bands

3.LS2.C; 3.LS4.D; 5.LS2.A

7-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

7-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	**LS2.A Interdependent Relationships in Ecosystems** • Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	**Patterns** • Patterns can be used to identify cause and effect relationships.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to a scientific idea, including that similar patterns of interactions occur between organisms and their environment, regardless of the ecosystem or the species involved.
b. Students use evidence and reasoning to construct an explanation for the given phenomenon.

2. Evidence

a. Students identify and describe the evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including evidence that:
    - Competitive relationships occur when organisms within an ecosystem compete for shared resources (e.g., data about the change in population of a given species when a competing species is introduced).
    - Predatory interactions occur between organisms within an ecosystem.
    - Mutually beneficial interactions occur between organisms within an ecosystem. Organisms involved in these mutually beneficial interactions can become so dependent upon one another that they cannot survive alone.
    - Resource availability, or lack thereof, can affect interactions between organisms (e.g., organisms in a resource-limited environment may have a competitive relationship, while those same organisms may not be in competition in a resource-rich environment).
    - Competitive, predatory, and mutually beneficial interactions occur across multiple different ecosystems.

b. Students use multiple valid and reliable sources for the evidence.

3. Reasoning

a. Students identify and describe quantitative patterns of interactions among organisms that can be used to identify causal relationships within ecosystems, related to the given phenomenon.
   - Changes in the amount and availability of a given resource (e.g., less food) may result in changes in the population of an organism (e.g., less food results in fewer organisms).
   - Changes in the amount or availability of a resource (e.g., more food) may result in changes in the growth of individual organisms (e.g., more food results in faster growth).
   - Resource availability drives competition among organisms, both within a population as well as between populations.
   - Resource availability may have effects on a population's rate of reproduction.

b. Students describe that regardless of the ecosystem or species involved, the patterns of interactions (competitive, mutually beneficial, predator/prey) are similar.

c. Students use reasoning to connect the evidence and support an explanation. In their reasoning, students use patterns in the evidence to predict common interactions among organisms in ecosystems as they relate to the phenomenon (e.g., given specific organisms in a given environment with specified resource availability, which organisms in the system will exhibit competitive interactions). Students predict the following types of interactions:
   - Predatory interactions.
   - Competitive interactions.
   - Mutually beneficial interactions.

Guided Questions

- What patterns can be predicted about the interactions among organisms across multiple ecosystems?

Catholic Identity Connections

- Mutually beneficial relationships among organisms across multiple ecosystems provide a model of how we might, as Christians, relate to one another. This can deepen our understanding of Christian community and the Body of Christ.
- Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
- We might also call to mind the following themes of Catholic Social Teaching:
  - Theme 2: Call to Family, Community and Participation
  - Theme 4: Option for the Poor and the Vulnerable
  - Theme 5: Solidarity

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics

6.SP.5 Summarize numerical data sets in relation to their context.

Connections to Other DCIs in Seventh Grade

MS.LS1.B

Articulation to DCIs across Grade-Bands

1.LS1.B

7-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

7-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe phenomena.	**LS2.B Cycle of Matter and Energy Transfer in Ecosystems** • Food webs are models that demonstrate how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a natural system. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Components of the model

a. To make sense of a phenomenon, students develop a model in which they identify the relevant components, including:
   - Organisms that can be classified as producers, consumers, and/or decomposers.
   - Nonliving parts of an ecosystem (e.g., water, minerals, air) that can provide matter to living organisms or receive matter from living organisms.
   - Energy.

b. Students define the boundaries of the ecosystem under consideration in their model (e.g., pond, part of a forest, meadow; a whole forest, which contains a meadow, pond, and stream).

2. Relationships

a. In the model, students describe relationships between components within the ecosystem, including:
   - Energy transfer into and out of the system.
   - Energy transfer and matter cycling (cycling of atoms).
     - Among producers, consumers, and decomposers (e.g., decomposers break down consumers and producers via chemical reactions and use the energy released from rearranging those molecules for growth and development).
     - Between organisms and the nonliving parts of the system (e.g., producers use matter from the nonliving parts of the ecosystem and energy from the sun to produce food from nonfood materials).

3. Connections

a. Students use the model to describe the cycling of matter and flow of energy among living and nonliving parts of the defined system, including:
   - When organisms consume other organisms, there is a transfer of energy and a cycling of atoms that were originally captured from nonliving parts of the ecosystem by producers.
   - The transfer of matter (atoms) and energy between living and nonliving parts of the ecosystem at every level within the system, which allows matter to cycle and energy to flow within and outside of the system.

b. Students use the model to track energy transfer and matter cycling in the system based on consistent and measurable patterns, including:
   - That the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem.
   - That matter and energy are conserved through transfers within and outside of the ecosystem.

Guided Questions

- How do matter and energy flow among living and nonliving parts of an ecosystem?
- How do cells transport materials?

Catholic Identity Connections

- This standard speaks to the interdependent relationships in creation as well as the exchange between the living and the dead. All of creation works together as a sacred whole. This provides insight into the Body of Christ. Connections might be made to the communion of saints.
- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out his role as a cooperator with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Share concern and care for the environment as part of God's creation. [CS S.712 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Mathematics

6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.

Connections to Other DCIs in Seventh Grade

MS.PS1.B; MS.ESS2.A

Articulation to DCIs across Grade-Bands

5.LS2.A; 5.LS2.B

<table>
<tr><th colspan="3">7-LS2 Ecosystems: Interactions, Energy, and Dynamics</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
7-LS2-4 Construct an argument supported by empirical evidence that show how changes to physical or biological components of an ecosystem affect populations.
Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes in ecosystems.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Engaging in Argument from Evidence
Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.
• Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomena or a solution to a problem.

Connections to Nature of Science

Scientific Knowledge Is Based on Empirical Evidence
• Science disciplines share common rules of obtaining and evaluating empirical evidence.</td><td>LS2.C Ecosystem Dynamics, Functioning, and Resilience
• Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.</td><td>Stability and Change
• Small changes in one part of a system might cause large changes in another part.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Seventh Grade</th></tr>
<tr><td colspan="3">1. Supported claims</td></tr>
<tr><td colspan="3">a. Students make a claim to be supported about a given explanation or model for a phenomenon. In their claim, students include the idea that changes to physical or biological components of an ecosystem can affect the populations living there.</td></tr>
<tr><td colspan="3">2. Identifying scientific evidence</td></tr>
<tr><td colspan="3">a. Students identify and describe the given evidence (e.g., evidence from data, scientific literature) needed for supporting the claim, including evidence about:
• Changes in the physical or biological components of an ecosystem, including the magnitude of the changes (e.g., data about rainfall, fires, predator removal, species introduction).
• Changes in the populations of an ecosystem, including the magnitude of the changes (e.g., changes in population size, types of species present and relative prevalence of a species within the ecosystem).
• Evidence of causal and correlational relationships between changes in the components of an ecosystem with the changes in populations.</td></tr>
<tr><td colspan="3">b. Students use multiple valid and reliable sources of evidence.</td></tr>
</table>

3. Evaluating and critiquing the evidence

a. Students evaluate the given evidence, identifying the necessary and sufficient evidence for supporting the claim.
b. Students identify alternative interpretations of the evidence and describe why the evidence supports the student's claim.

4. Reasoning and synthesis

a. Students use reasoning to connect the appropriate evidence to the claim and construct an oral or written argument about the causal relationship between physical and biological components of an ecosystem and changes in organism populations, based on patterns in the evidence. In the argument, students describe a chain of reasoning that includes:
    - Specific changes in the physical or biological components of an ecosystem cause changes that can affect the survival and reproductive likelihood of organisms within that ecosystem (e.g., scarcity of food or the elimination of a predator will alter the survival and reproductive probability of some organisms).
    - Factors that affect the survival and reproduction of organisms can cause changes in the populations of those organisms.
    - Patterns in the evidence suggest that many different types of changes (e.g., changes in multiple types of physical and biological components) are correlated with changes in organism populations.
    - Several consistent correlational patterns, along with the understanding of specific causal relationships between changes in the components of an ecosystem and changes in the survival and reproduction of organisms, suggest that many changes in physical or biological components of ecosystems can cause changes in populations of organisms.
    - Some small changes in physical or biological components of an ecosystem are associated with large changes in a population, suggesting that small changes in one component of an ecosystem can cause large changes in another component.

Guided Questions

- How do physical or biological changes affect the populations of an ecosystem?

Catholic Identity Connections

- Connections can be made to care of God’s creation, as follows:
    - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
    - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
    - Describe humanity’s natural situation in, and dependence upon, physical reality and how humans carry out his role as a cooperator with God in the work of creation. [CS S.712 IS7]
    - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
    - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
    - Share concern and care for the environment as part of God’s creation. [CS S.712 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RI.6.8	Delineate and evaluate the argument and specify claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.
WHST.6-8.1	Write arguments focused on discipline-specific content.
WHST.6-8.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.

Connections to Other DCIs in Seventh Grade

MS.LS4.C; MS.LS4.D; MS.ESS2.A; MS.ESS3.A; MS.ESS3.C

Articulation to DCIs across Grade-Bands

3.LS2.C; 3.LS4.D

7-LS2 Ecosystems: Interactions, Energy, and Dynamics		
Students who demonstrate understanding can: **7-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.** Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. • Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**LS2.C Ecosystem Dynamics, Functioning, and Resilience** • Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. **LS4.D Biodiversity and Humans** • Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on - for example, water purification and recycling. (secondary emphasis) **ETS1.B Developing Possible Solutions** • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary emphasis)	**Stability and Change** • Small changes in one part of a system might cause large changes in another part. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade
1. Identifying the given design solution and supporting evidence
a. Students identify and describe: • The given competing design solutions for maintaining biodiversity and ecosystem services. • The given problem involving biodiversity and/or ecosystem services that is being solved by the given design solutions, including information about why biodiversity and/or ecosystem services are necessary to maintaining a healthy ecosystem. • The given evidence about performance of the given design solutions.
2. Identifying any potential additional evidence that is relevant to the evaluation
a. Students identify and describe the additional evidence (in the form of data, information, or other appropriate forms) that is relevant to the problem, design solutions, and evaluation of the solutions, including: • The variety of species (biodiversity) found in the given ecosystem. • Factors that affect the stability of the biodiversity of the given ecosystem.

- Ecosystem services (e.g., water purification, nutrient recycling, prevention of soil erosion) that affect the stability of the system.

b. Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.

3. Evaluating and critiquing the design solution

a. In their evaluations, students use scientific evidence to:
   - Compare the ability of each of the competing design solutions to maintain ecosystem stability and biodiversity.
   - Clarify the strengths and weaknesses of the competing designs with respect to each criterion and constraint (e.g., scientific, social, and economic considerations).
   - Assess possible side effects of the given design solutions on other aspects of the ecosystem, including the possibility that a small change in the component of an ecosystem can produce a large change in another component of the ecosystem.

Guided Questions

- How can solutions be designed for maintaining biodiversity and ecosystem services?

Catholic Identity Connections

- St. Thomas Aquinas wrote, "For He brought things into being in order that His goodness might be communicated to creatures, and be represented by them; and because His goodness could not be adequately represented by one creature alone, He produced many and diverse creatures, that what was wanting to one in the representation of the divine goodness might be supplied by another. For goodness, which in God is simple and uniform, in creatures is manifold and divided and hence the whole universe together participates the divine goodness more perfectly, and represents it better than any single creature whatever" (Summa Theologiae, First Part, Question 47).
- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out his role as a cooperator with God in the work of creation. [CS S.712 IS7]
- Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
- Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Analyze how the pursuit of scientific knowledge, for utilitarian purposes alone or for the misguided manipulation of nature, thwarts the pursuit of authentic Truth and the greater glory of God. [CS S.712 IS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.8 Distinguish between facts, reasoned judgment based on research findings, and speculation in a text.

RI.8.8 Delineate and evaluate the argument and specify claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.

Mathematics

MP.4 Model with mathematics.

6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems.

Connections to Other DCIs in Seventh Grade

MS.ESS3.C

Articulation to DCIs across Grade-Bands

N/A

7-LS3	**Heredity: Inheritance and Variation of Traits**
Students who demonstrate understanding can:	
7-LS3-1	**Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.**
Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.	

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**LS3.A Inheritance of Traits** • Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. **LS3.B Variation of Traits** • In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. • Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism.	**Energy and Matter** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Components of the model

a. Students develop a model in which they identify the relevant components for making sense of a given phenomenon involving the relationship between mutations and the effects on the organism, including:
   - Genes located on chromosomes.
   - Proteins.
   - Traits of organisms.

2. Relationships

a. In the model, students describe the relationships between components, including:
   - Every gene has a certain structure, which determines the structure of a specific set of proteins.
   - Protein structure influences protein function (e.g., the structure of some blood proteins allows them to attach to oxygen, the structure of a normal digestive protein allows it to break down particular food molecules).
   - Observable organism traits (e.g., structural, functional, behavioral) result from the activity of proteins.

3 Connections

a. Students use the model to describe that structural changes to genes (e.g., mutations) may result in observable effects at the level of the organism, including why structural changes to genes:
   - May affect protein structure and function.
   - May affect how proteins contribute to observable structures and functions in organisms.
   - May result in trait changes that are beneficial, harmful, or neutral for the organism.

b. Students use the model to describe that beneficial, harmful, or neutral changes to protein function can cause beneficial, harmful, or neutral changes in the structure and function of organisms.

Guided Questions

- How do structural changes in the genetic code affect an organism?

Catholic Identity Connections

- Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
- Share concern and care for the environment as part of God's creation. [CS S.712 DS4]

Saints [SA]
- Our Lady of Lourdes, patron saint of bodily ills
- Our Lady of the Thorns, patron saint of blood donors
- St. Agnes of Rome, patron saint of bodily purity
- St. Agrippina, patron saint of bacterial disease and infection
- St. Godebertha, patron saint against infectious diseases

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.

Connections to Other DCIs in Seventh Grade

MS.LS1.A; MS.LS4.A

Articulation to DCIs across Grade-Bands

3.LS3.A; 3.LS3.B

7-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

7-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**LS3.A Inheritance of Traits** • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. **LS1.B Growth and Development of Organisms** • Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary emphasis)* **LS3.B Variation of Traits** • In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. • Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other.	**Energy and Matter** • Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore complex natural structures/systems can be analyzed to determine how they function.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Components of the model

a. Students develop a model (e.g., Punnett squares, diagrams, simulations) for a given phenomenon involving the differences in genetic variation that arise from sexual and asexual reproduction. In the model, students identify and describe the relevant components, including:
   - Chromosome pairs, including genetic variants, in asexual reproduction (e.g., parents, offspring).
   - Chromosome pairs, including genetic variants, in sexual reproduction (e.g., parents, offspring).

2. Relationships

a. In the model, students describe the relationships between components, including:
   - During reproduction (both sexual and asexual), parents transfer genetic information in the form of genes to their offspring.
   - Under normal conditions, offspring have the same number of chromosomes, and therefore genes, as their parents.
   - During asexual reproduction, a single parent's chromosomes (one set) are the source of genetic material in the offspring.
   - During sexual reproduction, two parents (two sets of chromosomes) contribute genetic material to the offspring.

3. Connections

a. Students use the model to describe a causal account for why sexual and asexual reproduction result in different amounts of genetic variation in offspring relative to their parents, including that:
   - In asexual reproduction:
     - Offspring have a single source of genetic information, and their chromosomes are complete copies of each single parent pair of chromosomes.
     - Offspring chromosomes are identical to parent chromosomes.
   - In sexual reproduction:
     - Offspring have two sources of genetic information (i.e., two sets of chromosomes) that contribute to each final pair of chromosomes in the offspring.
     - Because both parents are likely to contribute different genetic information, offspring chromosomes reflect a combination of genetic material from two sources and therefore contain new combinations of genes (genetic variation) that make offspring chromosomes distinct from those of either parent.

b. Students use the cause and effect relationships found in the model between the type of reproduction and the resulting genetic variation to predict that more genetic variation occurs in organisms that reproduce sexually compared to organisms that reproduce asexually.

Guided Questions

- How does asexual reproduction result in offspring with genetic information identical to the parent?
- How does sexual reproduction result in an offspring with genetic variation?

Catholic Identity Connections

- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- This standard can also be understood in terms of evolution, since asexual reproduction preceded sexual production. This points to the idea that greater diversity is God's intention.
- Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points..

Mathematics

MP.4 Model with mathematics.

6.SP.5 Summarize numerical data sets in relation to their context.

Connections to Other DCIs in Seventh Grade

N/A

Articulation to DCIs across Grade-Bands

3.LS3.A; 3.LS3.B

7-LS4	**Biological Evolution: Unity and Diversity**	
Students who demonstrate understanding can: **7-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.** Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. **Connections to Nature of Science Scientific** **Knowledge Is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**LS4.A Evidence of Common Ancestry and Diversity** • The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Organizing data

a. Students organize the given data (e.g., using tables, graphs, charts, images), including the appearance of specific types of fossilized organisms in the fossil record as a function of time, as determined by their locations in the sedimentary layers or the ages of rocks.
b. Students organize the data in a way that allows for the identification, analysis, and interpretation of similarities and differences in the data.

2. Identifying relationships

a. Students identify:
   - Patterns between any given set of sedimentary layers and the relative ages of those layers.
   - The time period(s) during which a given fossil organism is present in the fossil record.
   - Periods of time for which changes in the presence or absence of large numbers of organisms or specific types of organisms can be observed in the fossil record (e.g., a fossil layer with very few organisms immediately next to a fossil layer with many types of organisms).
   - Patterns of changes in the level of complexity of anatomical structures in organisms in the fossil record, as a function of time.

3. Interpreting data

a. Students analyze and interpret the data to determine evidence for the existence, diversity, extinction, and change in life forms throughout the history of Earth, using the assumption that natural laws operate today as they would have in the past. Students use similarities and differences in the observed patterns to provide evidence for:
   - When mass extinctions occurred.
   - When organisms or types of organisms emerged, went extinct, or evolved.
   - The long-term increase in the diversity and complexity of organisms on Earth.

Guided Questions

- How can the fossil record be used to document the existence, diversity, extinction, and change of life forms throughout history?

Catholic Identity Connections

- The fossil record tells the story of evolution on an ever-changing planet.
- Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
- The study of evolution through the fossil record may raise questions about the origin of the universe.
- Explain the supernatural design hypothesis in terms of the Borde-Vilenkin-Guth Proof, the Second Law of Thermodynamics, entropy, and anthropic coincidences (fine tuning of initial conditions and universal constants) (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS15]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

Connections to Other DCIs in Seventh Grade

MS.ESS1.C

Articulation to DCIs across Grade-Bands

3.LS4.A

7-LS4 Biological Evolution: Unity and Diversity		
Students who demonstrate understanding can: **7-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.** Clarification Statement: Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the appearance of anatomical structures.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas to construct an explanation for real- world phenomena, examples, or events.	**LS4.A Evidence of Common Ancestry and Diversity** • Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record enable the reconstruction of evolutionary history and the influence of evolutionary descent.	**Patterns** • Patterns can be used to identify cause and effect relationships. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates a given phenomenon to scientific ideas, including the following ideas about similarities and differences in organisms and their evolutionary relationships:
   - Anatomical similarities and differences among organisms can be used to infer evolutionary relationships, including:
     - Among modern organisms.
     - Between modern and fossil organisms.

b. Students use evidence and reasoning to construct an explanation for the given phenomenon.

2. Evidence

a. Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data, simulations) necessary for constructing the explanation, including similarities and differences in anatomical patterns in and between:
   - Modern, living organisms (e.g., skulls of modern crocodiles, skeletons of birds; features of modern whales and elephants).
   - Fossilized organisms (e.g., skulls of fossilized crocodiles, fossilized dinosaurs).

3. Reasoning

a. Students use reasoning to connect the evidence to support an explanation. Students describe the following chain of reasoning for the explanation:
   - Organisms that share a pattern of anatomical features are likely to be more closely related than are organisms that do not share a pattern of anatomical features, due to the cause and effect relationship between genetic makeup and anatomy (e.g., although birds and insects both have wings, the organisms are structurally very different and not very closely related; the wings of birds and bats are structurally similar, and the organisms are more closely related; the limbs of horses and zebras are structurally very similar, and they are more closely related than are birds and bats or birds and insects).
   - Changes over time in the anatomical features observable in the fossil record can be used to infer lines of evolutionary descent by linking extinct organisms to living organisms through a series of fossilized organisms that share a basic set of anatomical features.

Guided Questions

- How can anatomical similarities and differences be used to infer evolutionary relationships?

Catholic Identity Connections

- The universe was created by God in stages that built upon one another over a period of time.
- Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
- Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
- Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS14]
- Explain the supernatural design hypothesis in terms of the Borde-Vilenkin-Guth Proof, the Second Law of Thermodynamics, entropy, and anthropic coincidences (fine tuning of initial conditions and universal constants) (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS15]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
WHST.6-8.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
WHST.6-8.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.
SL.8.1	Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.8.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics

6.EE.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

Connections to Other DCIs in Seventh Grade

MS.LS3.A; MS.LS3.B; MS.ESS1.C

Articulation to DCIs across Grade-Bands

3.LS4.A

7-LS4 Biological Evolution: Unity and Diversity		
Students who demonstrate understanding can: **7-LS4-3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species (not including humans) to identify relationships not evident in the fully formed anatomy.** Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze displays of data to identify linear and nonlinear relationships.	**LS4.A Evidence of Common Ancestry and Diversity** • Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.	**Patterns** • Graphs, charts, and images can be used to identify patterns in data.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Organizing data

a. Students organize the given displays of pictorial data of embryos by developmental stage and by organism (e.g., early, middle, just prior to birth) to allow for the identification, analysis, and interpretation of relationships in the data.

2. Identifying relationships

a. Students analyze their organized pictorial displays to identify linear and nonlinear relationships, including:
   - Patterns of similarities in embryos across species (e.g., early mammal embryos and early fish embryos both contain gill slits; whale embryos and the embryos of land animals - even some snakes - have hind limbs).
   - Patterns of changes as embryos develop (e.g., mammal embryos lose their gill slits, but the gill slits develop into gills in fish).

3. Interpreting data

a. Students use patterns of similarities and changes in embryo development to describe evidence for relatedness among apparently diverse species, including similarities that are not evident in the fully formed anatomy (e.g., mammals and fish are more closely related than they appear to be based on their adult features, whales are related to land animals).

Guided Questions

- How can embryological evidence be used to identify relationships between organisms?

Catholic Identity Connections
• This standard speaks to the underlying unity of life that is revealed through a study of evolution. It thus relates to St. Francis of Assisi's language of kinship (father, son, sister, brother) when writing about various aspects of creation. [SA] All of life is intimately related in Christ. • Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12] • Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13] • Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (see Appendix E). [CS S.712 IS14]
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RST.6-8.1** Cite specific textual evidence to support analysis of science and technical texts. **RST.6-8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). **RST.6-8.9** Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
Connections to Other DCIs in Seventh Grade
N/A
Articulation to DCIs across Grade-Bands
N/A

7-LS4	**Biological Evolution: Unity and Diversity**	
Students who demonstrate understanding can: **7-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.** Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena.	**LS4.BA Natural Selection** • Natural selection leads to the predominance of certain traits in a population, and the suppression of others.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Articulating the explanation of phenomena

a. Students articulate a statement that relates the given phenomenon to scientific ideas about the cause and effect relationship between the inheritance of traits increasing the chances of successful reproduction and natural selection.
b. Students use evidence and reasoning to construct an explanation for the given phenomenon.

2. Evidence

a. Students identify and describe evidence (e.g., from students' own investigations, observations, reading material, archived data) necessary for constructing the explanation, including:
   - Individuals in a species have genetic variation that can be passed on to their offspring.
   - The probability of a specific organism surviving and reproducing in a specific environment.
   - The traits (i.e., specific variations of a characteristic) and the cause and effect relationships between those traits and the probability of survival and reproduction of a given organism in a specific environment.
   - The particular genetic variations (associated with those traits) that are carried by that organism.

3. Reasoning

a. Students use reasoning to connect the evidence and support an explanation that describes the relationship between genetic variation and the success of organisms in a specific environment. Students describe a chain of reasoning that includes:
- Any population in a given environment contains a variety of available, inheritable genetic traits.
- For a specific environment (e.g., different environments may have limited food availability, predators, nesting site availability, light availability), some traits confer advantages that make it more probable that an organism will be able to survive and reproduce there.
- In a population, there is a cause and effect relationship between the variation of traits and the probability that specific organisms will be able to survive and reproduce.
- Variation of traits is a result of genetic variations occurring in the population.
- The proportion of individual organisms that have genetic variations and traits that are advantageous in a particular environment will increase from generation to generation due to natural selection because the probability that those individuals will survive and reproduce is greater.
- Similarly, the proportion of individual organisms that have genetic variations and traits that are disadvantageous in a particular environment will be less likely to survive, and the disadvantageous traits will decrease from generation to generation due to natural selection.

Guided Questions

- How do genetic variations increase an organism's probability of survival and reproduction?

Catholic Identity Connections

- Analyze and articulate the Church’s approach to the theory of evolution. [CS S.712 IS12]
- Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
- Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (see Appendix E). [CS S.712 IS14]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 7 topics, texts, and issues, building on others' ideas and expressing their own clearly.

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

7.RP.2 Recognize and represent proportional relationships between quantities.

6.SP.5 Summarize numerical data sets in relation to their context.

Connections to Other DCIs in Seventh Grade

MS.LS2.A; MS.LS3.A; MS.LS3.B

Articulation to DCIs across Grade-Bands

3.LS3.B; 3.LS4.B

7-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

7-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Clarification Statement: Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy); and, on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and method used, and describe how they are supported or not supported by evidence.	**LS4.B Natural Selection** • In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits, determined by genes, which are then passed on to offspring.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society makes.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Obtaining information

a. Students gather information about at least two technologies that have changed the way humans influence the inheritance of desired traits in plants and animals through artificial selection by choosing desired parental traits, determined by genes, which are then often passed on to offspring. Examples could include gene therapy, genetic modification, and selective breeding of plants and animals.
b. Students use at least two appropriate and reliable sources of information for investigating each technology.

2. Evaluating information

a. Students assess the credibility, accuracy, and possible bias of each publication and method used in the information they gather.
b. Students use their knowledge of artificial selection and additional sources to describe how the information they gather is or is not supported by evidence.
c. Students synthesize the information from multiple sources to provide examples of how technologies have changed the ways that humans are able to influence the inheritance of desired traits in organisms.
d. Students use the information to identify and describe how a better understanding of cause and effect relationships in how traits occur in organisms has led to advances in technology that provide a higher probability of being able to influence the inheritance of desired traits in organisms.

Guided Questions

- How have humans influenced the inheritance of desired traits in organisms?

Catholic Identity Connections

- It is important to note that, in the case of humans, the Catholic Church has taken a stand against human cloning and stem cell research. This is clearly articulated in the first theme of Catholic Social Teaching: Life and Dignity of the Human Person.
- Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
- Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
- Demonstrate an understanding of the moral issues involving in vitro fertilization, human cloning, human genetic manipulation, and human experimentation and what the Church teaches regarding work in these areas. [CS S.712 IS17]
- Articulate how science properly situates itself within other academic disciplines (e.g., history, theology) for correction and completion in order to recognize the limited material explanation of reality to which it is properly attuned. [CS S.712 IS1]
- Analyze how the pursuit of scientific knowledge, for utilitarian purposes alone or for the misguided manipulation of nature, thwarts the pursuit of authentic Truth and the greater glory of God. [CS S.712 IS3]
- Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Connections to Other DCIs in Seventh Grade

N/A

Articulation to DCIs across Grade-Bands

4.LS1.D

7-LS4	Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

7-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 6-8 builds on K-5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to support scientific conclusions and design solutions.	**LS4.C Adaptation** • Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.	**Cause and Effect** • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

Examples of Observable Evidence of Student Performance by the End of Seventh Grade

1. Representation

a. Students identify the explanations for phenomena that they will support, which include:
   - Characteristics of a species change over time (i.e., over generations) through adaptation by natural selection in response to changes in environmental conditions.
   - Traits that better support survival and reproduction in a new environment become more common within a population in that environment.
   - Traits that do not support survival and reproduction as well become less common within a population in that environment.
   - When environmental shifts are too extreme, populations do not have time to adapt and may become extinct.

b. From the given mathematical and/or computational representations of phenomena, students identify the relevant components, including;
   - Population changes (e.g., trends, averages, histograms, graphs, spreadsheets) gathered from historical data or simulations.
   - The distribution of specific traits over time from data and/or simulations.
   - Environmental conditions (e.g., climate, resource availability) over time from data and/or simulations.

2. Mathematical modeling

a. Students use the given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of the phenomenon to identify relationships in the data and/or simulations, including:
   - Changes and trends over time in the distribution of traits within a population.
   - Multiple cause and effect relationships between environmental conditions and natural selection in a population.
   - The increases or decreases of some traits within a population can have more than one environmental cause.

3. Analysis

a. Students analyze the mathematical and/or computational representations to provide and describe evidence that distributions of traits in populations change over time in response to changes in environmental conditions. Students synthesize their analysis together with scientific information about natural selection to describe that species adapt through natural selection. This results in changes in the distribution of traits within a population and in the probability that any given organism will carry a particular trait.

b. Students use the analysis of the mathematical and/or computational representations (including proportional reasoning) as evidence to support the explanations that:
   - Through natural selection, traits that better support survival and reproduction are more common in a population than those traits that are less effective.
   - Populations are not always able to adapt and survive because adaptation by natural selection occurs over generations.

c. Based on their analysis, students describe that because there are multiple cause and effect relationships contributing to the phenomenon, for each different cause it is not possible to predict with 100% certainty what will happen.

Guided Questions

- How have humans influenced the inheritance of desired traits in organisms?

Catholic Identity Connections

- Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
- Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
- Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (see Appendix E). [CS S.712 IS14]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.4 Model with mathematics.

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

6.SP.5 Summarize numerical data sets in relation to their context.

7.RP.2 Recognize and represent proportional relationships between quantities.

Connections to Other DCIs in Seventh Grade

MS.LS2.A; MS.LS2.C; MS.LS3.B

Articulation to DCIs across Grade-Bands

3.LS4.C

Eighth Grade Standards

8-PS1 Matter and Its Interactions

8-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures.
8-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
8-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
8-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
8-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
8-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Catholic/Christian Scientists

- Physics
    - Roger Bacon (Franciscan friar and early advocate of the scientific method)
    - Blaise Pascal (mathematician, physicist, inventor)
    - André-Marie Ampère (electromagnetism)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

8-PS2 Motion and Stability: Forces and Interactions

8-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
8-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
8-PS2-3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
8-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
8-PS2-5 Construct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Catholic/Christian Scientists

- Physics
    - Roger Bacon (Franciscan friar and early advocate of the scientific method)
    - Blaise Pascal (mathematician, physicist, inventor)
    - André-Marie Ampère (electromagnetism)
    - Antoine César Becquerel (electric and luminescent phenomena)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

8-PS3 Energy

8-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
8-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
8-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
8-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
8-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Catholic/Christian Scientists

- Physics
  - Roger Bacon (Franciscan friar and early advocate of the scientific method)
  - Blaise Pascal (mathematician, physicist, inventor)
  - Francesco Lana de Terzi (Jesuit priest, aeronautics)
  - André-Marie Ampère (electromagnetism)
  - Antoine César Becquerel (electric and luminescent phenomena)
  - Hippolyte Fizeau (the velocity of light)
  - Alessandro Volta (invention of the battery)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

8-PS4 Waves and Their Applications in Technologies for Information Transfer

8-PS4-1 Use mathematical representations to describe a simple model for waves that include how the amplitude of a wave is related to the energy in a wave.
8-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
8-PS4-3 Integrate quantitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

Catholic/Christian Scientists

- Physics
  - Roger Bacon (Franciscan friar and early advocate of the scientific method)
  - Blaise Pascal (mathematician, physicist, inventor)
  - Marin Mersenne (acoustics)
  - André-Marie Ampère (electromagnetism)
  - Antoine César Becquerel (electric and luminescent phenomena)
  - Vincenzo Viviani (Viviani's theorem, Viviani's curve and his work in determining the speed of sound)
  - Hippolyte Fizeau (the velocity of light)
  - Guglielmo Marconi (long-distance radio transmission)
  - Alessandro Volta (invention of the battery)
  - Theodoric of Freiberg (the rainbow)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists

8-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

8-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures (i.e., elements and organization of the Periodic Table).

Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3-D ball and stick structures, or computer representations showing different molecules with different types of atoms.

Assessment Boundary: Assessment does not include bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to predict and/or describe phenomena.	**PS1.A Structure and Properties of Matter** • Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. • Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).	**Scale, Proportion, and Quantity** • Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Components of the model

a. Students develop models of atomic composition of simple molecules and extended structures that vary in complexity. In the models, students identify the relevant components, including:
   - Individual atoms.
   - Molecules.
   - Extended structures with repeating subunits.
   - Substances (e.g., solids, liquids, and gases at the macro level).

2. Relationships

a. In the model, students describe relationships between components, including:
   - Individual atoms, from two to thousands, combine to form molecules, which can be made up of the same type or different types of atom.
   - Some molecules can connect to each other.
   - In some molecules, the same atoms of different elements repeat; in other molecules, the same atom of a single element repeats.

3. Connections

a. Students use models to describe that:
   - Pure substances are made up of a bulk quantity of individual atoms or molecules. Each pure substance is made up of one of the following:
     - Individual atoms of the same type that are connected to form extended structures.
     - Individual atoms of different types that repeat to form extended structures (e.g., sodium chloride).
     - Individual atoms that are not attracted to each other (e.g., helium).
     - Molecules of different types of atoms that are not attracted to each other (e.g., carbon dioxide).
     - Molecules of different types of atoms that are attracted to each other to form extended structures (e.g., sugar, nylon).
     - Molecules of the same type of atom that are not attracted to each other (e.g., oxygen).
   - Students use the models to describe how the behavior of bulk substances depends on their structures at atomic and molecular levels, which are too small to see.

Guided Questions

- How can models be used to represent various molecular structures?

Catholic Identity Connections

- This standard leads to an exploration of molecules of different types of atoms that are and are not attracted to each other. The notion of attraction can illuminate the idea of Christian community and the Body of Christ in which all are bonded to one another. This can be connected to sacramental theology as well.
- This standard might also be connected to the Trinity. The imprint of the Trinity can be found at the heart of creation. Matter is made of atoms, which are comprised of protons, neutrons and electrons (the atom is composed of three essential components like the Trinity is composed of three Gods in One). What happens to God's creation if you split these apart?
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. (CS S.712 IS2)
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems.

8.EE.3 Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other.

Connections to Other DCIs in Eighth Grade

MS.ESS2.C

Articulation to DCIs across Grade-Bands

5.PS1.A

8-PS1	**Matter and Its Interactions**	
Students who demonstrate understanding can: **8-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS1.A Structure and Properties of Matter** • Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **PS1.B Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.	**Patterns** • Macroscopic patterns are related to the nature of microscopic and atomic-level structure.
Examples of Observable Evidence of Student Performance by the End of Eighth Grade		
1. Organizing data		
a. Students organize given data about the characteristic physical and chemical properties (e.g., density, melting point, boiling point, solubility, flammability, odor) of pure substances before and after they interact. b. Students organize the given data in a way that facilitates analysis and interpretation.		
2. Identifying relationships		
a. Students analyze the data to identify patterns (i.e., similarities and differences), including the changes in physical and chemical properties of each substance before and after the interaction (e.g., before the interaction, a substance burns, while after the interaction, the resulting substance does not burn).		
3. Interpreting data		
a. Students use the analyzed data to determine whether a chemical reaction has occurred. b. Students support their interpretation of the data by describing that the change in properties of substances is related to the rearrangement of atoms in the reactants and products in a chemical reaction (e.g., when a reaction has occurred, atoms from the substances present before the interaction must have been rearranged into new configurations, resulting in the properties of new substances).		

Guided Questions

- How can chemical and physical properties of substances be used to identify the substance?

Catholic Identity Connections

- This standard might lead to a discussion of how we, as members of the Body of Christ, interact; how people are changed – for the better or worse – due to knowing us. This connects to Catholic Social Teaching:
    - Theme 2: Call to Family, Community and Participation
    - Theme 6. Solidarity
- We are always changed for the better when we interact with God.
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

MP.2 Reason abstractly and quantitatively.

6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems.

6.SP.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

6.SP.5 Summarize numerical data sets in relation to their context

Connections to Other DCIs in Eighth Grade

MS.PS3.D; MS.ESS2.A

Articulation to DCIs across Grade-Bands

N/A

8-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

8-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.

Assessment Boundary: Assessment is limited to qualitative information.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or now supported by evidence.	**PS1.A Structure and Properties of Matter** • Each pure substance has characteristic physical and chemical properties (for any bulk quantify under given conditions) that can be used to identify it. **PS1.B Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Obtaining information

a. Students obtain information from published, grade-level appropriate material from at least two sources (e.g., text, media, visual displays, data) about:
   - Synthetic materials and the natural resources from which they are derived.
   - Chemical processes used to create synthetic materials from natural resources (e.g., burning of limestone for the production of concrete).
   - The societal need for the synthetic material (e.g., the need for concrete as a building material).

2. Evaluating information

a. Students determine and describe whether the gathered information is relevant for determining:
   - That synthetic materials, via chemical reactions, come from natural resources.
   - The effects of the production and use of synthetic resources on society.

b. Students determine the credibility, accuracy, and possible bias of each source of information, including the ideas included and methods described.

c. Students synthesize information that is presented in various modes (e.g., graphs, diagrams, photographs, text, mathematical, verbal) to describe:
   - How synthetic materials are formed, including the natural resources and chemical processes used.
   - The properties of the synthetic material(s) that make it different from the natural resource(s) from which is was derived.
   - How those physical and chemical properties contribute to the function of the synthetic material.
   - How the synthetic material satisfies a societal need or desire through the properties of its structure and function.
   - The effects of making and using synthetic materials on natural resources and society.

Guided Questions

- How have engineering advances and scientific discoveries impacted society?

Catholic Identity Connections

- Creating synthetic materials can benefit humanity, thus this standard might be examined in the light of Catholic Social Teaching.
  - Theme 1: Life and Dignity of the Human Person
  - Theme 4: Option for the Poor and Vulnerable
    - Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
    - Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
- Synthetic materials may also harm humanity and creation, thus we might also consider care of God's creation when teaching this standard.
  - Theme 7: Care of God's Creation
    - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
    - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
    - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]
    - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
    - Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
    - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using research terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Connections to Other DCIs in Eighth Grade

MS.LS2.A; MS.LS4.D; MS.ESS3.A; MS.ESS3.C

Articulation to DCIs across Grade-Bands

N/A

8-PS1	**Matter and Its Interactions**	
Students who demonstrate understanding can: **8-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.** Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to predict and/or describe phenomena.	**PS1.4 Structure and Properties of Matter** • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. • In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position, but do not change relative locations. • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. **PS3.A Definitions of Energy** • The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary emphasis) • The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary emphasis)	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Examples of Observable Features of the Student Performance by the End of Eighth Grade

1. Components of the model

a. To make sense of a given phenomenon, students develop a model in which they identify the relevant components, including:
   - Particles, including their motion.
   - The system within which the particles are contained.
   - The average kinetic energy of particles in the system.
   - Thermal energy of the system.
   - Temperature of the system.
   - A pure substance in one of the states of matter (e.g., solid, liquid, gas at the macro scale).

2. Relationships

a. In the model, students describe relationships between components, including:
   - The relationships between:
     - The motion of molecules in a system and the kinetic energy of the particles in the system.
     - The average kinetic energy of the particles and the temperature of the system.
     - The transfer of thermal energy from one system to another and:
       - A change in kinetic energy of the particles in that new system, or
       - A change in state of matter of the pure substance.
   - The state of matter of the pure substance (gas, liquid, solid) and the particle motion (freely moving and not in contact with other particles, freely moving and in loose contact with other particles, vibrating in fixed positions relative to other particles).

3. Connections

a. Students use their model to provide a causal account of the relationship between the addition or removal of thermal energy from a substance and the change in the average kinetic energy of the particles in the substance.

b. Students use their model to provide a causal account of the relationship between:
   - The temperature of the system.
   - Motions of molecules in the gaseous phase.
   - The collisions of those molecules with other materials, which exerts a force called pressure.

c. Students use their model to provide a causal account of what happens when thermal energy is transferred into a system, including that:
   - An increase in kinetic energy of the particles can cause:
     - An increase in the temperature of the system as the motion of the particles relative to each other increases, or
     - A substance to change state from a solid to a liquid or from a liquid to a gas.
   - The motion of molecules in a gaseous state increases, causing the moving molecules in the gas to have greater kinetic energy, thereby colliding with molecules in surrounding materials with greater force (i.e., the pressure of the system increases).

d. Students use their model to provide a causal account of what happens when thermal energy is transferred from a substance, including that:
   - Decreased kinetic energy of the particles can cause:
     - A decrease in the temperature of the system as the motion of the particles relative to each other decreases, or
     - A substance to change state from a gas to a liquid or from a liquid to a solid.
   - The pressure that a gas exerts decreases because the kinetic energy of the gas molecules decreases, and the slower molecules exert less force in collisions with other molecules in surrounding materials.

e. Students use their model to provide a causal account for the relationship between changes in pressure of a system and changes of the states of materials in the system.
   - With a decrease in pressure, a smaller addition of thermal energy is required for particles of a liquid to change to gas because particles in the gaseous state are colliding with the surface of the liquid less frequently and exerting less force on the particles in the liquid, thereby allowing the particles in the liquid to break away and move into the gaseous state with the addition of less energy.
   - With an increase in pressure, a greater addition of thermal energy is required for particles of a liquid to change to gas because particles in the gaseous state are colliding with the surface of the liquid more frequently and exerting greater force on the particles in the liquid, thereby limiting the movement of particles from the liquid to gaseous state.

Guided Questions

- How can the relationship between thermal energy, particle motion, temperature, and pressure be determined?
- How can this relationship be demonstrated in a model?
- How do pressure changes affect thermal energy?

Catholic Identity Connections

- God created the overall laws and principles under which the universe as we know and study it came to be. We are all functioning within those principles, just as we function under moral and theological obligations towards the common good.
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

6.NS.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.

Connections to Other DCIs in Eighth Grade

MS.ESS2.C

Articulation to DCIs across Grade-Bands

N/A

8-PS1 Matter and Its Interactions		
Students who demonstrate understanding can: **8-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.** Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms. Assessment Boundary: Assessment does not include the use of atomic masses or intermolecular forces.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Laws are regularities or mathematical descriptions of natural phenomena.	**PS1.B Chemical Reactions** • Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. • The total number of each type of atom is conserved, and thus the mass does not change.	**Energy and Matter** • Matter is conserved because atoms are conserved in physical and chemical processes.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade
1. Components of the model
a. To make sense of a given phenomenon, students develop a model in which they identify the relevant components for a given chemical reaction, including: • The types and number of molecules that make up the reactants. • The types and number of molecules that make up the products.
2. Relationships
a. In the model, students describe relationships between components, including: • Each molecule in each of the reactants is made up of the same type(s) and number of atoms. • When a chemical reaction occurs, the atoms that make up the molecules of reactants rearrange and form new molecules (i.e., products). • The number and types of atoms that make up the products are equal to the number and types of atoms that make up the reactants. • Each type of atom has a specific mass, which is the same for all atoms of that type.

3. Connections

a. Students use the model to describe that the atoms that make up the reactants rearrange and come together in different arrangements to form the products of a reaction.
b. Students use the model to provide a causal account that mass is conserved during chemical reactions because the number and types of atoms that are in the reactants equal the number and types of atoms that are in the products, and all atoms of the same type have the same mass regardless of the molecule in which they are found.

Guided Questions

- How can the law of conservation of matter be evidenced in the real world (e.g., balanced symbolic equations)?

Catholic Identity Connections

- Refer to the Catholic Identity section in the previous standard.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems.

Connections to Other DCIs in Eighth Grade

MS.LS1.C; MS.LS2.B; MS.ESS2.A

Articulation to DCIs across Grade-Bands

5.PS1.B

8-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

8-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.

Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**PS1.B Chemical Reactions** • Some chemical reactions release energy, others store energy. **ETS1.B Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (secondary emphasis) **ETS1.C Optimizing the Design Solution** • Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (secondary emphasis) • The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the rest results leads to greater refinement and ultimately to an optimal solution.	**Energy and Matter** • The transfer of energy can be tracked as energy flows through a designed or natural system.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Using scientific knowledge to generate design solutions

a. Given a problem to solve that requires either heating or cooling, students design and construct a solution (i.e., a device). In their designs, students:
   - Identify the components within the system related to the design solution, including:
     - The components within the system to or from which energy will be transferred to solve the problem.
     - The chemical reaction(s) and the substances that will be used to either release or absorb thermal energy via the device.
   - Describe how the transfer of thermal energy between the device and other components within the system will be tracked and used to solve the given problem.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe the given criteria, including:
    - Features of the given problem that are to be solved by the device.
    - The absorption or release of thermal energy by the device via a chemical reaction.

b. Students describe the given constraints, which may include:
    - Amount and cost of materials.
    - Safety.
    - Amount of time during which the device must function.

3. Evaluating potential solutions

a. Students test the solution for its ability to solve the problem via the release or absorption of thermal energy to or from the system.

b. Students use the results of their tests to systematically determine how well the design solution meets the criteria and constraints, and which characteristics of the design solution performed the best.

4. Modifying the design solution

a. Students modify the design of the device based on the results of iterative testing, and improve the design relative to the criteria and constraints.

Guided Questions

- How can data results be evaluated to determine whether energy is released or absorbed?
- How can the results be used to modify the rate of energy transfer?

Catholic Identity Connections

- This standard refers the engineering design process. The iterative process of testing might be related to that of our spiritual lives as we seek, by trial and error, to become holy people of God. In the Ignatian "Daily Examen," for example, one prayerfully reflects upon one's day in order to discern God's presence and work in one's life.
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]

Saints [SA]

- St. Patrick, patron saint of engineers

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Connections to Other DCIs in Eighth Grade

MS.PS3.D

Articulation to DCIs across Grade-Bands

N/A

8-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

8-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.

Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design an object, tool, process, or system.	**PS2.A Forces and Motion** • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's Third Law).	**Systems and System Models** • Models can be used to represent systems and their interactions - such as inputs, processes and outputs - and energy and matter flows within systems. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Using scientific knowledge to generate design solutions

a. Given a problem to solve involving a collision of two objects, students design a solution (e.g., an object, tool, process, or system). In their designs, students identify and describe:
   - The components within the system that are involved in the collision.
   - The force that will be exerted by the first object on the second object.
   - How Newton's Third Law will be applied to design the solution to the problem.
   - The technologies (i.e., any human-made material or device) that will be used in the solution.

2. Describing the criteria and constraints, including quantification when appropriate

a. Students describe the given criteria and constraints, including how they will be taken into account when designing the solution.
   - Students describe how the criteria are appropriate to solve the given problem. Ii. Students describe the constraints, which may include:
     - Cost.
     - Mass and speed of objects.
     - Time.
     - Materials.

3. Evaluating potential solutions

a. Students use their knowledge of Newton's Third Law to systematically determine how well the design solution meets the criteria and constraints.
b. Students identify the value of the device for society.
c. Students determine how the choice of technologies that are used in the design is affected by the constraints of the problem and the limits of technological advances.

Guided Questions

- How does the mass of two objects affect the distance each traveled in an impact collision?
- What are real-world examples of the third law of motion?

Catholic Identity Connections

- Our ability to design solutions to problems may be used toward the glory of God, the life and dignity of the human person, and care of God's creation.
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

MP.2 Reason abstractly and quantitatively.
6.NS.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.
6.EE.2 Write, read, and evaluate expressions in which letters stand for numbers.
7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.
7.EE.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Connections to Other DCIs in Eighth Grade

MS.PS3.C

Articulation to DCIs across Grade-Bands

3.PS2.A

8-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

8-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.

Assessment Boundary: Assessment is limited to forces and changes in motion in one dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Plan an investigation individually and collaboratively, and in the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Connections to Nature of Science Scientific** **Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS2.A Forces and Motion** • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a large force causes a larger change in motion. • All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Identifying the phenomenon to be investigated

a. Students identify the phenomenon under investigation, which includes the change in motion of an object.
b. Students identify the purpose of the investigation, which includes providing evidence that the change in an object's motion is due to the following factors:
   - Balanced or unbalanced forces acting on the object.
   - The mass of the object.

2. Identifying the evidence to address the purpose of the investigation

a. Students develop a plan for the investigation individually or collaboratively. In the plan, students describe:
   - That the following data will be collected:
     - Data on the motion of the object.
     - Data on the total forces acting on the object.
     - Data on the mass of the object.
   - Which data are needed to provide evidence for each of the following:
     - An object subjected to balanced forces does not change its motion (sum of F=0).
     - An object subjected to unbalanced forces changes its motion over time (sum of F≠0).

3 Planning the investigation

a. In the investigation plan, students describe:
  - How the following factors will be determined and measured:
    - The motion of the object, including a specified reference frame and appropriate units for distance and time.
    - The mass of the object, including appropriate units.
    - The forces acting on the object, including balanced and unbalanced forces.
  - Which factors will serve as independent and dependent variables in the investigation (e.g., mass is an independent variable, forces and motion can be independent or dependent).
  - The controls for each experimental condition.
  - The number of trials for each experimental condition.

Guided Questions

- What factors affect a change in inertia?
- How does speed or mass affect the velocity of an object?

Catholic Identity Connections

- God created the overall laws and principles under which the universe as we know and study it came to be. We are all functioning within those principles, just as we function under moral and theological obligations towards the common good.
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

MP.2	Reason abstractly and quantitatively.
6.EE.2	Write, read, and evaluate expressions in which letters stand for numbers.
7.EE.3	Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.
7.EE.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

Connections to Other DCIs in Eighth Grade

MS.PS3.A; MS.PS3.B; MS.ESS2.C

Articulation to DCIs across Grade-Bands

3.PS2.A

8-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

8-PS2-3 Ask questions about the data to determine the factors that affect the strength of electric and magnetic forces.

Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of any electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.

Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 6-8 builds on K-5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.	**PS2.B Types of Interactions** • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects.	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Addressing phenomena of the natural world or scientific theories

a. Students formulate questions that arise from examining given data of objects (which can include particles) interacting through electric and magnetic forces, the answers to which would clarify:
   - The cause and effect relationships that affect magnetic forces due to:
     - The magnitude of any electric current present in the interaction, or other factors related to the effect of the electric current (e.g., number of turns of wire in a coil).
     - The distance between the interacting objects.
     - The relative orientation of the interacting objects.
     - The magnitude of the magnetic strength of the interacting objects.
   - The cause and effect relationships that affect electric forces due to:
     - The magnitude and signs of the electric charges on the interacting objects.
     - The distance between the interacting objects.
     - Magnetic forces.

b. Based on scientific principles and given data, students frame hypotheses that:
   - Can be used to predict the strength of electric and magnetic forces due to cause and effect relationships.
   - Can be used to distinguish between possible outcomes, based on an understanding of the cause and effect relationships driving the system.

2. Identifying the scientific nature of the question

a. Students' questions can be investigated scientifically within the scope of a classroom, outdoor environment, museum, or other public facility.

Guided Questions

- How can the strength of magnetic forces be determined?
- How are electromagnetic forces used in motors?

Catholic Identity Connections

- The notion that electric and magnetic (electromagnetic) forces can be attractive or repulsive may be considered in light of human relationships, Christian community and the Body of Christ.
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs in Eighth Grade

N/A

Articulation to DCIs across Grade-Bands

3.PS2.B

8-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

8-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools, and charts displaying mass, strength of interaction, distance from the sun, and orbital periods of objects within the solar system.

Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. • Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS2.B Types of Interactions** • Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass (e.g., Earth and the sun).	**Systems and System Models** • Models can be used to represent systems and their interactions - such as inputs, processes, and outputs - and energy and matter flows within systems.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Supported claims

a. Students make a claim to be supported about a given phenomenon. In their claim, students include the idea that gravitational interactions are attractive and depend on the masses of interacting objects.

2. Identifying scientific evidence

a. Students identify and describe the given evidence that supports the claim, including:
- The masses of objects in the relevant system(s).
- The relative magnitude and direction of the forces between objects in the relevant system(s).

3. Evaluating and critiquing the evidence

a. Students evaluate the evidence and identify its strengths and weaknesses, including:
   - Types of sources.
   - Sufficiency, including validity and reliability, of the evidence to make and defend the claim.
   - Any alternative interpretations of the evidence, and why the evidence supports the given claim as opposed to any other claims.

4. Reasoning and synthesis

a. Students use reasoning to connect the appropriate evidence about the forces on objects and construct the argument that gravitational forces are attractive and mass dependent. Students describe the following chain of reasoning:
   - Systems of objects can be modeled as a set of masses interacting via gravitational forces.
   - In systems of objects, larger masses experience and exert proportionally larger gravitational forces.
   - In every case for which evidence exists, gravitational force is attractive.

b. To support the claim, students present their oral or written argument concerning the direction of gravitational forces and the role of the mass of the interacting objects.

Guided Questions

- Why are gravitational interactions dependent on an object's mass?

Catholic Identity Connections

- God created the overall laws and principles under which the universe as we know and study it came to be. We are all functioning within those principles, just as we function under moral and theological obligations towards the common good.
- Demonstrate confidence in human reason and in one’s ability to know the truth about God’s creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Describe humanity’s natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.6-8.1 Write arguments focused on discipline-specific content.

Connections to Other DCIs in Eighth Grade

MS.ESS1.A; MS.ESS1.B; MS.ESS2.C

Articulation to DCIs across Grade-Bands

5.PS2.B

8-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

8-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.

Assessment Boundary: Assessment is limited to electric and magnetic fields, and limited to qualitative evidence for the existence of fields.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation.	**PS2.B Types of Interactions** • Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively).	**Cause and Effect** • Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Identifying the phenomenon to be investigated

a. From the given investigation plan, students identify the phenomenon under investigation, which includes the idea that objects can interact at a distance.
b. Students identify the purpose of the investigation, which includes providing evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

2. Identifying the evidence to address the purpose of the investigation

a. From the given plan, students identify and describe the data that will be collected to provide evidence for each of the following:
   - Evidence that two intersecting objects can exert forces on each other even though the two interacting objects are not in contact with each other.
   - Evidence that distinguishes between electric and magnetic forces.
   - Evidence that the cause of a force on one object is the interaction with the second object (e.g., evidence for the presence of force disappears when the second object is removed from the vicinity of the first).

3. Planning the investigation

a. Students describe the rationale for why the given investigation plan includes:
   - Changing the distance between objects.
   - Changing the charge or magnetic orientation of objects.
   - Changing the magnitude of the charge on an object or the strength of the magnetic field.
   - A means to indicate or measure the presence of electric or magnetic forces.

4. Collecting the data

a. Students make and record observations according to the given plan. The data recorded may include observations of:
   - Motion of objects.
   - Suspension of objects.
   - Simulations of objects that produce either electric or magnetic fields through space and the effects of moving objects closer to or farther away from each other.

5. Evaluation of the design

a. Students evaluate the experimental design by assessing whether or not the data produced by the investigation can provide evidence that fields exist between objects that act on each other even though the objects are not in contact.

Guided Questions

- How do gravitational interactions affect the motion of satellites?
- What factors influence the attractiveness or repulsively of magnetic or electric forces?

Catholic Identity Connections

- God created the overall laws and principles under which the universe as we know and study it came to be. We are all functioning within those principles, just as we function under moral and theological obligations towards the common good.
- Students might reflect upon how they may exert forces on each other and the world without having physical contact. Social media could be used as an example.
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Connections to Other DCIs in Eighth Grade

N/A

Articulation to DCIs across Grade-Bands

3.PS2.B

8-PS3 Energy		
Students who demonstrate understanding can: **8-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.** Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	**PS3.A Definitions of Energy** • Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.	**Scale, Proportion, and Quantity** • Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Organizing data

a. Students use graphical displays to organize the following given data:
   - Mass of the object.
   - Speed of the object.
   - Kinetic energy of the object.

b. Students organize data in a way that facilitates analysis and interpretation.

2 Identifying relationships

a. Using the graphical display, students identify that kinetic energy:
   - Increases if either the mass or the speed of the object increases or if both increase.
   - Decreases if either the mass or the speed of the object decreases or if both decrease.

3 Interpreting data

a. Using the analyzed data, students describe:
   - The relationship between kinetic energy and mass as a linear proportional relationship in which:
     - The kinetic energy doubles as the mass of the object doubles.
     - The kinetic energy halves as the mass of the object halves.
   - The relationship between kinetic energy and speed as a nonlinear (square) proportional relationship in which:
     - The kinetic energy quadruples as the speed of the object doubles.
     - The kinetic energy decreases by a factor of four as the speed of the object is cut in half.

Guided Questions

- How can real-world examples be used to describe the relationship between kinetic energy, mass, and speed?
- How can various graphical displays (e.g., bar graphs, line graphs, pie graphs) be used to record and interpret data about kinetic energy?

Catholic Identity Connections

- God created the overall laws and principles under which the universe as we know and study it came to be. We are all functioning within those principles, just as we function under moral and theological obligations towards the common good.
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as cooperators with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Mathematics

MP.2 Reason abstractly and quantitatively.

6.RP.1 Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities.

6.RP.2 Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship.

7.RP.2 Recognize and represent proportional relationships between quantities.

8.EE.1 Know and apply the properties of integer exponents to generate equivalent numerical expressions.

8.EE.2 Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational.

8.F.3 Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear.

Connections to Other DCIs in Eighth Grade

MS.PS2.A

Articulation to DCIs across Grade-Bands

4.PS3.B

8-PS3 Energy

Students who demonstrate understanding can:

8-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

Assessment Boundary: Assessment is limited to two objects and the electric, magnetic, and gravitational interactions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 6-8 builds on K-5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms.	**PS1.A Definitions of Energy** • A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C Relationship Between Energy and Forces** • When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	**Systems and System Models** • Models can be used to represent systems and their interactions - such as inputs, processes, and outputs - and energy and matter flows within systems.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Components of the model

a. To make sense of a given phenomenon involving two objects interacting at a distance, students develop a model in which they identify the relevant components, including:
   - A system of two stationary objects that interact.
   - Forces (electric, magnetic, or gravitational) through which the two objects interact.
   - Distance between the two objects.
   - Potential energy.

2. Relationships

a. In the model, students identify and describe relationships between components, including:
   - When two objects interact at a distance, each one exerts a force on the other that can cause energy to be transferred to or from the object.
   - As the relative position of two objects (neutral, charged, magnetic) changes, the potential energy of the system (associated with interactions via electric, magnetic, and gravitational forces) changes (e.g., when a ball is raised, energy is stored in the gravitational interaction between the Earth and the ball).

3. Connections

a. Students use the model to provide a causal account for the idea that the amount of potential energy in a system of objects changes when the distance between stationary objects interacting in the system changes because:
   - A force has to be applied to move two attracting objects farther apart, transferring energy to the system.
   - A force has to be applied to move two repelling objects closer together, transferring energy to the system.

Guided Questions
• How can a model be used to determine what factors can affect the potential energy of an object? • How can the kinetic energy of one object be used to change the potential energy of a second object?
Catholic Identity Connections
• Refer to Catholic Identity section in the standard above (8-PS3-1).
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **SL.8.5** Include multimedia components and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
Connections to Other DCIs in Eighth Grade
N/A
Articulation to DCIs across Grade-Bands
N/A

<table>
<tr><th colspan="3">8-PS3 Energy</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
8-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.
Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
• Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.</td><td>PS3.A Definitions of Energy
• Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.

PS3.B Conservation of Energy and Energy Transfer
• Energy is spontaneously transferred out of hotter regions or objects and into colder ones.

ETS1.A Defining and Delimiting an Engineering Problem
• The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary emphasis)

ETS1.B Developing Possible Solutions
• A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary emphasis)</td><td>Energy and Matter
• The transfer of energy can be tracked as energy flows through a designed or natural system.</td></tr>
</table>

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Using scientific knowledge to generate design solutions

a. Given a problem to solve that requires either minimizing or maximizing thermal energy transfer, students design and build a solution to the problem. In the design, students:
   - Identify that thermal energy is transferred from hotter objects to colder objects.
   - Describe different types of materials used in the design solution and their properties (e.g., thickness, heat conductivity, reflectivity) and how these materials will be used to minimize or maximize thermal energy transfer.
   - Specify how the device will solve the problem.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe the given criteria and constraints that will be taken into account in the design solution:
   - Students describe criteria, including:
     - The minimum or maximum temperature difference that the device is required to maintain.
     - The amount of time that the device is required to maintain this difference.
     - Whether the device is intended to maximize or minimize the transfer of thermal energy.
   - Students describe constraints, which may include:
     - Materials.
     - Safety.
     - Time.
     - Cost.

3. Evaluating potential solutions

a. Students test the device to determine its ability to maximize or minimize the flow of thermal energy, using the rate of temperature change as a measure of success.
b. Students use their knowledge of thermal energy transfer and the results of the testing to evaluate the design systematically against the criteria and constraints.

Guided Questions

- What materials are best for minimizing or maximizing thermal energy transfer?
- Using data from a trial, what changes can be made to the device to improve efficiency?

Catholic Identity Connections

- Refer to Catholic Identity section in the standard above (8-PS3-1).

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Connections to Other DCIs in Eighth Grade

MS.PS1.B; MS.ESS2.A; MS.ESS2.C; MS.ESS2.D

Articulation to DCIs across Grade-Bands

4.PS3.B

8.PS3 Energy

Students who demonstrate understanding can:

8-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.

Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Plan an investigation individually and collaboratively, and in the design, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS3.A Definitions of Energy** • Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. **PS3.B Conservation of Energy and Energy Transfer** • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.	**Scale, Proportion, and Quantity** • Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Identifying the phenomenon under investigation

a. Students identify the phenomenon under investigation involving thermal energy transfer.
b. Students describe the purpose of the investigation, including determining the relationships among the following factors:
   - The transfer of thermal energy.
   - The type of matter.
   - The mass of the matter involved in thermal energy transfer.
   - The change in the average kinetic energy of the particles.

2. Identifying the evidence to address the purpose of the investigation

a. Individually or collaboratively, students develop an investigation plan that describes the data to be collected and the evidence to be derived from the data, including:
   - That the following data are to be collected:
     - Initial and final temperatures of the materials under investigation.
     - Types of matter used in the investigation.
     - Mass of matter used in the investigation.
   - How the collected data will be used to:
     - Provide evidence of proportional relationships between changes in temperatures of materials and the mass of those materials.
     - Relate the changes in temperature in the sample to the types of matter and to the change in the average kinetic energy of the particles.

3. Planning the investigation

a. In the investigation plan, students describe:
   - How the mass of the materials are to be measured and in what units.
   - How and when the temperatures of the materials are to be measured and in what units.
   - Details of the experimental conditions that will allow the appropriate data to be collected to address the purpose of the investigation (e.g., time between temperature measurements, amounts of sample used, types of materials used), including appropriate independent and dependent variables and controls.

Guided Questions

- How can the thermal energy of one substance be transferred to another substance?
- How can real-world scenarios explain the relationship between energy, matter, and mass?

Catholic Identity Connections

- Refer to Catholic Identity section in the standard above (8-PS3-1.)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Mathematics

MP.2 Reason abstractly and quantitatively.

6.SP.5 Summarize numerical data sets in relation to their context.

Connections to Other DCIs in Eighth Grade

MS.PS2.A

Articulation to DCIs across Grade-Bands

4.PS3.C

8-PS3 Energy

Students who demonstrate understanding can:

8-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.

Assessment Boundary: Assessment does not include calculations of energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. • Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS3.B Conservation of Energy and Energy Transfer** • When the motion energy of an object changes, there is inevitably some other change in energy at the same time.	**Energy and Matter** • Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).

Examples of Observable Evidence of Student Performance by the End of Eighth Grade

1. Supported claims

a. Students make a claim about a given explanation or model for a phenomenon. In their claim, students include the idea that when the kinetic energy of an object changes, energy is transferred to or from that object.

2. Identifying scientific evidence

a. Students identify and describe the given evidence that supports the claim, including the following when appropriate:
- The change in observable features (e.g., motion, temperature, sound) of an object before and after the interaction that changes the kinetic energy of the object.
- The change in observable features of other objects or the surroundings in the defined system.

3. Evaluating and critiquing the evidence

a. Students evaluate the evidence and identify its strengths and weaknesses, including:
- Types of sources.
- Sufficiency, including validity and reliability, of the evidence to make and defend the claim.
- Any alternative interpretations of the evidence and why the evidence supports the given claim as opposed to any other claims.

4. Reasoning and synthesis

a. Students use reasoning to connect the necessary and sufficient evidence and construct the argument. Students describe a chain of reasoning that includes:
- Based on changes in the observable features of the object (e.g., motion, temperature), the kinetic energy of the object changed.
- When the kinetic energy of the object increases or decreases, the energy (e.g., kinetic, thermal, potential) of other objects or the surroundings within the system increases or decreases, indicating that energy was transferred to or from the object.

b. Students present oral or written arguments to support or refute the given explanation or model for the phenomenon.

Guided Questions

- What evidence is needed to support the claim that energy is transferred between two substances or objects?

Catholic Identity Connections

- Refer to Catholic Identity section in the standard above (8-PS3-1.)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.1 Write arguments focused on discipline-specific content.

Mathematics

MP.2 Reason abstractly and quantitatively.

6.RP.1 Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities.

7.RP.2 Recognize and represent proportional relationships between quantities.

8.F.3 Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear.

Connections to Other DCIs in Eighth Grade

MS.PS2.A

Articulation to DCIs across Grade-Bands

4.PS3.C

8-PS4 Waves and Their Applications in Technologies for Information Transfer		
Students who demonstrate understanding can: **8-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.** Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 6-8 level builds on K-5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. **Connections to Nature of Science** **Scientific Knowledge Is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations.	**PS4.A Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	**Patterns** • Graphs and charts can be used to identify patterns in data.

Examples of Observable Evidence of Student Performance by the End of Eighth Grade
1. Representation
a. Students identify the characteristics of a simple mathematical wave model of a phenomenon, including: • Waves represent repeating quantities. • Frequency, as the number of times the pattern repeats in a given amount of time (e.g., beats per second). • Amplitude, as the maximum extent of the repeating quantity from equilibrium (e.g., height or depth of a water wave from average sea level). • Wavelength, as a certain distance in which the quantity repeats its value (e.g., the distance between tops of a series of water waves).
2. Mathematical modeling
a. Students apply the simple mathematical wave model to a physical system or phenomenon to identify how the wave model characteristics correspond with physical observations (e.g., frequency corresponds to sound pitch, amplitude corresponds to sound volume).
3. Analysis
a. Given data about a repeating physical phenomenon that can be represented as a wave, and amounts of energy present or transmitted, students use their simple mathematical wave models to identify patterns, including: • That the energy of the wave is proportional to the square of the amplitude (e.g., if the height of a water wave is doubled, each wave will have four times the energy). • That the amount of energy transferred by waves in a given time is proportional to frequency (e.g., if twice as many water waves hit the shore each minute, then twice as much energy will be transferred to the shore).

b. Students predict the change in the energy of the wave if any one of the parameters of the wave is changed.

Guided Questions

- How can the relationship between frequency and wavelength be represented in a graph?

Catholic Identity Connections

- Refer to Catholic Identity section in the standard above (8-PS3-1.)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
SL.8.5 Include multimedia components and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Mathematics
MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems.
7.RP.2 Recognize and represent proportional relationships between quantities.
8.F.3 Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear.

Connections to Other DCIs in Eighth Grade

N/A

Articulation to DCIs across Grade-Bands

4.PS3.A; 4.PS3.B; 4.PS4.A

8-PS4 Waves and Their Applications in Technologies for Information Transfer		
Students who demonstrate understanding can: **8-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.** Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions. Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena.	**PS4.A Wave Properties** • A sound wave needs a medium through which it is transmitted. **PS4.B Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. • A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. • However, because light can travel through space, it cannot be a matter wave, like sound or water waves.	**Structure and Function** • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.
Examples of Observable Evidence of Student Performance by the End of Eighth Grade		
1. Components of the model		

a. Students develop a model to make sense of a given phenomenon. In the model, students identify the relevant components, including:
• Type of wave.
    • Matter waves (e.g., sound or water waves) and their amplitudes and frequencies.
    • Light, including brightness (amplitude) and color (frequency).
• Various materials through which the waves are reflected, absorbed, or transmitted.
• Relevant characteristics of the wave after it has interacted with a material) e.g., frequency, amplitude, wavelength).
• Position of the source of the wave.		

2. Relationships

a. In the model, students identify and describe the relationships between components, including:
   - Waves interact with materials by being:
     - Reflected.
     - Absorbed.
     - Transmitted.
   - Light travels in straight lines, but the path of light is bent at the interface between materials when it travels from one material to another.
   - Light does not require a material for propogation (e.g., space), but matter waves do require a material for propagation.

3. Connections

a. Students use their model to make sense of given phenomena involving reflection, absorption, or transmission properties of different materials for light and matter waves.
b. Students use their model about phenomena involving light and/or matter waves to describe the differences between how light and matter waves interact with different materials.
c. Students use the model to describe why materials with certain properties are well-suited for particular functions (e.g., lenses and mirrors, sound absorbers in concert halls, colored light filters, sound barriers next to highways).

Guided Questions

- How can waves be transmitted, absorbed, or reflected through various materials?
- How can these waves be represented in real-world examples?

Catholic Identity Connections

- A sound wave needs a medium through which it is transmitted. God needs a medium through which his love is transmitted. Jesus, God's Son, was the perfect medium to transmit God's love into the world; he was God's voice. Through the teachings and example of Jesus, we too can become God's voice in the world.
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. God's light shone perfectly through Jesus, the Light of the World. How is God's light reflected, absorbed or transmitted through us?

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.8.5 Include multimedia components and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Connections to Other DCIs in Eighth Grade

MS.LS1.D

Articulation to DCIs across Grade-Bands

4.PS4.B

<table>
<tr><th colspan="3">8-PS4 Waves and Their Applications in Technologies for Information Transfer</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
8-PS4-3 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.
Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in Wi-Fi devices, and conversion of stored binary patterns to make sound or text on a computer screen.
Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods.
• Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings.</td><td>PS4.C Information Technologies and Instrumentation
• Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.</td><td>Structure and Function
• Structures can be designed to serve particular functions.

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
• Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.

Connections to Nature of Science

Science Is a Human Endeavor
• Advances in technology influence the progress of science and science has influenced advances in technology.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of Eighth Grade</th></tr>
<tr><td colspan="3">1. Obtaining information</td></tr>
<tr><td colspan="3">a. Given materials from a variety of different types of sources of information (e.g., texts, graphical, video, digital), students gather evidence sufficient to support a claim about a phenomenon that includes the idea that using waves to carry digital signals is a more reliable way to encode and transmit information than using waves to carry analog signals.</td></tr>
</table>

2. Evaluating information

a. Students combine the relevant information (from multiple sources) to support the claim by describing:
   - Specific features that make digital transmission of signals more reliable than analog transmission of signals, including that, when in digitized form, information can be:
     - Recorded reliably.
     - Stored for future recovery.
     - Transmitted over long distances without significant degradation.
   - At least one technology that uses digital encoding and transmissions of information. Students should describe how the digitization of that technology has advanced science and scientific investigations (e.g., digital probes, including thermometers and pH probes; audio recordings).

Guided Questions

- How have advances in technology influenced the progress of science and how have advances in science influenced the progress of technology?

Catholic Identity Connections

- Digitized signals are a more reliable way to encode and transmit information. The Scriptures, the Catholic Church and the sacraments are a reliable way to encode and transmit the message of God to his people.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

Connections to Other DCIs in Eighth Grade

N/A

Articulation to DCIs across Grade-Bands

4.PS4.C

High School Engineering Design

HS-ETS1 **Engineering Design**

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Catholic Identity

- The focus of the High School Engineering Design Science Standards is on solving real world, global challenges.
- Excerpts from "Engineering as a Calling" (http://www.cis.org.uk/upload/Resources/Students/Engineering_text_only.pdf):

"As the former US President and mining engineer Herbert Hoover wrote, '[Engineering] is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes… Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege.'

Hoover's quote provides a good definition of what an engineer is, but the Christian engineer's highest priority and primary motivation is to glorify God. A Christian engineer is someone who uses their God given gifts of specialist technical knowledge and practical abilities to transform creation into an image of what the new creation will be like, so that God is glorified and society is improved (Matthew 5:16, Jeremiah 29:7).

Many of the technological challenges described in Scripture are on very large scales: Noah's ark, building the temple, reconstruction of the walls of Jerusalem and so on. However, in all these cases the emphasis was on the heart of the individual. Local skill and labor was used, particularly in rebuilding the walls of Jerusalem (Nehemiah 3). In the construction of the tabernacle, specific tasks were undertaken by Spirit-filled craftsmen (Exodus 31:1-11). The status of craftsmen depended entirely on their God-given talents and to what use they put them to. Conversely, craftsmen who make idols are described as 'nothing but men' who 'will be brought down to terror and infamy.' (Isaiah 44:11).

When Paul visited Athens (Acts 17:16-34) it was among the most advanced cities at the time. Even today the ruins remain a testament to the Athenians' skill. In his commentary on Acts, John Stott says that Paul "might have been spellbound by the sheer splendor of the city's architecture, history and wisdom." However Paul saw past their works to their hearts and recognized that they did not glorify God. Paul placed particular emphasis and value on working with the hands (1 Corinthians 4:12, Ephesians 4:28, 1 Thessalonians 4:11) and demonstrated his flexibility in supporting his preaching ministry with practical work including tent making as the need arose.

'… But what of deeds without faith – a category which could incorporate much of modern engineering?' In 1 Corinthians 13: 1-13, we read that even great works of charity are meaningless without Faith, Hope and Love. The greatest technological engineering project will not succeed without a complete appreciation of the social purpose and the spiritual dimension. The Tower of Babel (Genesis 11) gives a strong case study of the folly of Christians in Science (www.cis.org.uk) embarking on a civil engineering project with cutting-edge technologies whilst ignoring God "Come, let us build ourselves a city, with a tower that reaches to the heavens, so that we may make a name for ourselves'. (Genesis 11:4b)." [S]

Catholic/Christian Scientists

- Johannes Gutenberg (Inventor of the printing press)
- Sr. Mary Kenneth Keller (Sister of Charity and first American woman to earn a PhD in computer science, helped develop BASIC)

Saints [SA]

- St. Patrick, patron saint of engineers

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9– 12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the problem to be solved

a. Students analyze a major global problem. In their analysis, students:
   - Describe the challenge with a rationale for why it is a major global challenge;
   - Describe, qualitatively and quantitatively, the extent and depth of the problem and its major consequences to society and/or the natural world on both global and local scales if it remains unsolved; and
   - Document background research on the problem from two or more sources, including research journals

2. Defining the process or system boundaries, and the components of the process or system

a. In their analysis, students identify the physical system in which the problem is embedded, including the major elements and relationships in the system and boundaries so as to clarify what is and is not part of the problem.

b. In their analysis, students describe societal needs and wants that are relative to the problem (e.g., for controlling CO2 emissions, societal needs include the need for cheap energy).

3. Defining the criteria and constraints

a. Students specify qualitative and quantitative criteria and constraints for acceptable solutions to the problem.

Catholic Identity Connections

- Connections might be made to one or more of the themes of Catholic Social Teaching, depending upon the challenge or problem to be solved. [CST]
    1. Life and Dignity of the Human Person
    2. Call to Family, Community, and Participation
    3. Rights and Responsibilities
    4. Option for the Poor and Vulnerable
    5. The Dignity of Work and the Rights of Workers
    6. Solidarity
    7. Care of God's Creation
- The following Newman Society Standards might also be addressed:
    - Life and Dignity of the Human Person
        - Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
        - Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
        - Demonstrate an understanding of the moral issues involving in vitro fertilization, human cloning, human genetic manipulation, and human experimentation and what the Church teaches regarding work in these areas. [CS S.712 IS17]
- Science
    - Analyze how the pursuit of scientific knowledge, for utilitarian purposes alone or for the misguided manipulation of nature, thwarts the pursuit of authentic Truth and the greater glory of God. [CS S.712 IS3]
- Creation
    - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
    - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
    - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
    - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs

Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems include: Physical Science: HS-PS2-3, HS-PS3-3

Connections to HS-ETS1.B: Developing Possible Solutions Problems include: Earth and Space Science: HS-ESS3-2, HS-ESS3-4, Life Science: HS-LS2-7, HS-LS4-6

Connections to MS-ETS1.C: Optimizing the Design Solution include: Physical Science: HS-PS1-6, HS-PS2-3

Articulation to DCIs across Grade-Bands

MS.ETS1.A; MS.ETS1.B

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Design a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed.	

Examples of Observable Evidence of Student Performance by the End of the Course

1. Using scientific knowledge to generate the design solution

a. Students restate the original complex problem into a finite set of two or more sub-problems (in writing or as a diagram or flow chart).
b. For at least one of the sub-problems, students propose two or more solutions that are based on student-generated data and/or scientific information from other sources.
c. Students describe how solutions to the sub-problems are interconnected to solve all or part of the larger problem.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe criteria and constraints for the selected sub-problem.
b. Students describe the rationale for the sequence of how sub-problems are to be solved, and which criteria should be given highest priority if tradeoffs must be made.

3. Defining the criteria and constraints

b. Students specify qualitative and quantitative criteria and constraints for acceptable solutions to the problem.

Catholic Identity Connections

- Connections might be made to one or more of the themes of Catholic Social Teaching, depending upon the challenge or problem to be solved.
- Please see the Newman Society Standards listed above for HS-ETS1-1

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics
MP.4 Model with mathematics.

Connections to Other DCIs

Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems include: Physical Science: HS-PS2-3, HS-PS3-3
Connections to HS-ETS1.B: Developing Possible Solutions Problems include: Earth and Space Science: HS-ESS3-2, HS-ESS3-4, Life Science: HS-LS2-7, HS-LS4-6
Connections to MS-ETS1.C: Optimizing the Design Solution include: Physical Science: HS-PS1-6, HS-PS2-3

Articulation to DCIs across Grade-Bands

MS.ETS1.A; MS.ETS1.B; MS.ETS1.C

HS-ETS1 Engineering Design		
Students who demonstrate understanding can: **HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Evaluating potential solutions

a. In their evaluation of a complex real-world problem, students:
- Generate a list of three or more realistic criteria and two or more constraints, including such relevant factors as cost, safety, reliability, and aesthetics that specifies an acceptable solution to a complex real-world problem;
- Assign priorities for each criterion and constraint that allows for a logical and systematic evaluation of alternative solution proposals;
- Analyze (quantitatively where appropriate) and describe the strengths and weaknesses of the solution with respect to each criterion and constraint, as well as social and cultural acceptability and environmental impacts;
- Describe possible barriers to implementing each solution, such as cultural, economic, or other sources of resistance to potential solutions; and
- Provide an evidence-based decision of which solution is optimum, based on prioritized criteria, analysis of the strengths and weaknesses (costs and benefits) of each solution, and barriers to be overcome.

2. Refining and/or optimizing the design solution

a. In their evaluation, students describe which parts of the complex real-world problem may remain even if the proposed solution is implemented.

Catholic Identity Connections

- Connections might be made to one or more of the themes of Catholic Social Teaching, depending upon the challenge or problem to be solved.
- Please see the Newman Society Standards listed above for HS-ETS1-1

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.

Connections to Other DCIs

Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems include: Physical Science: HS-PS2-3, HS-PS3-3
Connections to HS-ETS1.B: Developing Possible Solutions Problems include: Earth and Space Science: HS-ESS3-2, HS-ESS3-4 Life Science: HS-LS2-7, HS-LS4-6
Connections to MS-ETS1.C: Optimizing the Design Solution include: Physical Science: HS-PS1-6, HS-PS2-3

Articulation to DCIs across Grade-Bands

MS.ETS1.A; MS.ETS1.B

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**ETS1.B: Developing Possible Solutions** • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify the following components from a given computer simulation:
   - The complex real-world problem with numerous criteria and constraints;
   - The system that is being modeled by the computational simulation, including the boundaries of the systems;
   - What variables can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions; and
   - The scientific principle(s) and/or relationship(s) being used by the model.

2. Computational Modeling

a. Students use the given computer simulation to model the proposed solutions by:
   - Selecting logical and realistic inputs; and
   - Using the model to simulate the effects of different solutions, tradeoffs, or other decisions.

3. Analysis

a. Students compare the simulated results to the expected results.
b. Students interpret the results of the simulation and predict the effects of the proposed solutions within and between systems relevant to the problem based on the interpretation.
c. Students identify the possible negative consequences of solutions that outweigh their benefits.
d. Students identify the simulation's limitations.

Catholic Identity Connections

- Connections might be made to one or more of the themes of Catholic Social Teaching, depending upon the challenge or problem to be solved.
- Please see the Newman Society Standards listed above for HS-ETS1-1

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs

Connections to HS-ETS1.A: Defining and Delimiting Engineering Problems include: Physical Science: HS-PS2-3, HS-PS3-3

Connections to HS-ETS1.B: Developing Possible Solutions Problems include: Earth and Space Science: HS-ESS3-2, HS-ESS3-4, Life Science: HS-LS2-7, HS-LS4-6

Connections to MS-ETS1.C: Optimizing the Design Solution include: Physical Science: HS-PS1-6, HS-PS2-3

Articulation to DCIs across Grade-Bands

N/A

High School Physical Science Standards	
HS-PS1	**Matter and its Interactions**
HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS-PS1-8	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
HS-PS2	**Motion and Stability: Forces and Interactions**
HS-PS2-1	Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-2	Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3	Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
HS-PS2-4	Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5	Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-PS3	**Energy**
HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
HS-PS3-3	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-PS4	**Waves and their Applications in Technologies for Information Transfer**
HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS4-2	Evaluate questions about the advantages of using a digital transmission and storage of information.
HS-PS4-3	Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
HS-PS4-4	Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
HS-PS4-5	Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Catholic Identity

- As we move through the physical science standards, we may want to introduce students to some of the larger questions articulated in the following document:
  - **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness**

    "One method of assisting students to keep focus on these aspects of Catholic intellectual inquiry is to use the lenses of truth, goodness, and beauty to evaluate a subject under consideration… Which of these (i.e., poems, experiments, proofs, theories, people, functions, concepts) is more beautiful and why? What does this reveal about the nature of what is seen? Where is there unity and wholeness here? Where is there proportion and harmony here? How does this reveal God's graciousness, presence, and transcendence?

    When we explore issues of goodness with our students, we are fundamentally asking them to consider questions of how well someone or something fulfills its purpose. Goodness is understood as the perfection of being. A thing is good to the degree that it enacts and perfects those powers, activities, and capacities appropriate to its nature and purpose. What is this thing's purpose/end? What do we know from our senses and reason? From nature and natural law? What do we know from revelation? What makes this a good thing?

    A simple definition for truth is the mind being in accord with reality. We seek always to place our students and ourselves in proper relationship with the truth. Nothing we do can ever be opposed to the truth, that is, opposed to reality which has its being in God. Catholics hold that when our senses are in good condition and functioning properly under normal circumstances, and when our reason is functioning honestly and clearly, we can come to know reality and have the ability to make true judgments about reality. Is it true? Is our mind/concept in accord with reality? Are we looking at this clearly and with our senses and reason properly attuned? Is the thinking rational and logical? Is the information and reasoning clear and precise? …How does this square with what we know from revelation? If there is a disconnect, where further shall we explore?"

Catholic/Christian Scientists

- Physics
  - Roger Bacon (Franciscan friar and early advocate of the scientific method)
  - Blaise Pascal (mathematician, physicist, inventor)
  - Francesco Lana de Terzi (Jesuit priest, aeronautics)
  - Marin Mersenne (acoustics)
  - André-Marie Ampère (electromagnetism)
  - Antoine César Becquerel (electric and luminescent phenomena)
  - Vincenzo Viviani (Viviani's theorem, Viviani's curve and his work in determining the speed of sound)
  - Hippolyte Fizeau (the velocity of light)
  - Guglielmo Marconi (long-distance radio transmission)
  - Alessandro Volta (invention of the battery)
  - André-Marie Ampère (electromagnetism)
  - Sr. Mary Kenneth Keller (Sister of Charity and first American woman to earn a PhD in computer science, helped develop BASIC)

Saints [SA]

- St. Albert the Great (Albertus Magnus), patron saint of scientists
- St. Isadore of Seville, patron saint of computer scientists and the Internet

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.

Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Use a model to predict the relationships between systems or between components of a system.	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. From the given model, students identify and describe the components of the model that are relevant for their predictions, including:
- Elements and their arrangement in the periodic table;
- A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;
- Electrons in the outermost energy level of atoms (i.e., valence electrons); and
- The number of protons in each element.

2. Relationships

a. Students identify and describe the following relationships between components in the given model, including:
- The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.
- Elements in the periodic table are arranged by the numbers of protons in atoms.

3. Connections

a. Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.

b. Students predict the following patterns of properties:
- The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;
- The number and charges in stable ions that form from atoms in a group of the periodic table;
- The trend in reactivity and electronegativity of atoms down a group, and across a row in the periodic table, based on attractions of outermost (valence) electrons to the nucleus; and
- The relative sizes of atoms both across a row and down a group in the periodic table.

Catholic Identity Connections

- The Trinity reveals a relational God. It reminds us that everything in the universe is created and sustained by relationships. Relatedness is the essence of God and calls us into relationship with God and each other. The imprint of the Trinity can be found at the heart of creation. Matter is made of atoms, which are comprised of protons, neutrons and electrons (the atom is composed of three essential components like the Trinity is composed of three Gods in One). What happens to God's creation if you split these apart?
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

Connections to Other DCIs

HS.LS1.C

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.
Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**PS1.A: Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. **PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Articulating the explanation of phenomena

a. Students construct an explanation of the outcome of the given reaction, including:
   - The idea that the total number of atoms of each element in the reactant and products is the same;
   - The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity;
   - The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on their position in the periodic table; and
   - A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons).

2. Evidence

a. Students identify and describe the evidence to construct the explanation, including:
   - Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons;
   - Identification that the number and types of atoms are the same both before and after a reaction;
   - Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products;
   - The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic level as determined by using the periodic table; and
   - The outermost (valence) electron configuration and the relative electronegativity of the atoms that make up both the reactants and the products of the reaction based on their position in the periodic table.

3. Reasoning

a. Students describe their reasoning that connects the evidence, along with the assumption that theories and laws that describe their natural world operate today as they did in the past and will continue to do so in the future, to construct an explanation for how the patterns of outermost electrons and the electronegativity of elements can be used to predict the number and types of bonds each element forms.

b. In the explanation, students describe the causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.

3. Revising the explanation

a. Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.

Catholic Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Mathematics

N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.LS1.C; HS.ESS2.C

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.

Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS1.A: Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the phenomenon to be investigated

a. Students describe the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.

2. Identifying the evidence to answer this question

a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.

b. Students describe why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions:
   - The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).
   - Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.
   - The patterns of interactions between particles at the molecular scale are reflected in the patterns of behavior at the macroscopic scale.
   - Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.

3. Planning for the investigation

a. In the investigation plan, students include:
   - A rationale for the choice of substances to compare and a description of the composition of those substances at the atomic molecular scale.
   - A description of how the data will be collected, the number of trials, and the experimental set up and equipment required.

b. Students describe how the data will be collected, the number of trials, the experimental set up, and the equipment required.

4. Collecting the data

a. Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.

5. Refining the design

a. Students evaluate their investigation, including evaluation of:
   - Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation; and
   - The ability of the data to provide the evidence required.

b. If necessary, students refine the plan to produce more accurate, precise, and useful data.

Catholic Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS2.B

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.

Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS1.A: Structure and Properties of Matter** • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students use evidence to develop a model in which they identify and describe the relevant components, including:
   - The chemical reaction, the system, and the surroundings under study;
   - The bonds that are broken during the course of the reaction;
   - The bonds that are formed during the course of the reaction;
   - The energy transfer between the systems and their components or the system and surroundings;
   - The transformation of potential energy from the chemical system interactions to kinetic energy in the surroundings (or vice versa) by molecular collisions; and
   - The relative potential energies of the reactants and the products.

2. Relationships

a. In the model, students include and describe the relationships between components, including:
   - The net change of energy within the system is the result of bonds that are broken and formed during the reaction (Note: This does not include calculating the total bond energy changes.);
   - The energy transfer between system and surroundings by molecular collisions;
   - The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings (Note: This does not include calculating the total bond energy changes.); and
   - The release or absorption of energy depends on whether the relative potential energies of the reactants and products decrease or increase.

3. Connections

a. Students use the developed model to illustrate:
   - The energy change within the system is accounted for by the change in the bond energies of the reactants and products. (Note: This does not include calculating the total bond energy changes.)
   - Breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings.
   - The energy transfer between systems and surroundings is the difference in energy between the bond energies of the reactants and the products.
   - The overall energy of the system and surroundings is unchanged (conserved) during the reaction.
   - Energy transfer occurs during molecular collisions.
   - The relative total potential energies of the reactants and products can be accounted for by the changes in bond energy.

Catholic Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.4 Model with mathematics.

N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.A; HS.PS3.B; HS.PS3.D; HS.LS1.C

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B; MS.PS2.B; MS.PS3.D; MS.LS1.C

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.

Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Articulating the explanation of phenomena

a. Students construct an explanation that includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.

2. Evidence

a. Students identify and describe evidence to construct the explanation, including:
   - Evidence (e.g., from a table of data) of a pattern that increases in concentration (e.g., a change in one concentration while the other concentration is held constant) increase the reaction rate, and vice versa; and
   - Evidence of a pattern that increases in temperature usually increase the reaction rate, and vice versa.

3. Reasoning

a. Students use and describe the following chain of reasoning that integrates evidence, facts, and scientific principles to construct the explanation:
   - Molecules that collide can break bonds and form new bonds, producing new molecules.
   - The probability of bonds breaking in the collision depends on the kinetic energy of the collision being sufficient to break the bond, since bond breaking requires energy.
   - Since temperature is a measure of average kinetic energy, a higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.
   - At a fixed concentration, molecules that are moving faster also collide more frequently, so molecules with higher kinetic energy are likely to collide more often.
   - A high concentration means that there are more molecules in a given volume and thus more particle collisions per unit of time at the same temperature.

Catalogue Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics

MP.2	Reason abstractly and quantitatively.
N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.A

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B; MS.PS2.B; MS.PS3.A ; MS.PS3.B

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Clarification Statement: Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Refine a solution to a complex real- world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS1.B: Chemical Reactions** • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade- offs) may be needed. (secondary)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Using scientific knowledge to generate the design solution

a. Students identify and describe potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium. Students use evidence to describe the relative quantities of a product before and after changes to a given chemical reaction system (e.g., concentration increases, decreases, or stays the same), and will explicitly use Le Chatelier's principle, including:
   - How, at a molecular level, a stress involving a change to one component of an equilibrium system affects other components;
   - That changing the concentration of one of the components of the equilibrium system will change the rate of the reaction (forward or backward) in which it is a reactant, until the forward and backward rates are again equal; and
   - A description of a system at equilibrium that includes the idea that both the forward and backward reactions are occurring at the same rate, resulting in a system that appears stable at the macroscopic level.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe the prioritized criteria and constraints, and quantify each when appropriate. Examples of constraints to be considered are cost, energy required to produce a product, hazardous nature and chemical properties of reactants and products, and availability of resources.

3. Evaluating potential solutions

a. Students systematically evaluate the proposed refinements to the design of the given chemical system. The potential refinements are evaluated by comparing the redesign to the list of criteria (i.e., increased product) and constraints (e.g., energy required, availability of resources).

4. Refining and/or optimizing the design solution

a. Students refine the given designed system by making tradeoffs that would optimize the designed system to increase the amount of product, and describe the reasoning behind design decisions.

Catholic Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]
- We might also consider this standard in terms of the quest to achieve spiritual balance and equilibrium.

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Connections to Other DCIs

HS.PS3.A

Articulation to DCIs across Grade-Bands

MS.PS1.B

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

Assessment Boundary: Assessment does not include complex chemical reactions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to support claims.	**PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the relevant components in the mathematical representations:
   - Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass;
   - Molar mass of all components of the reaction;
   - Use of balanced chemical equation(s); and
   - Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.

b. The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information.

c. Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction.

2. Mathematical modeling

a. Students use the mole to convert between the atomic and macroscopic scale in the analysis.

b. Given a chemical reaction, students use the mathematical representations to
   - Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and
   - Calculate the mass of any component of a reaction, given any other component.

3. Analysis

a. Students describe how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
b. Students describe how the mass of a substance can be used to determine the number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).

Catholic Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N-Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.A; HS.LS1.C ; HS.LS2.B

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B; MS.LS1.C; MS.LS2.B; MS.ESS2.A

HS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.

Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students develop models in which they identify and describe the relevant components of the models, including:
   - Identification of an element by the number of protons;
   - The number of protons and neutrons in the nucleus before and after the decay;
   - The identity of the emitted particles (i.e., alpha, beta — both electrons and positrons, and gamma); and
   - The scale of energy changes associated with nuclear processes, relative to the scale of energy changes associated with chemical processes.

2. Relationships

a. Students develop five distinct models to illustrate the relationships between components underlying the nuclear processes of 1) fission, 2) fusion and 3) three distinct types of radioactive decay.

b. Students include the following features, based on evidence, in all five models:
   - The total number of neutrons plus protons is the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.
   - The scale of energy changes in a nuclear process is much larger (hundreds of thousands or even millions of times larger) than the scale of energy changes in a chemical process.

3. Connections

a. Students develop a fusion model that illustrates a process in which two nuclei merge to form a single, larger nucleus with a larger number of protons than were in either of the two original nuclei.
b. Students develop a fission model that illustrates a process in which a nucleus splits into two or more fragments that each have a smaller number of protons than were in the original nucleus.
c. In both the fission and fusion models, students illustrate that these processes may release energy and may require initial energy for the reaction to take place.
d. Students develop radioactive decay models that illustrate the differences in type of energy (e.g., kinetic energy, electromagnetic radiation) and type of particle (e.g., alpha particle, beta particle) released during alpha, beta, and gamma radioactive decay, and any change from one element to another that can occur due to the process.
e. Students develop radioactive decay models that describe that alpha particle emission is a type of fission reaction, and that beta and gamma emission are not.

Catholic Identity Connections

- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]
- Discussions of nuclear fission and fusion might be connected to nuclear weapons and the ethical issues they raise. Theme 1 of Catholic Social Teaching is Life and Dignity of the Human Person. The United States Conference of Catholic Bishops write, "Catholic teaching also calls on us to work to avoid war. Nations must protect the right to life by finding increasingly effective ways to prevent conflicts and resolve them by peaceful means." [CST]
- This standard might also result in a discussion of the pros, cons, and ethical considerations involved in nuclear energy and environmental stewardship.
- This standard might also be related to the Trinity. The Trinity reveals a relational God. It reminds us that everything in the universe is created and sustained by relationships. Relatedness is the essence of God and calls us into relationship with God and each other. The imprint of the Trinity can be found at the heart of creation. Matter is made of atoms, which are comprised of protons, neutrons and electrons (the atom is composed of three essential components like the Trinity is composed of three Gods in One). What happens to God's creation if you split these apart?

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.4 Model with mathematics.
N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.2 Define appropriate quantities for the purpose of descriptive modeling.
N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.A; HS.PS3.B; HS.PS3.C; HS.PS3.D; HS.ESS1.A; HS.ESS1.C

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B;MS.ESS2.A

HS-PS2 Motion and Stability: Forces and Interactions		
Students who demonstrate understanding can: **HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Assessment Boundary: Assessment is limited to one- dimensional motion and to macroscopic objects moving at non-relativistic speeds.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena.	**PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course
1. Organizing data
a. Students organize data that represent the net force on a macroscopic object, its mass (which is held constant), and its acceleration (e.g., via tables, graphs, charts, vector drawings).
2. Identifying relationships
a. Students use tools, technologies, and/or models to analyze the data and identify relationships within the datasets, including: • A more massive object experiencing the same net force as a less massive object has a smaller acceleration, and a larger net force on a given object produces a correspondingly larger acceleration; and • The result of gravitation is a constant acceleration on macroscopic objects as evidenced by the fact that the ratio of net force to mass remains constant.
3. Interpreting data
a. Students use the analyzed data as evidence to describe that the relationship between the observed quantities is accurately modeled across the range of data by the formula $a = F_{net}/m$ (e.g., double force yields double acceleration, etc.). b. Students use the data as empirical evidence to distinguish between causal and correlational relationships linking force, mass, and acceleration. c. Students express the relationship $F_{net}=ma$ in terms of causality, namely that a net force on an object causes the object to accelerate.

Catholic Identity Connections

- The discoveries of the laws of physics, such as Newton's Laws, prompt us to think about similarities and differences between natural law and God's laws. What are the criteria for each?
- Refer to Catholic Identity portion of the High School Physical Science Standards overview at the beginning of this section.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
WHST.11-12.9	Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A.SSE.1	Interpret expressions that represent a quantity in terms of its context.
A.SSE.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
A.CED.1	Create equations and inequalities in one variable and use them to solve problems.
A.CED.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A.CED.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
F-IF.7	Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases.
S-ID.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).

Connections to Other DCIs

HS.PS3.C; HS.ESS1.A ; HS.ESS1.C; HS.ESS2.C

Articulation to DCIs across Grade-Bands

MS.PS2.A; MS.PS3.C

HS-PS2	**Motion and Stability: Forces and Interactions**	
Students who demonstrate understanding can: **HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.** Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations.	**PS2.A: Forces and Motion** • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.
Examples of Observable Evidence of Student Performance by the End of the Course		
1. Representation a. Students clearly define the system of the two interacting objects that is represented mathematically, including boundaries and initial conditions. b. Students identify and describe the momentum of each object in the system as the product of its mass and its velocity, $p = mv$ (p and v are restricted to one-dimensional vectors), using the mathematical representations. c. Students identify the claim, indicating that the total momentum of a system of two interacting objects is constant if there is no net force on the system.		
2. Mathematical modeling a. Students use the mathematical representations to model and describe the physical interaction of the two objects in terms of the change in the momentum of each object as a result of the interaction. b. Students use the mathematical representations to model and describe the total momentum of the system by calculating the vector sum of momenta of the two objects in the system.		
3. Analysis a. Students use the analysis of the motion of the objects before the interaction to identify a system with essentially no net force on it. b. Based on the analysis of the total momentum of the system, students support the claim that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant. c. Students identify that the analysis of the momentum of each object in the system indicates that any change in momentum of one object is balanced by a change in the momentum of the other object, so that the total momentum is constant.		

Catholic Identity Connections

- Analogy: What energies do we let into our human systems/Christian communities? Are they positive or negative? How are they affected by us?
- How are our human systems/Christian communities affected by interacting with God? Is God affected by us or is he untouchable?
- Explain and promote the unity of faith and reason with confidence that there exists no contradiction between the God of nature and the God of the faith. [CS S.712 GS2]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
- Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A.CED.1	Create equations and inequalities in one variable and use them to solve problems.
A.CED.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A.CED.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Connections to Other DCIs

HS.ESS1.A; HS.ESS1.C; HS.ESS2.C

Articulation to DCIs across Grade-Bands

MS.PS2.A; MS.PS3.C

HS-PS2	**Motion and Stability: Forces and Interactions**	
Students who demonstrate understanding can: **HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.** Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute. Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**PS2.A: Forces and Motion** • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (secondary)	**Cause and Effect** • Systems can be designed to cause a desired effect.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Using scientific knowledge to generate the design solution

a. Students design a device that minimizes the force on a macroscopic object during a collision. In the design, students:
   - Incorporate the concept that for a given change in momentum, force in the direction of the change in momentum is decreased by increasing the time interval of the collision ($F\Delta t = m\Delta v$); and
   - Explicitly make use of the principle above so that the device has the desired effect of reducing the net force applied to the object by extending the time the force is applied to the object during the collision.

b. In the design plan, students describe the scientific rationale for their choice of materials and for the structure of the device.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe and quantify (when appropriate) the criteria and constraints, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost, mass, the maximum force applied to the object, and requirements set by society for widely used collision-mitigation devices (e.g., seatbelts, football helmets).

3. Evaluating potential solutions

a. Students systematically evaluate the proposed device design or design solution, including describing the rationales for the design and comparing the design to the list of criteria and constraints.
b. Students test and evaluate the device based on its ability to minimize the force on the test object during a collision. Students identify any unanticipated effects or design performance issues that the device exhibits.

4. Refining and/or optimizing the design solution

a. Students use the test results to improve the device performance by extending the impact time, reducing the device mass, and/or considering cost-benefit analysis.

Catholic Identity Connections

- Students might look at the idea of balance in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above.
- Explain and promote the unity of faith and reason with confidence that there exists no contradiction between the God of nature and the God of the faith. [CS S.712 GS2]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
- Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.PS2.A; MS.PS3.C

HS-PS2	**Motion and Stability: Forces and Interactions**	
Students who demonstrate understanding can: **HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.** Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. Assessment Boundary: Assessment is limited to systems with two objects.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science. • Laws are statements or descriptions of the relationships among observable phenomena.	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students clearly define the system of the interacting objects that is mathematically represented.
b. Using the given mathematical representations, students identify and describe the gravitational attraction between two objects as the product of their masses divided by the separation distance squared ($F_g = -G\frac{m_1 m_2}{d^2}$), where a negative force is understood to be attractive.
c. Using the given mathematical representations, students identify and describe the electrostatic force between two objects as the product of their individual charges divided by the separation distance squared ($F_e = k\frac{q_1 q_2}{d^2}$), where a negative force is understood to be attractive.

2. Mathematical modeling

a. Students correctly use the given mathematical formulas to predict the gravitational force between objects or predict the electrostatic force between charged objects.

3. Analysis

a. Based on the given mathematical models, students describe that the ratio between gravitational and electric forces between objects with a given charge and mass is a pattern that is independent of distance.
b. Students describe that the mathematical representation of the gravitational field ($F_g = -G\frac{m_1 m_2}{d^2}$) only predicts an attractive force because mass is always positive.
c. Students describe that the mathematical representation of the electric field ($F_e = k\frac{q_1 q_2}{d^2}$) predicts both attraction and repulsion because electric charge can be either positive or negative.
d. Students use the given formulas for the forces as evidence to describe that the change in the energy of objects interacting through electric or gravitational forces depends on the distance between the objects.

Catholic Identity Connections

- Analogy: Fields transfer energy through space. God's love is transferred through space to our open hearts and our prayers transfer the energy of love through space to God.
- Students might look at interconnectivity and fields in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A- Educating to Truth, Beauty, and Goodness** above.
- Explain and promote the unity of faith and reason with confidence that there exists no contradiction between the God of nature and the God of the faith. [CS S.712 GS2]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
- Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
- Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A.SSE.1	Interpret expressions that represent a quantity in terms of its context.
A.SSE.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

Connections to Other DCIs

HS.PS3.A; HS.ESS1.A; HS.ESS1.B; HS.ESS1.C; HS.ESS2.C; HS.ESS3.A

Articulation to DCIs across Grade-Bands

MS.PS2.B; MS.PS3.C; MS.ESS1.B

HS-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. **PS3.A: Definitions of Energy** • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary)	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the phenomenon to be investigated

a. Students describe the phenomenon under investigation, which includes the following idea: that an electric current produces a magnetic field and that a changing magnetic field produces an electric current.

2. Identifying the evidence to answer this question

a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data about 1) an observable effect of a magnetic field that is uniquely related to the presence of an electric current in the circuit, and 2) an electric current in the circuit that is uniquely related to the presence of a changing magnetic field near the circuit. Students describe why these effects seen must be causal and not correlational, citing specific cause-effect relationships.

3. Planning for the investigation

a. In the investigation plan, students include:
   - The use of an electric circuit through which electric current can flow, a source of electrical energy that can be placed in the circuit, the shape and orientation of the wire, and the types and positions of detectors;
   - A means to indicate or measure when electric current is flowing through the circuit;
   - A means to indicate or measure the presence of a local magnetic field near the circuit; and
   - A design of a system to change the magnetic field in a nearby circuit and a means to indicate or measure when the magnetic field is changing.

b. In the plan, students state whether the investigation will be conducted individually or collaboratively.

4. Collecting the data

a. Students measure and record electric currents and magnetic fields.

5. Refining the design

a. Students evaluate their investigation, including an evaluation of:
   - The accuracy and precision of the data collected, as well as limitations of the investigation; and
   - The ability of the data to provide the evidence required.

b. If necessary, students refine the investigation plan to produce more accurate, precise, and useful data such that the measurements or indicators of the presence of an electric current in the circuit and a magnetic field near the circuit can provide the required evidence.

Catholic Identity Connections

- Analogy: There is reciprocity in the functioning of the natural world. There is also reciprocity in the Body of Christ.
- Students might look at reciprocity in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness above.**

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.A; HS.PS3.C;HS.ESS2.A; HS.ESS3.A

Articulation to DCIs across Grade-Bands

MS.PS2.B; MS.ESS1.B

HS-PS2	Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).	**PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Communication style and format

a. Students use at least two different formats (including oral, graphical, textual and mathematical) to communicate scientific and technical information, including fully describing the structure, properties, and design of the chosen material(s). Students cite the origin of the information as appropriate.

2. Connecting the DCIs and the CCCs

a. Students identify and communicate the evidence for why molecular level structure is important in the functioning of designed materials, including:
   - How the structure and properties of matter and the types of interactions of matter at the atomic scale determine the function of the chosen designed material(s); and
   - How the material's properties make it suitable for use in its designed function.

b. Students explicitly identify the molecular structure of the chosen designed material(s) (using a representation appropriate to the specific type of communication — e.g., geometric shapes for drugs and receptors, ball and stick models for long-chained molecules).

c. Students describe the intended function of the chosen designed material(s).

d. Students describe the relationship between the material's function and its macroscopic properties (e.g., material strength, conductivity, reactivity, state of matter, durability) and each of the following:
   - Molecular level structure of the material;
   - Intermolecular forces and polarity of molecules; and
   - The ability of electrons to move relatively freely in metals.

e. Students describe the effects that attractive and repulsive electrical forces between molecules have on the arrangement (structure) of the chosen designed material(s) of molecules (e.g., solids, liquids, gases, network solid, polymers).

f. Students describe that, for all materials, electrostatic forces on the atomic and molecular scale results in contact forces (e.g., friction, normal forces, stickiness) on the macroscopic scale.

Catalic Identity Connections

- Students might look at this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above.
- Students might consider how attraction and repulsion among its members affects the Body of Christ. Sometimes create tension is good, resulting in something new and better. Other times it may be destructive.
- We might also think about the times when Jesus reached out and healed those whom society found as repulsive.

Scripture [S]

- "Ever since the creation of the world, his invisible attributes of eternal power and divinity have been able to be understood and perceived in what he has made." (Romans 1:20)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.11-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS2.B

HS-PS3 Energy

Students who demonstrate understanding can:

HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.

Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system.	**PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **PS3.B: Conservation of Energy and Energy Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. • The availability of energy limits what can occur in any system.	**Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the components to be computationally modeled, including:
   - The boundaries of the system and that the reference level for potential energy = 0 (the potential energy of the initial or final state does not have to be zero);
   - The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in each component), including a quantification in an algebraic description to calculate the total initial energy of the system;
   - The energy flows in or out of the system, including a quantification in an algebraic description with flow into the system defined as positive; and
   - The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system.

2. Computational Modeling

a. Students use the algebraic descriptions of the initial and final energy state of the system, along with the energy flows to create a computational model (e.g., simple computer program, spreadsheet, simulation software package application) that is based on the principle of the conservation of energy.
b. Students use the computational model to calculate changes in the energy of one component of the system when changes in the energy of the other components and the energy flows are known.

3. Analysis

a. Students use the computational model to predict the maximum possible change in the energy of one component of the system for a given set of energy flows.
b. Students identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic descriptions of energy changes and flows in the system.

Catholic Identity Connections

- Analogy: Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. We might think about how we, as Christians, individually and in groups, transport energy to one another, and the quality and effect of our energy upon one another.
- Students might look at this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS1.B; HS.LS2.B; HS.ESS1.A; HS.ESS2.A

Articulation to DCIs across Grade-Bands

MS.PS3.A; MS.PS3.B ; MS.ESS2.A

HS-PS3 Energy		
Students who demonstrate understanding can: **HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).** Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.A: Definitions of Energy** • Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. • That there is a single quantity called energy is due to the fact that a system’s total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**Energy and Matter** • Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.
Examples of Observable Evidence of Student Performance by the End of the Course		
1. Components of the model		
a. Students develop models in which they identify and describe the relevant components, including: • All the components of the system and the surroundings, as well as energy flows between the system and the surroundings; • Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system; and • Depicting the forms in which energy is manifested at two different scales: b. Macroscopic , such as motion, sound, light, thermal energy, potential energy or energy in fields; and c. Molecular/atomic, such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields (potential energy), and energy in fields.		

2. Relationships

a. Students describe the relationships between components in their models, including:
- Changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy).
- Thermal energy includes both the kinetic and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases.
- The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level.
- Chemical energy can be considered in terms of systems of nuclei and electrons in electrostatic fields (bonds).
- As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields.

3. Connections

a. Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system.
b. Students use their models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects on both the macroscopic and microscopic scales.

Catholic Identity Connections

- Analogy: This standard looks at energy flows between the components of the system and the surroundings, as well as energy flows between the system and the surroundings. This is true at the microscopic and macroscopic levels. We might also think about this in terms of energy exchanges between individuals and between the Body of Christ and the world.
- Students might look at this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above.
- Adhere to the idea of the simultaneous complexity and simplicity of physical reality. [CS S.712 DS5]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.

Connections to Other DCIs

HS.PS1.A; HS.PS1.B; HS.PS2.B; HS.ESS2.A

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS2.B; MS.PS3.A; MS.PS3.C

HS-PS3 Energy

Students who demonstrate understanding can:

HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.

Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**PS3.A: Definitions of Energy** • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment. **ETS1.A: Defining and Delimiting an Engineering Problem** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary)	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Using scientific knowledge to generate the design solution

a. Students design a device that converts one form of energy into another form of energy.
b. Students develop a plan for the device in which they:
   - Identify what scientific principles provide the basis for the energy conversion design;
   - Identify the forms of energy that will be converted from one form to another in the designed system;
   - Identify losses of energy by the design system to the surrounding environment;
   - Describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design; and
   - Describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risk.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe and quantify (when appropriate) prioritized criteria and constraints for the design of the device, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost and efficiency of energy conversion.

3. Evaluating potential solutions

a. Students build and test the device according to the plan.
b. Students systematically and quantitatively evaluate the performance of the device against the criteria and constraints.

4. Refining and/or optimizing the design solution

a. Students use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs.

Catholic Identity Connections

- Analogy: Energy can be converted from one form to another. This might provide insight into the Trinity in which the energy of God's being is expressed in the forms or persons of Father, Son and Holy Spirit.
- This standard applies the engineering design process of trial and error, which might also be applied to our spiritual lives. Scripture, tradition, the Church and her sacraments help us to stay focused on God.
- Students might look at energy conversion in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics

MP.2 Reason abstractly and quantitatively.
MP.4 Model with mathematics.
N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.ESS3.A

Articulation to DCIs across Grade-Bands

MS.PS3.A; MS.PS3.B; MS.ESS2.A

HS-PS3 Energy		
Students who demonstrate understanding can: **HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water. Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS3.B: Conservation of Energy and Energy Transfer** • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms — for example, to thermal energy in the surrounding environment.	**Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the phenomenon to be investigated

a. Students describe the purpose of the investigation, which includes the following idea, that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

2. Identifying the evidence to answer this question

a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including:
   - The measurement of the reduction of temperature of the hot object and the increase in temperature of the cold object to show that the thermal energy lost by the hot object is equal to the thermal energy gained by the cold object and that the distribution of thermal energy is more uniform after the interaction of the hot and cold components; and
   - The heat capacity of the components in the system (obtained from scientific literature).

3. Planning for the investigation

a. In the investigation plan, students describe:
   - How a nearly closed system will be constructed, including the boundaries and initial conditions of the system;
   - The data that will be collected, including masses of components and initial and final temperatures; and
   - The experimental procedure, including how the data will be collected, the number of trials, the experimental set up, and equipment required.

4. Collecting the data

a. Students collect and record data that can be used to calculate the change in thermal energy of each of the two components of the system.

5. Refining the design

a. Students evaluate their investigation, including:
   - The accuracy and precision of the data collected, as well as the limitations of the investigation; and
   - The ability of the data to provide the evidence required.

b. If necessary, students refine the plan to produce more accurate, precise, and useful data that address the experimental question.

c. Students identify potential causes of the apparent loss of energy from a closed system (which should be zero in an ideal system) and adjust the design of the experiment accordingly.

Catholic Identity Connections

- Analogy: This standard addresses the transportation and distribution of thermal energy and the tendency of systems to evolve toward more stable states (more uniform energy distribution). The Christian spiritual life is always directed toward a more stable state of union with God. Scripture, tradition, the Church and her sacraments stabilize our sometimes unbalanced lives and move us to greater wholeness and holiness.
- Students might look at the standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.

Connections to Other DCIs

HS.ESS1.A; HS.ESS2.A; HS.ESS2.D

Articulation to DCIs across Grade-Bands

MS.PS3.B

HS-PS3 Energy		
Students who demonstrate understanding can: **HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other. Assessment Boundary: Assessment is limited to systems containing two objects.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed.	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students develop a model in which they identify and describe the relevant components to illustrate the forces and changes in energy involved when two objects interact, including:
   - The two objects in the system, including their initial positions and velocities (limited to one dimension).
   - The nature of the interaction (electric or magnetic) between the two objects.
   - The relative magnitude and the direction of the net force on each of the objects.
   - Representation of a field as a quantity that has a magnitude and direction at all points in space and which contains energy.

2. Relationships

a. In the model, students describe the relationships between components, including the change in the energy of the objects, given the initial and final positions and velocities of the objects.

3. Connections

a. Students use the model to determine whether the energy stored in the field increased, decreased, or remained the same when the objects interacted.
b. Students use the model to support the claim that the change in the energy stored in the field (which is qualitatively determined to be either positive, negative, or zero) is consistent with the change in energy of the objects.
c. Using the model, students describe the cause and effect relationships on a qualitative level between forces produced by electric or magnetic fields and the change of energy of the objects in the system.

Catholic Identity Connections	
• Analogy: We might examine cause and effect in our relationships and the qualities of these effects on others and creation. • Students might look at this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A- Educating to Truth, Beauty, and Goodness** above.	
Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
Mathematics	
MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
Connections to Other DCIs	
HS.PS2.B	
Articulation to DCIs across Grade-Bands	
MS.PS1.A; MS.PS3.C	

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the relevant components in the mathematical representations:
   - Mathematical values for frequency, wavelength, and speed of waves traveling in various specified media; and
   - The relationships between frequency, wavelength, and speed of waves traveling in various specified media.

2. Mathematical modeling

a. Students show that the product of the frequency and the wavelength of a particular type of wave in a given medium is constant, and identify this relationship as the wave speed according to the mathematical relationship ($v = f \bullet \lambda$).
b. Students use the data to show that the wave speed for a particular type of wave changes as the medium through which the wave travels changes.
c. Students predict the relative change in the wavelength of a wave when it moves from one medium to another (thus different wave speeds using the mathematical relationship ($v = f \bullet \lambda$). Students express the relative change in terms of cause (different media) and effect (different wavelengths but same frequency).

3. Analysis

a. Using the mathematical relationship ($v = f \bullet \lambda$), students assess claims about any of the three quantities when the other two quantities are known for waves travelling in various specified media.
b. Students use the mathematical relationships to distinguish between cause and correlation with respect to the supported claims.

Catholic Identity Connections	
• This standard underscores the idea that relationships are fundamental to the processes and functioning of creation. This has implications on many levels. (Refer to the section on "Systems/relational Thinking" in the introduction to Catholic Identity.)	
Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
Mathematics	
MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
A-SSE.1	Interpret expressions that represent a quantity in terms of its context.
A-SSE.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
A.CED.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
Connections to Other DCIs	
HS.ESS2.A	
Articulation to DCIs across Grade-Bands	
MS.PS4.A; MS.PS4.B	

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.

Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set or the suitability of a design.	**PS4.A: Wave Properties** • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**Stability and Change** • Systems can be designed for greater or lesser stability. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems. • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Addressing phenomena or scientific theories

a. Students evaluate the given questions in terms of whether or not answers to the questions would:
   - Provide examples of features associated with digital transmission and storage of information (e.g., can be stored reliably without degradation over time, transferred easily, and copied and shared rapidly; can be easily deleted; can be stolen easily by making a copy; can be broadly accessed); and

b. In their evaluation of the given questions, students:
   - Describe the stability and importance of the systems that employ digital information as they relate to the advantages and disadvantages of digital transmission and storage of information; and
   - Discuss the relevance of the answers to the question to real-life examples (e.g., emailing your homework to a teacher, copying music, using the internet for research, social media).

2. Evaluating empirical testability

a. Students evaluate the given questions in terms of whether or not answers to the questions would provide means to empirically determine whether given features are advantages or disadvantages.

Catholic Identity Connections
• As Catholics it is important to understand effective means of communicating. Accurate transmission of information is important to Catholics in order that the scripture, tradition, and the official teachings of the Church are preserved, properly understood, and passed down to the next generation of young Christian leaders. • Students might look this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above. Truth is particularly pertinent here.
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **RST.9-10.8** Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. **RST.11-12.8** Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
Connections to Other DCIs
N/A
Articulation to DCIs across Grade-Bands
MS.PS4.A; MS.PS4.B; MS.PS4.C

HS-PS4 Waves and Their Applications in Technologies for Information Transfer		
Students who demonstrate understanding can: **HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Assessment Boundary: Assessment does not include using quantum theory.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment. The science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**PS4.A: Wave Properties** • [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) **PS4.B: Electromagnetic Radiation** • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**Systems and System Models** • Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the given explanation and associated claims, evidence, and reasoning

a. Students identify the given explanation that is to be supported by the claims, evidence, and reasoning to be evaluated, and that includes the following idea: Electromagnetic radiation can be described either by a wave model or a particle model, and for some situations one model is more useful than the other.
b. Students identify the given claims to be evaluated.
c. Students identify the given evidence to be evaluated, including the following phenomena:
   - Interference behavior by electromagnetic radiation; and
   - The photoelectric effect.
d. Students identify the given reasoning to be evaluated.

2. Evaluating given evidence and reasoning

a. Students evaluate the given evidence for interference behavior of electromagnetic radiation to determine how it supports the argument that electromagnetic radiation can be described by a wave model.
b. Students evaluate the phenomenon of the photoelectric effect to determine how it supports the argument that electromagnetic radiation can be described by a particle model.
c. Students evaluate the given claims and reasoning for modeling electromagnetic radiation as both a wave and particle, considering the transfer of energy and information within and between systems, and why for some aspects the wave model is more useful and for other aspects the particle model is more useful to describe the transfer of energy and information.

Catholic Identity Connections

- Analogy: Through the Holy Spirit the message of God reaches human hearts uncorrupted.
- The notion that something can act as either a wave or a particle may be related to the Catholic teaching that Jesus was both divine and human.
- Students might look this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A- Educating to Truth, Beauty, and Goodness** above. Truth is particularly pertinent here.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics

MP.2 Reason abstractly and quantitatively.

A-SSE.1 Interpret expressions that represent a quantity in terms of its context.

A-SSE.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.CED.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Connections to Other DCIs

HS.PS3.D; HS.ESS1.A; HS.ESS2.D

Articulation to DCIs across Grade-Bands

MS.PS4.B

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

Assessment Boundary: Assessment is limited to qualitative descriptions.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**PS4.B: Electromagnetic Radiation** • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Obtaining information

a. Students obtain at least two claims proposed in published material (using at least two sources per claim) regarding the effect of electromagnetic radiation that is absorbed by matter. One of these claims deals with the effect of electromagnetic radiation on living tissue.

2. Evaluating information

a. Students use reasoning about the data presented, including the energies of the photons involved (i.e., relative wavelengths) and the probability of ionization, to analyze the validity and reliability of each claim.
b. Students determine the validity and reliability of the sources of the claims.
c. Students describe the cause and effect reasoning in each claim, including the extrapolations to larger scales from cause and effect relationships of mechanisms at small scales (e.g., extrapolating from the effect of a particular wavelength of radiation on a single cell to the effect of that wavelength on the entire organism).

Catholic Identity Connections

- By analogy, this standard invites us to contemplate the effect of God's love upon the fabric of our lives. Cause and effect relationships may also be applied to human interactions. In what ways does our energy damage one another?
- This standard is also concerned with information literacy, which is essential to our Catholic education. Reading the Bible in context and understanding the four senses of scripture -- literal, allegorical, moral and anagogical -- contribute to information literacy within the Catholic tradition.
- Students might look this standard in terms of truth, beauty and goodness. See **Cardinal Newman Society – Excerpts from Appendix A - Educating to Truth, Beauty, and Goodness** above. Truth is particularly pertinent here.

Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
Connections to Other DCIs	
HS.PS1.C; HS.PS3.A; HS.PS3.D; HS.LS1.C	
Articulation to DCIs across Grade-Bands	
MS.PS3.D; MS.PS4.B; MS.PS4.C; MS.LS1.C; MS.ESS2.D	

HS-PS4 Waves and Their Applications in Technologies for Information Transfer		
Students who demonstrate understanding can: **HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.** Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology. Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**PS3.D: Energy in Chemical Processes** • Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary) **PS4.A: Wave Properties** • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. **PS4.B: Electromagnetic Radiation** • Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS4.C: Information Technologies and Instrumentation** • Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	**Cause and Effect** • Systems can be designed to cause a desired effect. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems.

Examples of Observable Evidence of Student Performance by the End of the Course
1. Communication style and format
a. Students use at least two different formats (e.g., oral, graphical, textual, and mathematical) to communicate technical information and ideas, including fully describing at least two devices and the physical principles upon which the devices depend. One of the devices must depend on the photoelectric effect for its operation. Students cite the origin of the information as appropriate.
2. Connecting the DCIs and the CCCs
a. When describing how each device operates, students identify the wave behavior utilized by the device or the absorption of photons and production of electrons for devices that rely on the photoelectric effect, and qualitatively describe how the basic physics principles were utilized in the design through research and development to produce this functionality (e.g., absorbing electromagnetic energy and converting it to thermal energy to heat an object; using the photoelectric effect to produce an electric current). b. For each device, students discuss the real-world problem it solves or need it addresses, and how civilization now depends on the device. c. Students identify and communicate the cause and effect relationships that are used to produce the functionality of the device.
Catholic Identity Connections

• Understanding the technology of solar cells contributes to environmental literacy and can be applied to the 7th theme of Catholic Social Teaching – Care of God's Creation. [CST]
• Creation
    • Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
    • Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
    • Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
    • Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
    • Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
    • Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
• Refer to ***Laudato Si'***, Chapter 2 – "*The Gospel of Creation*" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
Connections to Other DCIs
HS.PS3.A
Articulation to DCIs across Grade-Bands
MS.PS4.A; MS.PS4.B; MS.PS4.C

High School Life Science Standards

HS-LS1 **From Molecules to Organisms: Structures and Processes**

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy**.**
HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.
HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Scripture [S]

- "Before I formed you in the womb, I knew you." (Jeremiah 1:5)
- The Old Testament contains medical information that was very advanced for its time and predates medical discoveries as recent as 100 years ago. Examples of the medical knowledge of the Israelites include:
    - Sanitary practices in the Bible: Numbers 19:3-22, Leviticus11:1-47; 15:1-33, Deuteronomy 23:12.
    - Bacteria: Leviticus 13:52
    - Laws of quarantine: Leviticus 13, 14, 22, Numbers 19:20
    - The first antiseptic – hyssop: Numbers 19:18, Ps 51:7
    - Fetal alcohol syndrome: Judges 13:3-4
    - Dietary guidelines: Genesis 1:29, Genesis 9:3, Leviticus 11

Catholic/Christian Scientists

- Louis Pasteur (bacteriology)
- Gregor Mendel (genetics through plant research), member of the Catholic Truth Society and Knight Commander of the Order of St. Gregory the Great
- Bartolomeo Eustachi (one of the founders of human anatomy)
- Sr. Paula González (biology)
- Antoine Laurent de Jussieu (natural classification of flowering plants)
- Jean-Baptiste Lamarck (his theories on evolution preceded those of Darwin)
- Andreas Vesalius (modern human anatomy)
- Theodor Schwann (theory of the cellular structure of animal organisms)
- Jérôme Lejeune (the link of diseases to chromosome abnormalities)
- Anna Morandi Manzolini (anatomist and anatomical wax artist)
- Leonardo da Vinci (Renaissance anatomist, scientist, mathematician, and painter).

- Botany
  - Carl Linnaeus
  - Stephan Endlicher
  - James Britton
  - Andrea Cesalpino
  - James Britten

Saints [SA]

- The Virgin Mary, said "yes" to Life
- St. Ambrose, patron saint of beekeepers
- St. Ansovinus, patron saint of gardeners
- St. Anthony of Padua, patron saint of harvests and lost animals
- St. Dorothy, patron saint of horticulture
- St. Gall, patron saint of birds
- St. Isadore the Farmer, patron saint of farmers
- St. Phocus, patron saint of gardeners, agricultural workers, farm workers, farmers and field hands
- St. Alexandra, patron saint of humanity
- St. Margaret of Castello, patron saint of pro-life groups
- St. Maximilian Kolbe, patron saint of the pro-life movement

HS-LS2 **Ecosystems: Interactions, Energy, and Dynamics**

HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Catholic Identity

- The hymn of Saint Francis of Assisi: Praised be you, my Lord, with all your creatures, especially Sir Brother Sun, who is the day and through whom you give us light. And he is beautiful and radiant with great splendor; and bears a likeness of you, Most High. Praised be you, my Lord, through Sister Moon and the stars, in heaven you formed them clear and precious and beautiful. Praised be you, my Lord, through Brother Wind, and through the air, cloudy and serene, and every kind of weather through whom you give sustenance to your creatures. Praised be you, my Lord, through Sister Water, who is very useful and humble and precious and chaste. Praised be you, my Lord, through Brother Fire, through whom you light the night, and he is beautiful and playful and robust and strong.
- "*The creation accounts in the book of Genesis contain, in their own symbolic and narrative language, profound teachings about human existence and its historical reality. They suggest that human life is grounded in three fundamental and closely intertwined relationships: with God, with our neighbor and with the earth itself. According to the Bible, these three vital relationships have been broken, both outwardly and within us. This rupture is sin. The harmony between the Creator, humanity and creation as a whole was disrupted by our presuming to take the place of God and refusing to acknowledge our creaturely limitations. … As a result, the originally harmonious relationship between human beings and nature became conflictual (cf. Gen 3:17-19). It is significant that the harmony which Saint Francis of Assisi experienced with all creatures was seen as a healing of that rupture"* (Pope Francis, ***Laudato Si'***, para. 66). [M]
- *"Together with our obligation to use the earth's goods responsibly, we are called to recognize that other living beings have a value of their own in God's eyes: "by their mere existence they bless him and give him glory", and indeed, "the Lord rejoices in all his works*" (Psalm 104:31). (Pope Francis, ***Laudato Si'***, para. 69).

Scripture [S]

- "The earth is the Lord's and all it holds, the world and those who dwell in it." (Psalm 24:1)

Catholic/Christian Scientists

- Ecology
    - Rachel Carson (marine biologist)
    - Sr. Paula Gonzales (biology, solar energy)
    - Fr. Thomas Berry (religion, ecology, cultural history)

Saints [SA]

- St. Francis of Assisi, patron saint of animals and the environment
- St. Kateri Tekakwitha, patron saint of the environment and ecology

HS-LS3	**Heredity: Inheritance and Variation of Traits**
HS-LS3-1	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
HS-LS3-2	Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
HS-LS3-3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Scripture [S]

- The genealogy of Jesus
  - Matthew 1, Luke. 3:23-38
- "That which is born of the flesh is flesh, and that which is born of the Spirit is spirit." (Jonah 3:6)
- Plants in the Bible:
  - http://ww2.odu.edu/~lmusselm/plant/bible/allbibleplantslist.php
  - http://www.newadvent.org/cathen/12149a.htm
  - Below is a list of the flowers dedicated to the Blessed Mother. (https://www.catholicculture.org/culture/library/view.cfm?recnum=5855)
    - White Lily "Annunciation Lily", symbol of Mary's Immaculate Purity.
    - Impatiens "Our Lady's Earrings", symbolical pure adornments of the ears of Mary who heard the word of God and kept it.
    - Violet symbol of Mary's humility "regarded by the Lord".
    - Lady-Slipper "Our Lady's Slipper", symbol of Mary's graceful Visitation trip to visit Elizabeth in the hill country: "All her steps were most beauteous."
    - Thistle-Down another Visitation symbol, from its graceful movement in air currents.
    - Rose symbol of the Blessed Virgin of prophecy, the Rose plant bearing the flower, Christ.
    - Daisy "Mary's Flower of God".
    - Periwinkle "Virgin Flower", emblem of the Blessed Virgin.
    - Columbine symbol of the dove of the Holy Spirit, Mary's overshadowing, indwelling, divine Spouse.
    - Pansy "Trinity Flower", symbol of the Trinity, first revealed to Mary.
    - Strawberry "Fruitful Virgin", in flower and fruit at the same time.

Catholic/Christian Scientists

- Biology
  - Gregor Mendel (genetics through plant research)
  - Bartolomeo Eustachi (one of the founders of human anatomy)
  - Sr. Paula González (biology)
  - Antoine Laurent de Jussieu (natural classification of flowering plants)
  - Andreas Vesalius (modern human anatomy)
  - Theodor Schwann (theory of the cellular structure of animal organisms)
  - Jérôme Lejeune (the link of diseases to chromosome abnormalities)

- Anna Morandi Manzolini (anatomist and anatomical wax artist)
- Leonardo da Vinci (Renaissance anatomist, scientist, mathematician, and painter)

- Botany
  - Carl Linnaeus
  - Stephan Endlicher
  - James Britton
  - Andrea Cesalpino

HS-LS4 **Biological Evolution: Unity and Diversity**

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.
HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.
HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Catholic Identity

- Pope Francis on evolution:

“*The continued acceleration of changes affecting humanity and the planet is coupled today with a more intensified pace of life and work which might be called “rapidification”. Although change is part of the working of complex systems, the speed with which human activity has developed contrasts with the naturally slow pace of biological evolution. Moreover, the goals of this rapid and constant change are not necessarily geared to the common good or to integral and sustainable human development”* (Pope Francis, ***Laudato Si’***, para. 18).

“*Human beings, even if we postulate a process of evolution, also possess a uniqueness which cannot be fully explained by the evolution of other open systems. Each of us has his or her own personal identity and is capable of entering into dialogue with others and with God himself. Our capacity to reason, to develop arguments, to be inventive, to interpret reality and to create art, along with other not yet discovered capacities, are signs of a uniqueness which transcends the spheres of physics and biology. The sheer novelty involved in the emergence of a personal being within a material universe presupposes a direct action of God and a particular call to life and to relationship on the part of a ‘Thou’ who addresses himself to another ‘thou’. The biblical accounts of creation invite us to see each human being as a subject who can never be reduced to the status of an object” (*Pope Francis, ***Laudato Si’***, para. 81).

“*The ultimate destiny of the universe is in the fullness of God, which has already been attained by the risen Christ, the measure of the maturity of all things. … The ultimate purpose of other creatures is not to be found in us. Rather, all creatures are moving forward with us and through us towards a common point of arrival, which is God, in that transcendent fullness where the risen Christ embraces and illumines all things. Human beings, endowed with intelligence and love, and drawn by the fullness of Christ, are called to lead all creatures back to their Creator”* (Pope Francis, ***Laudato Si’***, para. 83).

Catholic/Christian Scientists

- Biology
    - Louis Pasteur (bacteriology)
    - Gregor Mendel (genetics through plant research), member of the Catholic Truth Society and Knight Commander of the Order of St. Gregory the Great
    - Bartolomeo Eustachi (one of the founders of human anatomy)
    - Sr. Paula González (biology)
    - Antoine Laurent de Jussieu (natural classification of flowering plants)
    - Andreas Vesalius (modern human anatomy)
    - Theodor Schwann (theory of the cellular structure of animal organisms)
    - Jérôme Lejeune (the link of diseases to chromosome abnormalities)
    - Anna Morandi Manzolini (anatomist and anatomical wax artist)
    - Leonardo da Vinci (Renaissance anatomist, scientist, mathematician, and painter)
- Botany
    - Carl Linnaeus
    - Stephan Endlicher
    - James Britton
    - Andrea Cesalpino
    - James Britten
    - Evolution
    - Jean-Baptiste Lamarck (his theories on evolution preceded those of Darwin)
    - Illia Delio, OSF (a Catholic sister and biologist who writes about evolution)

HS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.A: Structure and Function** • Systems of specialized cells within organisms help them perform the essential functions of life. • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Investigating or designing

a. Students construct an explanation that includes the idea that regions of DNA called genes determine the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

2. Evidence

a. Students identify and describe the evidence to construct their explanation, including that:
   - All cells contain DNA;
   - DNA contains regions that are called genes;
   - The sequence of genes contains instructions that code for proteins; and
   - Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism.

b. Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, peer review, students' own investigations).

3. Reasoning

a. Students use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation. Students describe the following chain of reasoning in their explanation:
   - Because all cells contain DNA, all cells contain genes that can code for the formation of proteins.
   - Body tissues are systems of specialized cells with similar structures and functions, each of whose functions are mainly carried out by the proteins they produce.
   - Proper function of many proteins is necessary for the proper functioning of the cells.
   - Gene sequence affects protein function, which in turn affects the function of body tissues.

Catholic Identity Connections

- Systems of specialized cells within organisms help them perform the essential functions of life. Systemic thinking is important when studying theology and the structure and life of the church, as members of the Body of Christ have specialized roles. We can help students to understand their roles and discern their vocations.

Scripture [S]

- "Now you are Christ's body, and individually parts of it. Some people God has designated in the church to be, first, apostles; second, prophets; third, teachers; then, mighty deeds; then, gifts of healing, assistance, administration, and varieties of tongues." (1Corinthians 12:27-28)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Connections to Other DCIs

HS.LS3.A

Articulation to DCIs across Grade-Bands

MS.LS1.A; MS.LS3.A; MS.LS3.B

HS-LS1	**From Molecules to Organisms: Structures and Processes**	
Students who demonstrate understanding can: **HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.** Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system. Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.	**LS1.A: Structure and Function** • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system.
Examples of Observable Evidence of Student Performance by the End of the Course		
1. Components of the model		
a. Students develop a model in which they identify and describe the relevant parts (e.g., organ system, organs, and their component tissues) and processes (e.g., transport of fluids, motion) of body systems in multicellular organisms.		

2. Relationships
a. In the model, students describe the relationships between components, including: • The functions of at least two major body systems in terms of contributions to overall function of an organism; • Ways the functions of two different systems affect one another; and • A system's function and how that relates both to the system's parts and to the overall function of the organism.
3. Connections
a. Students use the model to illustrate how the interaction between systems provides specific functions in multicellular organisms. b. Students make a distinction between the accuracy of the model and actual body systems and functions it represents.
Catholic Identity Connections
• This standard can aid students in understanding the hierarchical structural organization of the church.
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
Connections to Other DCIs
N/A
Articulation to DCIs across Grade-Bands
MS.LS1.A

<table>
<tr><th colspan="3">HS-LS1 From Molecules to Organisms: Structures and Processes</th></tr>
<tr><td colspan="3">Students who demonstrate understanding can:
HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.
Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.</td></tr>
<tr><th>Science and Engineering Practices</th><th>Disciplinary Core Ideas</th><th>Crosscutting Concepts</th></tr>
<tr><td>Planning and Carrying Out Investigations
Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
• Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.</td><td>LS1.A: Structure and Function
• Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.</td><td>Stability and Change
• Feedback (negative or positive) can stabilize or destabilize a system.</td></tr>
<tr><th colspan="3">Examples of Observable Evidence of Student Performance by the End of the Course</th></tr>
<tr><td colspan="3">1. Identifying the phenomenon under investigation</td></tr>
<tr><td colspan="3">a. Students describe the phenomenon under investigation, which includes the following idea: that feedback mechanisms maintain homeostasis.</td></tr>
</table>

2. Identifying the evidence to answer this question

a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including:
   - Changes within a chosen range in the external environment of a living system; and
   - Responses of a living system that would stabilize and maintain the system's internal conditions (homeostasis), even though external conditions change, thus establishing the positive or negative feedback mechanism.

b. Students describe why the data will provide information relevant to the purpose of the investigation.

3. Planning for the investigation

a. In the investigation plan, students describe:
   - How the change in the external environment is to be measured or identified;
   - How the response of the living system will be measured or identified;
   - How the stabilization or destabilization of the system's internal conditions will be measured or determined;
   - The experimental procedure, the minimum number of different systems (and the factors that affect them) that would allow generalization of results, the evidence derived from the data, and identification of limitations on the precision of data to include types and amounts; and
   - Whether the investigation will be conducted individually or collaboratively.

4. Collecting the data

a. Students collect and record changes in the external environment and organism responses as a function of time

5. Refining the design

a. Students evaluate their investigation, including:
   - Assessment of the accuracy and precision of the data, as well as limitations (e.g., cost, risk, time) of the investigation, and make suggestions for refinement; and
   - Assessment of the ability of the data to provide the evidence required.

b. If necessary, students refine the investigation plan to produce more generalizable data.

Catholic Identity Connections

- Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. This is true in Christian community as well. Both kinds of feedback are important, so long as it is constructive and ultimately contributes to the living Body of Christ.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS1.A

HS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-4 Use a model to illustrate the role of cellular division (mitosis).

Assessment Boundary: Assessment does not include specific gene control mechanisms.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.B: Growth and Development of Organisms** • In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to maintain homeostasis for cellular function. Through a multistep process, mitosis takes one somatic cell with diploid number of chromosomes, replicates the DNA, then divides into two genetically identical, diploid daughter cells. Cellular division produces and maintains a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. From the given model, students identify and describe the components of the model relevant for illustrating the role of mitosis and differentiation in producing and maintaining complex organisms, including:
   - Identical genetic material is passed from one cell to the next.
   - Parent and daughter cells (i.e., inputs and outputs of mitosis); and
   - A multi-cellular organism as a collection of differentiated cells that began as unspecialized embryonic stem cells that later specialized during development into differentiated cells.

2. Relationships

a. Students identify and describe the relationships between components of the given model, including:
   - Daughter cells receive identical genetic information from a parent cell or a fertilized egg.
   - Mitotic cell division produces two genetically identical daughter cells from one parent cell.
   - Differences between different cell types within a multicellular organism are due to gene expression — not different genetic material within that organism.

3. Connections

a. Students use the given model to illustrate that mitotic cell division results in more cells that:
   - Allow growth of the organism;
   - Can replace dead cells to maintain a complex organism.

b. Students make a distinction between the accuracy of the model and the actual process of cellular division.

Catalic Identity Connections

- This standard underscores the church's pro-life position in that nature is created in such a way as to make sure that life carries on into future generations. In connecting to evolution, one can point out that mitosis preceded meiosis; the process of evolution moves toward greater differentiation and complexity. Biodiversity is a good thing, as it provides increased chances of an organism's survival, which is God's will for creation. Life always finds a way.
- Creation
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
  - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Evolution
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.4	Model with mathematics.
F-IF.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.
F-BF.1	Write a function that describes a relationship between two quantities.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS1.A; MS.LS1.B; MS.LS3.A

HS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.

Assessment Boundary: Assessment does not include specific biochemical steps.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. From the given model, students identify and describe the components of the model relevant for illustrating that photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen, including:
   - Energy in the form of light;
   - Breaking or forming chemical bonds can release or absorb energy; and
   - Matter in the form of carbon dioxide, water, sugar, and oxygen.

2. Relationships

a. Students identify the following relationship between components of the given model: Sugar and oxygen are produced by carbon dioxide and water by the process of photosynthesis.

3. Connections

a. Students use the given model to illustrate:
   - The transfer of matter and flow of energy between the organism and its environment during photosynthesis; and
   - Photosynthesis as resulting in the storage of energy in the difference between the energies of the chemical bonds of the inputs (carbon dioxide and water) and outputs (sugar and oxygen).

Catholic Identity Connections

- Plants transform the sun's light to make food. Transformation is an important aspect of Eucharistic theology and the spiritual life of God's people. It can be found throughout the physical world, in the church and sacraments, and also within people's hearts. This is because Christ is the fulfillment of creation.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Connections to Other DCIs

HS.PS1.B; HS.PS3.B

Articulation to DCIs across Grade-Bands

MS.PS1.B; MS.PS3.D; MS.LS1.C; MS.LS2.B

HS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-6 Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.

Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Articulating the explanation of phenomena

a. Students construct an explanation that includes:
   - The relationship between the carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism and those same atoms found in amino acids and other large carbon-based molecules; and
   - That larger carbon-based molecules and amino acids can be a result of chemical reactions between sugar molecules (or their component atoms) and other atoms.

2. Evidence

a. Students identify and describe the evidence to construct the explanation, including:
   - All organisms take in matter (allowing growth and maintenance) and rearrange the atoms in chemical reactions.
   - Cellular respiration involves chemical reactions between sugar molecules and other molecules in which energy is released that can be used to drive other chemical reactions.
   - Sugar molecules are composed of carbon, oxygen, and hydrogen atoms.
   - Amino acids and other complex carbon-based molecules are composed largely of carbon, oxygen, and hydrogen atoms.
   - Chemical reactions can create products that are more complex than the reactants.
   - Chemical reactions involve changes in the energies of the molecules involved in the reaction.

b. Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, students' own investigations).

3. Reasoning

a. Students use reasoning to connect the evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation that atoms from sugar molecules may combine with other elements via chemical reactions to form other large carbon-based molecules. Students describe the following chain of reasoning for their explanation:
   - The atoms in sugar molecules can provide most of the atoms that comprise amino acids and other complex carbon-based molecules.
   - The energy released in respiration can be used to drive chemical reactions between sugars and other substances, and the products of those reactions can include amino acids and other complex carbon-based molecules.
   - The matter flows in cellular processes are the result of the rearrangement of primarily the atoms in sugar molecules because those are the molecules whose reactions release the energy needed for cell processes.

4. Revising the explanation

a. Given new evidence or context, students revise or expand their explanation about the relationships between atoms in sugar molecules and atoms in large carbon-based molecules, and justify their revision.

Catholic Identity Connections

- Living systems are designed by the Creator in such a way as to build upon one another so as to nurture and sustain life. God's love is poured out in creation.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Connections to Other DCIs

HS.PS1.B

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B; MS.PS3.D; MS.LS1.C; MS.ESS2.E

HS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.

Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model based on evidence to illustrate the relationships between systems or between components of a system.	**LS1.C: Organization for Matter and Energy Flow in Organisms** • As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. • As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new energy compounds are formed that can be utilized by any cell throughout the organism. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.	**Energy and Matter** • Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. From a given model, students identify and describe the components of the model relevant for their illustration of cellular respiration, including:
   - Matter in the form of food molecules, oxygen, and the products of their reaction (e.g., water and CO2);
   - The breaking and formation of chemical bonds; and
   - Energy from the chemical reactions.

2. Relationships

a. From the given model, students describe the relationships between components, including:
   - Carbon dioxide and water are produced from sugar and oxygen by the process of cellular respiration; and
   - The process of cellular respiration releases energy because the energy released when the bonds that are formed in CO2 and water is greater than the energy required to break the bonds of sugar and oxygen.

3. Connections
a. Students use the given model to illustrate that: • The chemical reaction of oxygen and food molecules releases energy as the matter is rearranged, existing chemical bonds are broken, and new chemical bonds are formed, but matter and energy are neither created nor destroyed. • Food molecules and oxygen transfer energy to the cell to sustain life's processes, including the maintenance of body temperature despite ongoing energy transfer to the surrounding environment.
Catholic Identity Connections
• Energy transfer and transformation are the basis of life processes. The Sacraments are about transformation in our spiritual life process.
Diocese of Owensboro ELA and Mathematics Standards Connections
ELA/Literacy **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
Connections to Other DCIs
HS.PS1.B; HS.PS2.B; HS.PS3.B
Articulation to DCIs across Grade-Bands
MS.PS1.B; MS.PS3.D; MS.LS1.C; MS.LS2.B

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate, and competition. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets. Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to support explanations.	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the components in the given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) that are relevant to supporting given explanations of factors that affect carrying capacities of ecosystems at different scales. The components include:
   - The population changes gathered from historical data or simulations of ecosystems at different scales; and
   - Data on numbers and types of organisms as well as boundaries, resources, and climate.

b. Students identify the given explanation(s) to be supported, which include the following ideas:

c. Factors (including boundaries, resources, climate, and competition) affect carrying capacity of an ecosystem, and:
   - Some factors have larger effects than do other factors.
   - Factors are interrelated.
   - The significance of a factor is dependent on the scale (e.g., a pond vs. an ocean) at which it occurs.

2. Mathematical and/or computational modeling

a. Students use given mathematical and/or computational representations (e.g., trends, averages, histograms, graphs, spreadsheets) of ecosystem factors to identify changes over time in the numbers and types of organisms in ecosystems of different scales.

3. Analysis

a. Students analyze and use the given mathematical and/or computational representations
   - To identify the interdependence of factors (both living and nonliving) and resulting effect on carrying capacity; and
   - As evidence to support the explanation and identify the factors that have the largest effect on the carrying capacity of an ecosystem for a given population.

Catholic Identity Connections

- This standard might lead to a discussion of carrying capacity in Christian community. How might we meet the needs of all members of the Body of Christ so that everyone has what they need -- physically, mentally, emotionally and spiritually – to thrive? Catholic Social Teaching speaks clearly to this idea. [CST]
- In contrast to nature, the carrying capacity of God's love is unlimited. The parable of the multiplication of the loaves and fishes teaches us that the Kingdom of God stretches beyond the boundaries and rules of this world. [S] Through the sacraments we encounter the abundance of God's love and grace, which knows no end. [SA]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
- Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
- Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS2.A; MS.LS2.C; MS.ESS3.A; MS.ESS3.C

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.
Assessment Boundary: Assessment is limited to provided data.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to support and revise explanations. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**LS2.A: Interdependent Relationships in Ecosystems** • Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. **LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Scale, Proportion, and Quantity** • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the components in the given mathematical representations (which include trends, averages, and graphs of the number of organisms per unit of area in a stable system) that are relevant to supporting and revising the given explanations about factors affecting biodiversity and ecosystems, including:
   - Data on numbers and types of organisms are represented.
   - Interactions between ecosystems at different scales are represented.

b. Students identify the given explanation(s) to be supported of factors affecting biodiversity and population levels, which include the following ideas:
   - The populations and number of organisms in ecosystems vary as a function of the physical and biological dynamics of the ecosystem.
   - The response of an ecosystem to a small change might not significantly affect populations, whereas the response to a large change can have a large effect on populations that then feeds back to the ecosystem at a range of scales.
   - Ecosystems can exist in the same location on a variety of scales (e.g., plants and animals vs. microbes), and these populations can interact in ways that significantly change these ecosystems (e.g., interactions among microbes, plants, and animals can be an important factor in the resources available to both a microscopic and macroscopic ecosystem).

2. Mathematical and/or computational modeling

a. Students use the given mathematical representations (including trends, averages, and graphs) of factors affecting biodiversity and ecosystems to identify changes over time in the numbers and types of organisms in ecosystems of different scales.

3. Analysis

a. Students use the analysis of the given mathematical representations of factors affecting biodiversity and ecosystems
  - To identify the most important factors that determine biodiversity and population numbers of an ecosystem.
  - As evidence to support explanation(s) for the effects of both living and nonliving factors on biodiversity and population size, as well as the interactions of ecosystems on different scales.
  - To describe how, in the model, factors affecting ecosystems at one scale can cause observable changes in ecosystems at a different scale.

b. Students describe the given mathematical representations in terms of their ability to support explanation(s) for the effects of modest to extreme disturbances on an ecosystems' capacity to return to original status or become a different ecosystem.

4. Revision

a. Students revise the explanation(s) based on new evidence about any factors that affect biodiversity and populations (e.g., data illustrating the effect of a disturbance within the ecosystem).

Catholic Identity Connections

- This standard builds directly upon HS-LS2-1. Catholic Identity Connections are the same.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.ESS2.E; HS.ESS3.A; HS.ESS3.C; HS.ESS3.D

Articulation to DCIs across Grade-Bands

MS.LS2.A; MS.LS2.C; MS.ESS3.C

HS-LS2	Ecosystems: Interactions, Energy, and Dynamics	
Students who demonstrate understanding can: **HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments. Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, and peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.	**Energy and Matter** • Energy drives the cycling of matter within and between systems.

Examples of Observable Evidence of Student Performance by the End of the Course
1. Articulating the explanation of phenomena
a. Students construct an explanation that includes that: • Energy from photosynthesis and respiration drives the cycling of matter and flow of energy under aerobic or anaerobic conditions within an ecosystem. • Anaerobic respiration occurs primarily in conditions where oxygen is not available.

2. Evidence

a. Students identify and describe the evidence to construct the explanation, including:
   - All organisms take in matter and rearrange the atoms in chemical reactions.
   - Photosynthesis captures energy in sunlight to create chemical products that can be used as food in cellular respiration.
   - Cellular respiration is the process by which the matter in food (sugars, fats) reacts chemically with other compounds, rearranging the matter to release energy that is used by the cell for essential life processes.

b. Students use a variety of valid and reliable sources for the evidence, which may include theories, simulations, peer review, and students' own investigations.

3. Reasoning

a. Students use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct their explanation. Students describe the following chain of reasoning used to construct their explanation:
   - Energy inputs to cells occur either by photosynthesis or by taking in food.
   - Since all cells engage in cellular respiration, they must all produce products of respiration.
   - The flow of matter into and out of cells must therefore be driven by the energy captured by photosynthesis or obtained by taking in food and released by respiration.
   - The flow of matter and energy must occur whether respiration is aerobic or anaerobic.

4. Revising the explanation

a. Given new data or information, students revise their explanation and justify the revision (e.g., recent discoveries of life surrounding deep sea ocean vents have shown that photosynthesis is not the only driver for cycling matter and energy in ecosystems).

Catholic Identity Connections

- There are generally fewer organisms at higher levels of a food web. This points to a sacrificial aspect of creation, which is the basis of the Paschal Mystery.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

Mathematics

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS1.B; HS.PS3.B; HS.PS3.D; HS.ESS2.A

Articulation to DCIs across Grade-Bands

MS.PS1.B; MS.PS3.D; MS.LS1.C; MS.LS2.B

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.

Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematical and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to support claims.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.	**Energy and Matter** • Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the components in the mathematical representations that are relevant to supporting the claims. The components could include relative quantities related to organisms, matter, energy, and the food web in an ecosystem.
b. Students identify the claims about the cycling of matter and energy flow among organisms in an ecosystem.

2. Mathematical modeling

a. Students describe how the claims can be expressed as a mathematical relationship in the mathematical representations of the components of an ecosystem
b. Students use the mathematical representation(s) of the food web to:
   - Describe the transfer of matter (as atoms and molecules) and flow of energy upward between organisms and their environment;
   - Identify the transfer of energy and matter between tropic levels; and
   - Identify the relative proportion of organisms at each trophic level by correctly identifying producers as the lowest trophic level having the greatest biomass and energy and consumers decreasing in numbers at higher trophic levels.

3. Analysis

a. Students use the mathematical representation(s) to support the claims that include the idea that matter flows between organisms and their environment.
b. Students use the mathematical representation(s) to support the claims that include the idea that energy flows from one trophic level to another as well as through the environment.
c. Students analyze and use the mathematical representation(s) to account for the energy not transferred to higher trophic levels but which is instead used for growth, maintenance, or repair, and/or transferred to the environment, and the inefficiencies in transfer of matter and energy.

Catholic Identity Connections

- An understanding of cycling and energy can help students understand Christian community in which all members are fed and nurtured.
- A social analysis of the food web may help students understand unjust economic systems in which many lower paid workers (often the “working poor”) support a few wealthy people at the top. This can be connected to Catholic Social Teaching regarding the dignity of work and the rights of workers.

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.B; HS.PS3.D

Articulation to DCIs across Grade-Bands

MS.PS3.D; MS.LS1.C; MS.LS2.B

HS-LS2	**Ecosystems: Interactions, Energy, and Dynamics**	
Students who demonstrate understanding can: **HS-LS2-5 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** Clarification Statement: Examples of models could include simulations and mathematical models. Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or components of a system.	**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems** • Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. **PS3.D: Energy in Chemical Processes** • The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (secondary)	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students use evidence to develop a model in which they identify and describe the relevant components, including:
   - The inputs and outputs of photosynthesis;
   - The inputs and outputs of cellular respiration; and
   - The biosphere, atmosphere, hydrosphere, and geosphere.

2. Relationships

a. Students describe relationships between components of their model, including:
   - The exchange of carbon (through carbon-containing compounds) between organisms and the environment; and
   - The role of storing carbon in organisms (in the form of carbon-containing compounds) as part of the carbon cycle.

3. Connections

a. Students describe the contribution of photosynthesis and cellular respiration to the exchange of carbon within and among the biosphere, atmosphere, hydrosphere, and geosphere in their model.
b. Students make a distinction between the model's simulation and the actual cycling of carbon via photosynthesis and cellular respiration.

Catholic Identity Connections

- An understanding of systems can help students understand the Church, Christian community, and the Body of Christ.

Diocese of Owensboro ELA and Mathematics Standards Connections

N/A

Connections to Other DCIs

HS.PS1.B; HS.ESS2.D

Articulation to DCIs across Grade-Bands

MS.PS3.D; MS.LS1.C; MS.LS2.B; MS.ESS2.A

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9– 12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the given explanation and the supporting claims, evidence, and reasoning

a. Students identify the given explanation that is supported by the claims, evidence, and reasoning to be evaluated, and which includes the following idea: The complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
b. From the given materials, students identify:
    - The given claims to be evaluated;
    - The given evidence to be evaluated; and
    - The given reasoning to be evaluated.

2. Identifying any potential additional evidence that is relevant to the evaluation

a. Students identify and describe additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given claims, evidence, and reasoning:
    - The factors that affect biodiversity;
    - The relationships between species and the physical environment in an ecosystem; and
    - Changes in the numbers of species and organisms in an ecosystem that has been subject to a modest or extreme change in ecosystem conditions.

3. Evaluating and critiquing

a. Students describe the strengths and weaknesses of the given claim in accurately explaining a particular response of biodiversity to a changing condition, based on an understanding of the factors that affect biodiversity and the relationships between species and the physical environment in an ecosystem.
b. Students use their additional evidence to assess the validity and reliability of the given evidence and its ability to support the argument that resiliency of an ecosystem is subject to the degree of change in the biological and physical environment of an ecosystem.
c. Students assess the logic of the reasoning, including the relationship between degree of change and stability in ecosystems, and the utility of the reasoning in supporting the explanation of how:
    - Modest biological or physical disturbances in an ecosystem result in maintenance of relatively consistent numbers and types of organisms.
    - Extreme fluctuations in conditions or the size of any population can challenge the functioning of ecosystems in terms of resources and habitat availability, and can even result in a new ecosystem.

Catholic Identity Connections

- This standard can be related directly to climate change, thus to Care of God's Creation which is the 7th theme of Catholic Social Teaching [CST]. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Creation
    - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
    - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
    - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
    - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
    - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
    - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics

MP.2	Reason abstractly and quantitatively.
S-ID.1	Represent data with plots on the real number line.
S-IC.1	Understand statistics as a process for making inferences about population parameters based on a random sample from that population.
S-IC.6	Evaluate reports based on data.

Connections to Other DCIs

HS.ESS2.E

Articulation to DCIs across Grade-Bands

MS.LS2.A; MS.LS2.C; MS.ESS3.C

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics		
Students who demonstrate understanding can: **HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.** Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** • Moreover, anthropogenic changes (induced by human activity) in the environment — including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change — can disrupt an ecosystem and threaten the survival of some species. **LS4.D: Biodiversity and Humans** • Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary) • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary) (Note: This Disciplinary Core Idea is also addressed by HSLS4-6.) **ETS1.B: Developing Possible Solutions** • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Using scientific knowledge to generate the design solution

a. Students design a solution that involves reducing the negative effects of human activities on the environment and biodiversity, and that relies on scientific knowledge of the factors affecting changes and stability in biodiversity. Examples of factors include but are not limited to:
   - Overpopulation;
   - Overexploitation;
   - Habitat destruction;
   - Pollution;
   - Introduction of invasive species; and
   - Changes in climate.

b. Students describe the ways the proposed solution decreases the negative effects of human activity on the environment and biodiversity.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe and quantify (when appropriate) the criteria (amount of reduction of impacts and human activities to be mitigated) and constraints (for example, cost, human needs, and environmental impacts) for the solution to the problem, along with the tradeoffs in the solution.

3. Evaluating potential solutions

a. Students evaluate the proposed solution for its impact on overall environmental stability and changes.
b. Students evaluate the cost, safety, and reliability, as well as social, cultural, and environmental impacts, of the proposed solution for a select human activity that is harmful to an ecosystem.

4. Refining and/or optimizing the design solution

a. Students refine the proposed solution by prioritizing the criteria and making tradeoffs as necessary to further reduce environmental impact and loss of biodiversity while addressing human needs.

Catholic Identity Connections

- This standard can be related directly to climate change, thus to Care of God's Creation which is the 7th theme of Catholic Social Teaching [CST]. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Creation
  - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
  - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
  - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
  - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
  - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]
- When considering biodiversity, you might also refer to the following:
  - "For He brought things into being in order that His goodness might be communicated to creatures, and be represented by them; and because His goodness could not be adequately represented by one creature alone, He produced many and diverse creatures, that what was wanting to one in the representation of the divine goodness might be supplied by another. For goodness, which in God is simple and uniform, in creatures is manifold and divided and hence the whole universe together participates the divine goodness more perfectly, and represents it better than any single creature whatever" (St. Thomas Aquinas, Summa Theologiae, First Part, Question 47). [TH]
- *"When we can see God reflected in all that exists, our hearts are moved to praise the Lord for all his creatures and to worship him in union with them"* (Pope Francis, ***Laudato Si'***, para. 87). [MA]
- St. Francis of Assisi – Canticle of the Sun - http://www.loyolapress.com/our-catholic-faith/prayer/traditional-catholic-prayers/saints-prayers/canticle-of-the-sun-saint-francis-of-assisi [TH]
- Also refer to ***Laudato* Si'** by Pope Francis -- "Loss of Biodiversity" – paragraphs 32-42. Pope Francis writes, "*Because of us, thousands of species will no longer give glory to God by their very existence, nor convey their message to us. We have no such right*" (para. 33).

Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST.9-10.8	Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
Mathematics	
MP.2	Reason abstractly and quantitatively.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs
HS.ESS2.D; HS.ESS2.E; HS.ESS3.A; HS.ESS3.C

Articulation to DCIs across Grade-Bands
MS.LS2.C; MS.ESS3.C; MS.ESS3.D

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

HS-LS2-8 Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9– 12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Connections to Nature of Science** **Scientific Knowledge is Open to Revision in Light of New Evidence** • Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.	**LS2.D: Social Interactions and Group Behavior** • Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the given explanation and the supporting evidence

a. Students identify the given explanation that is supported by the evidence to be evaluated, and which includes the following idea: Group behavior can increase the chances for an individual and a species to survive and reproduce.
b. Students identify the given evidence to be evaluated.

2. Identifying any potential additional evidence that is relevant to the evaluation

a. Students identify additional evidence (in the form of data, information, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, and which includes evidence for causal relationships between specific group behaviors (e.g., flocking, schooling, herding, cooperative hunting, migrating, swarming) and individual survival and reproduction rates.

3. Evaluating and critiquing

a. Students use their additional evidence to assess the validity, reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the outcomes of group behavior.
b. Students evaluate the given evidence for the degree to which it supports a causal claim that group behavior can have a survival advantage for some species, including how the evidence allows for distinguishing between causal and correlational relationships, and how it supports cause and effect relationships between various kinds of group behavior and individual survival rates (for example, the relationship between moving in a group and individual survival rates, compared to the survival rate of individuals of the same species moving alone or outside of the group).

Catholic Identity Connections

- Group behavior, when positive, increases the chances of survival. As Catholics, we have a shared identity in Christ, as revealed by the scriptures and tradition. The Holy Spirit bonds us into the Body of Christ. The Church and her sacraments help us to stay faithful to God. Catholic Social Teachings shape our collective actions. This standard might be connected to all 7 themes of Catholic Social Teaching:
    1. Life and Dignity of the Human Person
    2. Call to Family, Community, and Participation
    3. Rights and Responsibilities
    4. Option for the Poor and Vulnerable
    5. The Dignity of Work and the Rights of Workers
    6. Solidarity
    7. Care of God’s Creation

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author’s claim or a recommendation for solving a scientific or technical problem.

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS1.B

HS-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

HS-LS3-1 Design a model to exhibit the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9-12 builds on K-8 experiences and progresses to formulating, refining and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from examining models or a theory to clarify relationships. • Ask questions to design a model to exhibit the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.	**LS1.A: Structure and Function** • All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins. (secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.) **LS3.A: Inheritance of Traits** • Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Addressing phenomena or scientific theories

a. Students use models of DNA to formulate questions, the answers to which would clarify:
   - The cause and effect relationships (including distinguishing between causal and correlational relationships) between DNA, the proteins it codes for, and the resulting traits observed in an organism;
   - That the DNA and chromosomes that are used by the cell can be regulated in multiple ways; and
   - The relationship between the non-protein coding sections of DNA and their functions (e.g., regulatory functions) in an organism.

2. Evaluating empirical testability

a. Students' questions are empirically testable by scientists.

Catholic Identity Connections

- A discussion of DNA may be connected to the first theme of Catholic Social Teaching – Life and Dignity of the Human Person.
- Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
- Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
- Demonstrate an understanding of the moral issues involving in vitro fertilization, human cloning, human genetic manipulation, and human experimentation and what the Church teaches regarding work in these areas. [CS S.712 IS17]
- Science
    - Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
    - Analyze how the pursuit of scientific knowledge, for utilitarian purposes alone or for the misguided manipulation of nature, thwarts the pursuit of authentic Truth and the greater glory of God. [CS S.712 IS3]
    - Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]

Scripture [S]

- "Before I formed you in the womb, I knew you." (Jeremiah 1:5)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS3.A; MS.LS3.B

HS-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.	**LS3.B: Variation of Traits** • In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. • Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Developing a claim

a. Students make a claim that includes the idea that inheritable genetic variations may result from:
   - New genetic combinations through meiosis;
   - Viable errors occurring during replication; and
   - Mutations caused by environmental factors.

2. Identifying scientific evidence

a. Students identify and describe evidence that supports the claim, including:
   - Variations in genetic material naturally result during meiosis when corresponding sections of chromosome pairs exchange places.
   - Genetic mutations can occur due to:
     - Errors during replication; and/or
     - Environmental factors.
   - Genetic material is inheritable.

b. Students use scientific knowledge, literature, student-generated data, simulations and/or other sources for evidence.

3. Evaluating and critiquing evidence

a. Students identify the following strengths and weaknesses of the evidence used to support the claim:
    - Types and numbers of sources;
    - Sufficiency to make and defend the claim, and to distinguish between causal and correlational relationships; and
    - Validity and reliability of the evidence

4. Reasoning and synthesis

a. Students use reasoning to describe links between the evidence and claim, such as:
    - Genetic mutations produce genetic variations between cells or organisms.
    - Genetic variations produced by mutation and meiosis can be inherited.

b. Students use reasoning and valid evidence to describe that new combinations of DNA can arise from several sources, including meiosis, errors during replication, and mutations caused by environmental factors.

c. Students defend a claim against counter-claims and critique by evaluating counter-claims and by describing the connections between the relevant and appropriate evidence and the strongest claim.

Catholic Identity Connections

- God is in what is known and unknown.
- Again, we might emphasize the proclivity of diversity in creation and relate it to evolution. Mitosis preceded meiosis, which results in greater differentiation and complexity in order to increase changes of survival. Diversity is a good thing to be celebrated, not something to be "tolerated."
- A discussion of DNA may be connected to the first theme of Catholic Social Teaching – Life and Dignity of the Human Person – which relates to stem cell research and cloning. [CST]
- Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
- Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
- Demonstrate an understanding of the moral issues involving in vitro fertilization, human cloning, human genetic manipulation, and human experimentation and what the Church teaches regarding work in these areas. [CS S.712 IS17]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "*The Gospel of Creation*" for scriptures related to care of God's creation. [S]

Scripture [S]

- "You formed my inmost being; you knit me in my mother's womb.
  I praise you, because I am wonderfully made; Wonderful are your works!
  My very self you know.
  My bones are not hidden from you, when I was being made in secret, fashioned in the depths of the earth.
  Your eyes saw me unformed; in your book all are written down; my days were shaped, before one came to be." (Psalm 139:13-16)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.1 Write arguments focused on discipline-specific content.

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS3.A; MS.LS3.B

HS-LS3 Heredity: Inheritance and Variation of Traits		
Students who demonstrate understanding can: **HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.** Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits. Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**LS3.B: Variation of Traits** • Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	**Scale, Proportion, and Quantity** • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Connections to Nature of Science** **Science is a Human Endeavor** • Technological advances have influenced the progress of science and science has influenced advances in technology. • Science and engineering are influenced by society and society is influenced by science and engineering.

Examples of Observable Evidence of Student Performance by the End of the Course
1. Organizing data
a. Students organize the given data by the frequency, distribution, and variation of expressed traits in the population.
2. Identifying relationships
a. Students perform and use appropriate statistical analyses of data, including probability measures, to determine the relationship between a trait's occurrence
3. Interpreting data
a. Students analyze and interpret data to explain the distribution of expressed traits, including: • Recognition and use of patterns in the statistical analysis to predict changes in trait distribution within a population if environmental variables change; and • Description of the expression of a chosen trait and its variations as causative or correlational to some environmental factor based on reliable evidence.

Catholic Identity Connections

• An emphasis on environmental factors can be related to the 7th theme of Catholic Social Teaching: Care of God's Creation.
• Creation
    • Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
    • Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
    • Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
• Insofar as humans are affected by environmental factors, this standard also relates the 1st theme of Catholic Social Teaching: Life and Dignity of the Human Person, and to the following:
• Exhibit a primacy of care and concern at all stages of life for each human person as an image and likeness of God. [CS S.712 GS1]
• Value the human body as the temple of the Holy Spirit. [CS S.712 GS3]
• Scripture: Refer to ***Laudato Si'***, Chapter 2 – "*The Gospel of Creation*" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections
Mathematics **MP.2** Reason abstractly and quantitatively.
Connections to Other DCIs
HS.LS2.A; HS.LS2.C; HS.LS4.B; HS.LS4.C
Articulation to DCIs across Grade-Bands
MS.LS2.A; MS.LS3.B; MS.LS4.C

HS-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

HS-LS4-1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**LS4.A: Evidence of Common Ancestry and Diversity** • Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Communication style and format

a. Students use at least two different formats (e.g., oral, graphical, textual and mathematical), to communicate scientific information, including that common ancestry and biological evolution are supported by multiple lines of empirical evidence. Students cite the origin of the information as appropriate.

2. Connecting the DCIs and the CCCs

a. Students identify and communicate evidence for common ancestry and biological evolution, including:
   - Information derived from DNA sequences, which vary among species but have many similarities between species;
   - Similarities of the patterns of amino acid sequences, even when DNA sequences are slightly different, including the fact that multiple patterns of DNA sequences can code for the same amino acid;
   - Patterns in the fossil record (e.g., presence, location, and inferences possible in lines of evolutionary descent for multiple specimens); and
   - The pattern of anatomical and embryological similarities.

b. Students identify and communicate connections between each line of evidence and the claim of common ancestry and biological evolution.

c. Students communicate that together, the patterns observed at multiple spatial and temporal scales (e.g., DNA sequences, embryological development, fossil records) provide evidence for causal relationships relating to biological evolution and common ancestry.

Catalic Identity Connections

- This standard provides an opportunity to explore the church's teaching on evolution and on the unity of creation.
- Evolution
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
  - Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
  - Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS14]
- We might also keep in mind the following, regarding Science:
  - Explain and promote the unity of faith and reason with confidence that there exists no contradiction between the God of nature and the God of the faith. [CS S.712 GS2]
  - Articulate how science properly situates itself within other academic disciplines (e.g., history, theology) for correction and completion in order to recognize the limited material explanation of reality to which it is properly attuned. [CS S.712 IS1]
  - Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
  - Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
  - Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
  - Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
  - Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST-11.12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics

MP.2	Reason abstractly and quantitatively.

Connections to Other DCIs

HS.LS3.A; HS.LS3.B; HS.ESS1.C

Articulation to DCIs across Grade-Bands

LS3.A; LS3.B; MS.LS4.A; MS.ESS1.C

HS-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

HS-LS4-2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.

Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS4.B: Natural Selection** • Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals. **LS4.C: Adaptation** • Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Articulating the explanation of phenomena

a. Students construct an explanation that includes a description that evolution is caused primarily by one or more of the four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

2. Evidence

a. Students identify and describe evidence to construct their explanation, including that:
   - As a species grows in number, competition for limited resources can arise.
   - Individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring.
   - Individuals can have specific traits that give them a competitive advantage relative to other individuals in the species.

b. Students use a variety of valid and reliable sources for the evidence (e.g., data from investigations, theories, simulations, peer review).

3. Reasoning

a. Students use reasoning to connect the evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation. Students describe the following chain of reasoning for their explanation:
   - Genetic variation can lead to variation of expressed traits in individuals in a population.
   - Individuals with traits that give competitive advantages can survive and reproduce at higher rates than individuals without the traits because of the competition for limited resources.
   - Individuals that survive and reproduce at a higher rate will provide their specific genetic variations to a greater proportion of individuals in the next generation.
   - Over many generations, groups of individuals with particular traits that enable them to survive and reproduce in distinct environments using distinct resources can evolve into a different species.
   - As an environment changes so do the species seen as 'fit' within that environment.

b. Students use the evidence to describe the following in their explanation:
   - The difference between natural selection and biological evolution (natural selection is a process, and biological evolution can result from that process); and
   - The cause and effect relationship between genetic variation, the selection of traits that provide comparative advantages, and the evolution of populations that all express the trait.

Catholic Identity Connections

- This standard provides an opportunity to explore the church's teaching on evolution.
- Evolution
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
  - Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
  - Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS14]
- We might also keep in mind the following, regarding Science:
  - Explain and promote the unity of faith and reason with confidence that there exists no contradiction between the God of nature and the God of the faith. [CS S.712 GS2]
  - Articulate how science properly situates itself within other academic disciplines (e.g., history, theology) for correction and completion in order to recognize the limited material explanation of reality to which it is properly attuned. [CS S.712 IS1]
  - Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
  - Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]
  - Evaluate the errors present in the belief system of scientific naturalism or scientism (which includes materialism and reductionism), which posits that scientific exploration and explanation is the only valid source of meaning. [CS S.712 IS8]
  - Distinguish the difference between the use of the scientific method and the use of theological inquiry to know and understand God's creation and universal truths. [CS S.712 IS9]
  - Articulate the limitations of science (the scientific method and constraints of the physical world) to know and understand God and transcendent reality. [CS S.712 IS10]

Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST-11.12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research.
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
Mathematics	
MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
Connections to Other DCIs	
HS.LS2.A; HS.LS2.D; HS.LS3.B; HS.ESS2.E; HS.ESS3.A	
Articulation to DCIs across Grade-Bands	
MS.LS2.A; LS3.B; MS.LS4.B; MS.LS4.C	

HS-LS4 Biological Evolution: Unity and Diversity		
Students who demonstrate understanding can: **HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.	**LS4.B: Natural Selection** • Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information — that is, trait variation — that leads to differences in performance among individuals. • The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. **LS4.C: Adaptation** • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. • Adaptation also means that the distribution of traits in a population can change when conditions change.	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Organizing data

a. Students organize data (e.g., using tables, graphs and charts) by the distribution of genetic traits over time.
b. Students describe what each dataset represents

2. Identifying relationships

a. Students perform and use appropriate statistical analyses of data, including probability measures, to determine patterns of change in numerical distribution of traits over various time and population scales.

3. Interpreting data

a. Students use the data analyses as evidence to support explanations about the following:
   - Positive or negative effects on survival and reproduction of individuals as relating to their expression of a variable trait in a population;
   - Natural selection as the cause of increases and decreases in heritable traits over time in a population, but only if it affects reproductive success; and
   - The changes in distribution of adaptations of anatomical, behavioral, and physiological traits in a population, based on their ever changing environment.

Catholic Identity Connections

- This standard provides an opportunity to explore the church's teaching on evolution.
- Evolution
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
  - Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
  - Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS14]
- While natural selection is a key aspect of biological evolution, the church, with its concern for the poor and most vulnerable, works according to a different, Christ-centered ethic in which the weakest among us received special care. See theme 4 of Catholic Social Teaching: Option for the Poor and Vulnerable. [CST] And while Christians are in the world, we are not of the world. This requires adaptation.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs

HS.LS2.D; HS.LS3.B

Articulation to DCIs across Grade-Bands

MS.LS2.A; LS3.B; MS.LS4.B; MS.LS4.C

HS-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS4.C: Adaptation** • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Articulating the explanation of phenomena

a. Students construct an explanation that identifies the cause and effect relationship between natural selection and adaptation.

2. Evidence

a. Students identify and describe the evidence to construct their explanation, including:
   - Changes in a population occur when some feature of the environment changes;
   - Relative survival rates of organisms with different traits in a specific environment;
   - The fact that individuals in a species have genetic variation (through mutations and sexual reproduction) that is passed on to their offspring; and
   - The fact that individuals can have specific traits that give them a competitive advantage relative to other individuals in the species.

b. Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, peer review, students' own investigations)

3. Reasoning

a. Students use reasoning to synthesize the valid and reliable evidence to distinguish between cause and correlation to construct the explanation about how natural selection provides a mechanism for species to adapt to changes in their environment, including the following elements:
   - Biotic and abiotic differences in ecosystems contribute to changes in gene frequency over time through natural selection.
   - Increasing gene frequency in a population results in an increasing fraction of the population in each successive generation that carries a particular gene and expresses a particular trait.
   - Over time, this process leads to a population that is adapted to a particular environment by the widespread expression of a trait that confers a competitive advantage in that environment.

Catholic Identity Connections

- This standard provides an opportunity to explore the church's teaching on evolution.
- Evolution
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
  - Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
  - Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS14]
- While natural selection is a key aspect of biological evolution, the church, with its concern for the poor and most vulnerable, works according to a different, Christ-centered ethic in which the weakest among us receive special care. See theme 4 of Catholic Social Teaching: Option for the Poor and Vulnerable. [CST] And while Christians are in the world, we are not of the world. This requires adaptation.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research**.**

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs

HS.LS2.A; HS.LS2.D

Articulation to DCIs across Grade-Bands

MS.LS4.B; MS.LS4.C

HS-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species. • Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the given claims and evidence to be evaluated

a. Students identify the given claims, which include the idea that changes in environmental conditions may result in:
   - Increases in the number of individuals of some species;
   - The emergence of new species over time; and
   - The extinction of other species.

b. Students identify the given evidence to be evaluated.

2. Identifying any potential additional evidence that is relevant to the evaluation

a. Students identify and describe additional evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the claims and to evaluating the given evidence, including:
   - Data indicating the change over time in:
     - The number of individuals in each species;
     - The number of species in an environment; and
     - The environmental conditions.
   - Environmental factors that can determine the ability of individuals in a species to survive and reproduce.

3. Evaluating and critiquing evidence

a. Students use their additional evidence to assess the validity, reliability, strengths, and weaknesses of the given evidence, along with its ability to support logical and reasonable arguments about the outcomes of group behavior.

b. Students assess the ability of the given evidence to be used to determine causal or correlational effects between environmental changes, the changes in the number of individuals in each species, the number of species in an environment, and/or the emergence or extinction of species.

4. Reasoning and synthesis

a. Students evaluate the degree to which the given empirical evidence can be used to construct logical arguments that identify causal links between environmental changes and changes in the number of individuals or species based on environmental factors that can determine the ability of individuals in a species to survive and reproduce

Catholic Identity Connections

- The extinction of species is an issue that deserves our concern as Catholics. If, as St. Thomas Aquinas writes, it takes all of God's creation to reveal the fullness of God's goodness – then extinction of species means that our experience of God's goodness is diminished. [TH]
- To cause extinction of species is to go against the direction of evolution and to harm God's creation and ourselves. In ***Laudato Si'*** Pope Francis quotes Patriarch Bartholomew as saying: *"For human beings… to destroy the biological diversity of God's creation; foe human beings to degrade the integrity of the earth by causing changes in its climate, by stripping the earth of its natural forests or destroying its wetlands; for human beings to contaminate the earth's waters, its land, its air, and its life – these are sins."* For, "*to commit a crime against the natural world is a sin against ourselves and a sin against God.*" (para. 8). [M]
- Creation
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
  - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
  - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
  - Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
  - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
  - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "*The Gospel of Creation*" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST-11.12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs

HS.LS2.A; HS.LS2.D; HS.LS3.B; HS.ESS2.E; HS.ESS3.A

Articulation to DCIs across Grade-Bands

MS.LS2.A; MS.LS2.C; MS.LS4.C; HS.ESS3.C

HS-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematical and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create or revise a simulation of a phenomenon, designed device, process, or system.	**LS4.C: Adaptation** • Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline — and sometimes the extinction — of some species. **LS4.D: Biodiversity and Humans** • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary) • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (secondary)	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students create or revise a simulation that:
   - Models effects of human activity (e.g., overpopulation, overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) on a threatened or endangered species or to the genetic variation within a species; and
   - Provides quantitative information about the effect of the solutions on threatened or endangered species.

b. Students describe the components that are modeled by the computational simulation, including human activity (e.g., overpopulation, overexploitation, adverse habitat alterations, pollution, invasive species, changes in climate) and the factors that affect biodiversity.

c. Students describe the variables that can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions.

2. Computational modeling

a. Students use logical and realistic inputs for the simulation that show an understanding of the reliance of ecosystem function and productivity on biodiversity, and that take into account the constraints of cost, safety, and reliability as well as cultural, and environmental impacts.
b. Students use the simulation to identify possible negative consequences of solutions that would outweigh their benefits.

3. Analysis

a. Students compare the simulation results to expected results.
b. Students analyze the simulation results to determine whether the simulation provides sufficient information to evaluate the solution.
c. Students identify the simulation's limitations.
d. Students interpret the simulation results, and predict the effects of the specific design solutions on biodiversity based on the interpretation.

4. Revision

a. Students revise the simulation as needed to provide sufficient information to evaluate the solution.

Catholic Identity Connections

- Creation
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
  - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
  - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
  - Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
  - Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
  - Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "*The Gospel of Creation*" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Connections to Other DCIs

HS.ESS2.D; HS.ESS2.E; HS.ESS3.A; HS.ESS3.C; HS.ESS3.D

Articulation to DCIs across Grade-Bands

MS.LS2.C; HS.ESS3.C

High School Earth and Space Science Standards

HS-ESS1 **Earth's Place in the Universe**

HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Catholic Identity

- Biblical star and constellation names: [S]
  - Kimah, the Pleiades
  - the Kesil, Orion
  - Ash, or Ayish, the Hyades
  - Mezarim, the Bears (Great and Little)
  - Mazzaroth, Venus (Lucifer and Hesperus)
  - Hadre theman — "the chambers of the south" — Canopus, the Southern Cross, and a Centauri
  - Nachash, Draco
- For more on Astronomy in the Bible, see: http://www.newadvent.org/cathen/02029a.htm

Catholic/Christian Scientists

- G.G. Coriolis Galileo Galilei (astronomer)
- Martin Stanislaus Brennan (priest, astronomer and writer)
- Giovanni Domenico Cassini (first to observe four of Saturn's moons and the co-discoverer of the Great Red Spot on Jupiter)
- Christopher Clavius (Jesuit, the Gregorian calendar)
- Nicolas Louis de Lacaille (French astronomer, cataloged stars, nebulous objects, and constellations)
- Pierre-Simon Laplace (the "Newton of France")
- Paolo dal Pozzo Toscanelli (Italian mathematician, astronomer and cosmographer)
- Eduard Heis (contributed the first true delineation of the Milky Way)
- Gaspard-Gustave Coriolis (laws regarding rotating systems - the Corialis effect)
- Léon Foucault (the Foucault pendulum - measures the effect of the earth's rotation)
- Daniello Bartoli
- Jean-Baptiste Biot

- Nicolaus Copernicus
- Hippolyte Fizeau
- Francisco Maria Grimaldi
- Georges Lemaitre
- Etienne-Louis Malus
- Charles W. Misner
- Giusseppe Piazzi
- Jean Picard
- Giovanni Battista Riccioli
- Galileo Galilei;
- Nicolas-Claude Fabri de Peiresc (discovered the Orion Nebula)

Saints [SA]

- St. Dominic, patron saint of astronomers

HS-ESS2 **Earth's Systems**

HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Catholic/Christian Scientists

- Evangelista Torricelli (Inventor of the barometer)
- Nicolas Steno (stratigraphy)
- Georgius Agricola (mineralogy)
- Jean Baptiste Julien d'Omalius d'Halloy (modern geology)
- René Just Haüy (crystallography)
- Abraham Ortelius (created the first modern atlas and theorized on continental drift)
- Wilhelm Heinrich Waagen (geologist and paleontologist)
- Johann Joachim Winckelmann (scientific archaeology)
- Teilhard de Chardin (paleontology)

Saints [SA]

- St. Barbara, patron saint of geology

HS-ESS3 Earth and Human Activity

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Catholic Identity

- Pope Francis on natural resources: "*In the face of possible risks to the environment which may affect the common good now and in the future, decisions must be made 'based on a comparison of the risks and benefits foreseen for the various possible alternatives'. This is especially the case when a project may lead to a greater use of natural resources, higher levels of emission or discharge, an increase of refuse, or significant changes to the landscape, the habitats of protected species or public spaces. Some projects, if insufficiently studied, can profoundly affect the quality of life of an area due to very different factors such as unforeseen noise pollution, the shrinking of visual horizons, the loss of cultural values, or the effects of nuclear energy use. …*" (Pope Francis, ***Laudato Si'***, para. 184).

  Pope Francis on water: "*Other indicators of the present situation have to do with the depletion of natural resources. We all know that it is not possible to sustain the present level of consumption in developed countries and wealthier sectors of society, where the habit of wasting and discarding has reached unprecedented levels. The exploitation of the planet has already exceeded acceptable limits and we still have not solved the problem of poverty*" (Pope Francis, ***Laudato Si'***, para. 27).

  "*Fresh drinking water is an issue of primary importance, since it is indispensable for human life and for supporting terrestrial and aquatic ecosystems. Sources of fresh water are necessary for health care, agriculture and industry. Water supplies used to be relatively constant, but now in many places demand exceeds the sustainable supply, with dramatic consequences in the short and long term. Large cities dependent on significant supplies of water have experienced periods of shortage, and at critical moments these have not always been administered with sufficient oversight and impartiality. Water poverty especially affects Africa where large sectors of the population have no access to safe drinking water or experience droughts which impede agricultural production. Some countries have areas rich in water while others endure drastic scarcity*" (para. 28).

  "*One particularly serious problem is the quality of water available to the poor. Every day, unsafe water results in many deaths and the spread of water-related diseases, including those caused by microorganisms and chemical substances. Dysentery and cholera, linked to inadequate hygiene and water supplies, are a significant cause of suffering and of infant mortality. Underground water sources in many places are threatened by the pollution produced in certain mining, farming and industrial activities, especially in countries lacking adequate regulation or controls. It is not only a question of industrial waste. Detergents and chemical products, commonly used in many places of the world, continue to pour into our rivers, lakes and seas*" (para. 29).

"Even as the quality of available water is constantly diminishing, in some places there is a growing tendency, despite its scarcity, to privatize this resource, turning it into a commodity subject to the laws of the market. Yet access to safe drinkable water is a basic and universal human right, since it is essential to human survival and, as such, is a condition for the exercise of other human rights. Our world has a grave social debt towards the poor who lack access to drinking water, because they are denied the right to a life consistent with their inalienable dignity. This debt can be paid partly by an increase in funding to provide clean water and sanitary services among the poor. But water continues to be wasted, not only in the developed world but also in developing countries which possess it in abundance. This shows that the problem of water is partly an educational and cultural issue, since there is little awareness of the seriousness of such behavior within a context of great inequality" (para. 30).

"Greater scarcity of water will lead to an increase in the cost of food and the various products which depend on its use. Some studies warn that an acute water shortage may occur within a few decades unless urgent action is taken. The environmental repercussions could affect billions of people; it is also conceivable that the control of water by large multinational businesses may become a major source of conflict in this century" (para. 31). [M]

HS-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.

Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.

Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system	**ESS1.A: The Universe and Its Stars** • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. **PS3.D: Energy in Chemical Processes and Everyday Life** • Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary)	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students use evidence to develop a model in which they identify and describe the relevant components, including:
   - Hydrogen as the sun's fuel;
   - Helium and energy as the products of fusion processes in the sun; and
   - That the sun, like all stars, has a life span based primarily on its initial mass, and that the sun's lifespan is about 10 billion years.

2. Relationships

a. In the model, students describe relationships between the components, including a description of the process of radiation, and how energy released by the sun reaches Earth's system.

3. Connections

a. Students use the model to predict how the relative proportions of hydrogen to helium change as the sun ages.
b. Students use the model to qualitatively describe the scale of the energy released by the fusion process as being much larger than the scale of the energy released by chemical processes.
c. Students use the model to explicitly identify that chemical processes are unable to produce the amount of energy flowing out of the sun over long periods of time, thus requiring fusion processes as the mechanism for energy release in the sun.

Catholic Identity Connections

- The sun has a very long life span, but it will eventually die. While physical creation participates in cycles of birth, life and death, our souls are created for eternity with God.
- Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.1	Interpret expressions that represent a quantity in terms of its context.
A-CED.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A-CED.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Connections to Other DCIs

HS.PS1.C; HS.PS3.A

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS4.B; MS.ESS1.A; MS.ESS2.A; MS.ESS2.D

HS-ESS1 Earth's Place in the Universe		
Students who demonstrate understanding can: **HS-ESS1-2 Construct an explanation of the Big Bang theory (emergent universe) based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.** Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. **PS4.B: Electromagnetic Radiation** • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary)	**Energy and Matter** • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. • Science assumes the universe is a vast single system in which basic laws are consistent.
Examples of Observable Evidence of Student Performance by the End of the Course		
1. Articulating the explanation of phenomena		
a. Students construct an explanation that includes a description of how astronomical evidence from numerous sources is used collectively to support the Big Bang theory (emergent universe), which states that the universe is expanding and that thus it was hotter and denser in the past, and that the entire visible universe emerged from a very tiny region and expanded.		

2. Evidence

a. Students identify and describe the evidence to construct the explanation, including:
   - The composition (hydrogen, helium and heavier elements) of stars;
   - The hydrogen-helium ratio of stars and interstellar gases;
   - The redshift of the majority of galaxies and the redshift vs. distance relationship; and
   - The existence of cosmic background radiation.

b. Students use a variety of valid and reliable sources for the evidence, which may include students' own investigations, theories, simulations, and peer review.

c. Students describe the source of the evidence and the technology used to obtain that evidence.

3. Reasoning

a. Students use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation for the early universe (the Big Bang theory). Students describe the following chain of reasoning for their explanation:
   - Redshifts indicate that an object is moving away from the observer, thus the observed redshift for most galaxies and the redshift vs. distance relationship is evidence that the universe is expanding.
   - The observed background cosmic radiation and the ratio of hydrogen to helium have been shown to be consistent with a universe that was very dense and hot a long time ago and that evolved through different stages as it expanded and cooled (e.g., the formation of nuclei from colliding protons and neutrons predicts the hydrogen-helium ratio [numbers not expected from students], later formation of atoms from nuclei plus electrons, background radiation was a relic from that time).
   - An expanding universe must have been smaller in the past and can be extrapolated back in time to a tiny size from which it expanded.

Catholic Identity Connections

- The Big Bang theory (emergent universe) supports the idea of an original unity of all of creation. Our Christian scriptures tell us that all will be reconciled to Christ at the end of time.
- Pope John Paul II writes that science is "endowing us with an understanding and appreciation of our universe as a whole and of the incredibly rich variety of intricately related processes and structures which constitute its animate and inanimate components. … The unity we perceive in creation on the basis of our faith in Jesus Christ as Lord of the universe, and the correlative unity for which we strive in our human communities, seems to be reflected and even reinforced in what contemporary science is revealing to us. … The quest for the unification of all four fundamental physical forces – gravitation, electromagnetism, the strong and weak nuclear interactions – has met with increasing success. … Is it not important for us to note that in a world of such detailed specialization as contemporary physics there exists this drive towards convergence?" (https://w2.vatican.va/content/john-paul-ii/en/letters/1988/documents/hf_jp-ii_let_19880601_padre-coyne.html) [MA]
- Pope Francis addresses the unity of creation at the end of time when he writes, "*The ultimate destiny of the universe is in the fullness of God, which has already been attained by the risen Christ, the measure of the maturity of all things.*" He continues, "*…all creatures are moving forward with us and through us towards a common point of arrival, which is God, in that transcendent fullness where the risen Christ embraces and illumines all things*" (***Laudato Si'***, #83). [MA]

Diocese of Owensboro ELA and Mathematics Standards Connections	
ELA/Literacy	
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
Mathematics	
MP.2	Reason abstractly and quantitatively.
N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N-Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.1	Interpret expressions that represent a quantity in terms of its context.
A-CED.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A-CED.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Connections to Other DCIs
HS.PS1.A; HS.PS1.C; HS.PS3.A; HS.PS3.B; HS.PS4.A

Articulation to DCIs across Grade-Bands
MS.PS1.A; MS.PS4.B; MS.ESS1.A

HS-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.

Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.

Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Communication style and format

a. Students use at least two different formats (e.g., oral, graphical, textual, and mathematical) to communicate scientific information, and cite the origin of the information as appropriate.

2. Connecting the DCIs and the CCCs

a. Students identify and communicate the relationships between the life cycle of the stars, the production of elements, and the conservation of the number of protons plus neutrons in stars. Students identify that atoms are not conserved in nuclear fusion, but the total number of protons plus neutrons is conserved.

b. Students describe that:
- Helium and a small amount of other light nuclei (i.e., up to lithium) were formed from high-energy collisions starting from protons and neutrons in the early universe before any stars existed.
- More massive elements, up to iron, are produced in the cores of stars by a chain of processes of nuclear fusion, which also releases energy.
- Supernova explosions of massive stars are the mechanism by which elements more massive than iron are produced.
- There is a correlation between a star's mass and stage of development and the types of elements it can create during its lifetime.
- Electromagnetic emission and absorption spectra are used to determine a star's composition, motion and distance to Earth.

Catholic Identity Connections

- Understanding of cycles helps us to contemplate the Paschal Mystery.
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]

Scripture [S]

- "There is an appointed time for everything, and a time for every affair under the heavens.
  A time to give birth, and a time to die; a time to plant, and a time to uproot the plant.
  A time to kill, and a time to heal; a time to tear down, and a time to build.
  A time to weep, and a time to laugh; a time to mourn, and a time to dance.
  A time to scatter stones, and a time to gather them; a time to embrace, and a time to be far from embraces.
  A time to seek, and a time to lose; a time to keep, and a time to cast away.
  A time to rend, and a time to sew; a time to be silent, and a time to speak.
  A time to love, and a time to hate; a time of war, and a time of peace." (Ecclesiastes 3:1-8)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs

HS.PS1.A; HS.PS1.C

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.ESS1.A

HS-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.

Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's laws of orbital motions should not deal with more than two bodies, nor involve calculus.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematical and Computational Thinking Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical or computational representations of phenomena to describe explanations.	**ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.	**Scale, Proportion, and Quantity** • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the following relevant components in the given mathematical or computational representations of orbital motion: the trajectories of orbiting bodies, including planets, moons, or human-made spacecraft; each of which depicts a revolving body's eccentricity e = f/d, where f is the distance between foci of an ellipse, and d is the ellipse's major axis length (Kepler's first law of planetary motion).

2. Mathematical or computational modeling

a. Students use the given mathematical or computational representations of orbital motion to depict that the square of a revolving body's period of revolution is proportional to the cube of its distance to a gravitational center ($T^2 \propto R^3$, where T is the orbital period and R is the semi-major axis of the orbit — Kepler's third law of planetary motion).

3. Analysis
a. Students use the given mathematical or computational representation of Kepler's second law of planetary motion (an orbiting body sweeps out equal areas in equal time) to predict the relationship between the distance between an orbiting body and its star, and the object's orbital velocity (i.e., that the closer an orbiting body is to a star, the larger its orbital velocity will be). b. Students use the given mathematical or computational representation of Kepler's third law of planetary motion ($T^2 \propto R^3$, where T is the orbital period and R is the semi-major axis of the orbit) to predict how either the orbital distance or orbital period changes given a change in the other variable. c. Students use Newton's law of gravitation plus his third law of motion to predict how the acceleration of a planet towards the sun varies with its distance from the sun, and to argue qualitatively about how this relates to the observed orbits.

Catholic Identity Connections

- Articulate how science properly situates itself within other academic disciplines (e.g., history, theology) for correction and completion in order to recognize the limited material explanation of reality to which it is properly attuned. [CS S.712 IS1]
- Demonstrate confidence in human reason and in one's ability to know the truth about God's creation and the fundamental intelligibility of the world. [CS S.712 IS2]
- Relate how the search for truth, even when it concerns a finite reality of the natural world or of humans, is never-ending and always points beyond to something higher than the immediate object of study. [CS S.712 IS4]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N-Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N-Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N-Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
A-SSE.1	Interpret expressions that represent a quantity in terms of its context.
A-CED.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
A-CED.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

Connections to Other DCIs

HS.PS2.B

Articulation to DCIs across Grade-Bands

MS.PS2.A; MS.PS2.B; MS.ESS1.A; MS.ESS1.B

HS-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

Clarification Statement: Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9– 12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.	**ESS1.C: The History of Planet Earth** • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary) **PS1.C: Nuclear Processes** • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)	**Patterns** • Empirical evidence is needed to identify patterns.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Identifying the given explanation and the supporting evidence

a. Students identify the given explanation, which includes the following idea: that crustal materials of different ages are arranged on Earth's surface in a pattern that can be attributed to plate tectonic activity and formation of new rocks from magma rising where plates are moving apart.
b. Students identify the given evidence to be evaluated.

2. Identifying any potential additional evidence that is relevant to the evaluation

a. Students identify and describe additional relevant evidence (in the form of data, information, models, or other appropriate forms) that was not provided but is relevant to the explanation and to evaluating the given evidence, including:
   - Measurement of the ratio of parent to daughter atoms produced during radioactive decay as a means for determining the ages of rocks;
   - Ages and locations of continental rocks;
   - Ages and locations of rocks found on opposite sides of mid-ocean ridges; and
   - The type and location of plate boundaries relative to the type, age, and location of crustal rocks.

3. Evaluating and critiquing

a. Students use their additional evidence to assess and evaluate the validity of the given evidence.
b. Students evaluate the reliability, strengths, and weaknesses of the given evidence along with its ability to support logical and reasonable arguments about the motion of crustal plates.

4. Reasoning/synthesis

a. Students describe how the following patterns observed from the evidence support the explanation about the ages of crustal rocks:
    - The pattern of the continental crust being older than the oceanic crust;
    - The pattern that the oldest continental rocks are located at the center of continents, with the ages decreasing from their centers to their margin; and
    - The pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges.
b. Students synthesize the relevant evidence to describe the relationship between the motion of continental plates and the patterns in the ages of crustal rocks, including that:
    - At boundaries where plates are moving apart, such as mid-ocean ridges, material from the interior of the Earth must be emerging and forming new rocks with the youngest ages.
    - The regions furthest from the plate boundaries (continental centers) will have the oldest rocks because new crust is added to the edge of continents at places where plates are coming together, such as subduction zones.
    - The oldest crustal rocks are found on the continents because oceanic crust is constantly being destroyed at places where plates are coming together, such as subduction zones.

Catholic Identity Connections

- Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history.
- Pope John Paul II: "…The unity we perceive in creation on the basis of our faith in Jesus Christ as Lord of the universe, and the correlative unity for which we strive in our human communities, seems to be reflected and even reinforced in what contemporary science is revealing to us. … " (https://w2.vatican.va/content/john-paul-ii/en/letters/1988/documents/hf_jp-ii_let_19880601_padre-coyne.html) [MA]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics

MP.2 Reason abstractly and quantitatively.

N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.B; HS.PS4.A; HS.ESS2.A

Articulation to DCIs across Grade-Bands

MS.ESS1.C; MS.ESS2.A; MS.ESS2.B

HS-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.	**ESS1.C: The History of Planet Earth** • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. **PS1.C: Nuclear Processes** • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Stability and Change

a. Students construct an account of Earth's formation and early history that includes that:
   - Earth formed along with the rest of the solar system 4.6 billion years ago.
   - The early Earth was bombarded by impacts just as other objects in the solar system were bombarded.
   - Erosion and plate tectonics on Earth have destroyed much of the evidence of this bombardment, explaining the relative scarcity of impact craters on Earth.

2. Evidence

a. Students include and describe the following evidence in their explanatory account:
  - The age and composition of Earth's oldest rocks, lunar rocks, and meteorites as determined by radiometric dating;
  - The composition of solar system objects;
  - Observations of the size and distribution of impact craters on the surface of Earth and on the surfaces of solar system objects (e.g., the moon, Mercury, and Mars); and
  - The activity of plate tectonic processes, such as volcanism, and surface processes, such as erosion, operating on Earth.

3. Reasoning

a. Students use reasoning to connect the evidence to construct the explanation of Earth's formation and early history, including that:
  - Radiometric ages of lunar rocks, meteorites and the oldest Earth rocks point to an origin of the solar system 4.6 billion years ago, with the creation of a solid Earth crust about 4.4 billion years ago.
  - Other planetary surfaces and their patterns of impact cratering can be used to infer that Earth had many impact craters early in its history.
  - The relative lack of impact craters and the age of most rocks on Earth compared to other bodies in the solar system can be attributed to processes such as volcanism, plate tectonics, and erosion that have reshaped Earth's surface, and that this is why most of Earth's rocks are much younger than Earth itself.

Catholic Identity Connections

- The Earth's story is a chapter of the larger story of an unfolding universe that changes over time. Creation is ongoing. You might revisit the **Cardinal Newman Society** standards on evolution:
  - Analyze and articulate the Church's approach to the theory of evolution. [CS S.712 IS12]
  - Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. [CS S.712 IS13]
  - Explain how understanding the physiological properties of a human being do not address the existence of the transcendent spirit of the human person (Catholic Curriculum Science Standards, Appendix E). [CS S.712 IS14]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

WHST.9-12.1 Write arguments focused on discipline-specific content.

Mathematics

MP.2 Reason abstractly and quantitatively.

N-Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N-Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N-Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

F-IF.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

S-ID.6 Represent data on two quantitative variables on a scatter plot, and describe how those variables are related.

Connections to Other DCIs

HS.PS2.A; HS.PS2.B

Articulation to DCIs across Grade-Bands

MS.PS2.B; MS.ESS1.B; MS.ESS1.C; MS.ESS2.A; MS.ESS2.B

HS-ESS2 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

Clarification Statement: Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion).

Assessment Boundary: Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE)	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students use evidence to develop a model in which they identify and describe the following components:
   - Descriptions and locations of specific continental features and specific ocean-floor features;
   - A geographic scale, showing the relative sizes/extents of continental and/or ocean-floor features;
   - Internal processes (such as volcanism and tectonic uplift) and surface processes (such as weathering and erosion); and
   - A temporal scale showing the relative times over which processes act to produce continental and/or ocean-floor features.

2. Relationships

a. In the model, students describe the relationships between components, including:
   - Specific internal processes, mainly volcanism, mountain building or tectonic uplift, are identified as causal agents in building up Earth's surface over time.
   - Specific surface processes, mainly weathering and erosion, are identified as causal agents in wearing down Earth's surface over time.
   - Interactions and feedbacks between processes are identified (e.g., mountain-building changes weather patterns that then change the rate of erosion of mountains).
   - The rate at which the features change is related to the time scale on which the processes operate. Features that form or change slowly due to processes that act on long time scales (e.g., continental positions due to plate drift) and features that form or change rapidly due to processes that act on short time scales (e.g., volcanic eruptions) are identified.

3. Connections

a. Students use the model to illustrate the relationship between 1) the formation of continental and ocean floor features and 2) Earth's internal and surface processes operating on different temporal or spatial scales.

Catholic Identity Connections

- Creation
  - Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
  - Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
  - Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
  - Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS2.B

Articulation to DCIs across Grade-Bands

MS.PS2.B; MS.LS2.B; MS.ESS1.C; MS.ESS2.A; MS.ESS2.B; MS.ESS2.C; MS.ESS2.D

HS-ESS2 Earth's Systems		
Students who demonstrate understanding can: **HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** Clarification Statement: Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space.	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **Connections to Engineering, Technology, and Applications of Science** **Influence of Engineering, Technology, and Science on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Organizing data

a. Students organize data that represent measurements of changes in hydrosphere, cryosphere, atmosphere, biosphere, or geosphere in response to a change in Earth's surface.
b. Students describe what each data set represents.

2. Identifying relationships

a. In the model, students describe the relationships between components, including:
   - Specific internal processes, mainly volcanism, mountain building or tectonic uplift, are identified as causal agents in building up Earth's surface over time.
   - Specific surface processes, mainly weathering and erosion, are identified as causal agents in wearing down Earth's surface over time.
   - Interactions and feedbacks between processes are identified (e.g., mountain-building changes weather patterns that then change the rate of erosion of mountains).
   - The rate at which the features change is related to the time scale on which the processes operate. Features that form or change slowly due to processes that act on long time scales (e.g., continental positions due to plate drift) and features that form or change rapidly due to processes that act on short time scales (e.g., volcanic eruptions) are identified.

3. Interpreting data

a. Students use the analyzed data to describe a mechanism for the feedbacks between two of Earth's systems and whether the feedback is positive or negative, increasing (destabilizing) or decreasing (stabilizing) the original changes.
b. Students use the analyzed data to describe a particular unanticipated or unintended effect of a selected technology on Earth's systems if present.
c. Students include a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data.

Catholic Identity Connections

- The Clarification Statement connects this standard to climate change, thus it relates to care of God's creation.
- Care for God's creation is the 7th theme of Catholic Social Teaching [CST] and has been added to the Corporal Works of Mercy and the Spiritual Works of Mercy. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
- Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. (CS S.712 IS6)
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
- Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
- Share concern and care for the environment as part of God's creation. [CS S.712 DS4]

Scripture [S]
- Feedbacks in the Earth's dynamics also relate to the Body of Christ - "If [one] part suffers, all the parts suffer with it; if one part is honored, all the parts share its joy." (1 Corinthians 12:26)

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Mathematics

MP.2 Reason abstractly and quantitatively.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.B; HS.PS4.B; HS.LS2.B; HS.LS2.C; HS.LS4.D; HS.ESS3.C; HS.ESS3.D

Articulation to DCIs across Grade-Bands

MS.PS3.D; MS.PS4.B; MS.LS2.B; MS.LS2.C; MS.LS4.C; MS.ESS2.A; MS.ESS2.B; MS.ESS2.C; MS.ESS2.D; MS.ESS3; MS.ESS3.D

HS-ESS2 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Clarification Statement: Emphasis is on both a one dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. • Science includes the process of coordinating patterns of evidence with current theory.	**ESS2.A: Earth Materials and Systems** • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.	**Energy and Matter** • Energy drives the cycling of matter within and between systems. **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students develop a model (i.e., graphical, verbal, or mathematical) in which they identify and describe the components based on both seismic and magnetic evidence (e.g., the pattern of the geothermal gradient or heat flow measurements) from Earth's interior, including:
   - Earth's interior in cross-section and radial layers (crust, mantle, liquid outer core, solid inner core) determined by density;
   - The plate activity in the outer part of the geosphere;
   - Radioactive decay and residual thermal energy from the formation of the Earth as a source of energy;
   - The loss of heat at the surface of the earth as an output of energy; and
   - The process of convection that causes hot matter to rise (move away from the center) and cool matter to fall (move toward the center).

2. Relationships

a. Students describe the relationships between components in the model, including:
   - Energy released by radioactive decay in the Earth's crust and mantle and residual thermal energy from the formation of the Earth provide energy that drives the flow of matter in the mantle.
   - Thermal energy is released at the surface of the Earth as new crust is formed and cooled.
   - The flow of matter by convection in the solid mantle and the sinking of cold, dense crust back into the mantle exert forces on crustal plates that then move, producing tectonic activity.
   - The flow of matter by convection in the liquid outer core generates the Earth's magnetic field.
   - Matter is cycled between the crust and the mantle at plate boundaries. Where plates are pushed together, cold crustal material sinks back into the mantle, and where plates are pulled apart, mantle material can be integrated into the crust, forming new rock.

3. Connections

a. Students use the model to describe the cycling of matter by thermal convection in Earth's interior, including:
   - The flow of matter in the mantle that causes crustal plates to move;
   - The flow of matter in the liquid outer core that generates the Earth's magnetic field, including evidence of polar reversals (e.g., seafloor exploration of changes in the direction of Earth's magnetic field);
   - The radial layers determined by density in the interior of Earth; and
   - The addition of a significant amount of thermal energy released by radioactive decay in Earth's crust and mantle.

Catholic Identity Connections

- Earth's systems are dynamic and interactive. Plate tectonics can be viewed as the surface expression of mantle convection. So too, what happens on the surface of our lives is an expression of what is happening in our deep, spiritual core.
- Practicing the Corporal Works of Mercy, the Spiritual Works of Mercy and Catholic Social Teachings are outward expressions of our inner spiritual lives.
- The sacraments, which are outward signs, instituted by Christ to give grace, nurture and sustain our inner lives so that we can, in turn, manifest Christ in the world.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS2.B; HS.PS3.B; HS.PS3.D

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS1.B; MS.PS2.B; MS.PS3.A; MS.PS3.B; MS.ESS2.A; MS.ESS2.B

HS-ESS2 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.

Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Use a model to provide mechanistic accounts of phenomena. **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS1.B: Earth and the Solar System** • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary) **ESS2.A: Earth Materials and System** • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Examples of Observable Evidence of Student Performance by the End of the Course
1. Components of the model
a. From the given model, students identify and describe the components of the model relevant for their mechanistic descriptions. Given models include at least one factor that affects the input of energy, at least one factor that affects the output of energy, and at least one factor that affects the storage and redistribution of energy. Factors are derived from the following list: • Changes in Earth's orbit and the orientation of its axis; • Changes in the sun's energy output; • Configuration of continents resulting from tectonic activity; • Ocean circulation; • Atmospheric composition (including amount of water vapor and CO2); • Atmospheric circulation; • Volcanic activity; • Glaciation; • Changes in extent or type of vegetation cover; and • Human activities. b. From the given model, students identify the relevant different time scales on which the factors operate.
2. Relationships
a. Students identify and describe the relationships between components of the given model, and organize the factors from the given model into three groups: • Those that affect the input of energy; • Those that affect the output of energy; and • Those that affect the storage and redistribution of energy b. Students describe the relationships between components of the model as either causal or correlational.
3. Connections
a. Students use the given model to provide a mechanistic account of the relationship between energy flow in Earth's systems and changes in climate, including: • The specific cause and effect relationships between the factors and the effect on energy flow into and out of Earth's systems; and • The net effect of all of the competing factors in changing the climate.

Catholic Identity Connections

- Pope Francis writes about climate change in ***Laudato Si'***. He quotes Patriarch Bartholomew as saying: *"For human beings… to destroy the biological diversity of God's creation; for human beings to degrade the integrity of the earth by causing changes in its climate, by stripping the earth of its natural forests or destroying its wetlands; for human beings to contaminate the earth's waters, its land, its air, and its life – these are sins". For "to commit a crime against the natural world is a sin against ourselves and a sin against God*" (para. 20). [MA]
- Climate as a common good.
- "*The climate is a common good, belonging to all and meant for all. At the global level, it is a complex system linked to many of the essential conditions for human life. A very solid scientific consensus indicates that we are presently witnessing a disturbing warming of the climatic system. In recent decades this warming has been accompanied by a constant rise in the sea level and, it would appear, by an increase of extreme weather events, even if a scientifically determinable cause cannot be assigned to each particular phenomenon. Humanity is called to recognize the need for changes of lifestyle, production and consumption, in order to combat this warming or at least the human causes which produce or aggravate it"* (***Laudato Si'***, para. 23). [MA]
- *"Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day. Its worst impact will probably be felt by developing countries in coming decades. Many of the poor live in areas particularly affected by phenomena related to warming, and their means of subsistence are largely dependent on natural reserves and ecosystemic services such as agriculture, fishing and forestry. They have no other financial activities or resources which can enable them to adapt to climate change or to face natural disasters, and their access to social services and protection is very limited. For example, changes in climate, to which animals and plants cannot adapt, lead them to migrate; this in turn affects the livelihood of the poor, who are then forced to leave their homes, with great uncertainty for their future and that of their children"* (para. 25). (For more on climate change, see ***Laudato Si'***, paragraphs 23-26.) [MA]
- Understanding climate as a common good helps us to connect climate change with Catholic Social Teaching, particularly as pertains to: Life and Dignity of the Human Person; Rights and Responsibilities; Option for the Poor and Vulnerable; Solidarity; Care of God's Creation. [CST]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.A; HS.PS3.B; HS.LS2.C; HS.LS4.D; HS.ESS1.C; HS.ESS3.C; HS.ESS3.D

Articulation to DCIs across Grade-Bands

MS.PS3.A; MS.PS3.B; MS.PS3.D; MS.PS4.B; MS.LS1.C; MS.LS2.B; MS.LS2.C; MS.ESS2.A; MS.ESS2.B; MS.ESS2.C; MS.ESS2.D; MS.ESS3.C; MS.ESS3.D

HS-ESS2 Earth's Systems		
Students who demonstrate understanding can: **HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Planning and Carrying Out Investigations Planning and carrying out investigations in 9- 12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Structure and Function** • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.
Examples of Observable Evidence of Student Performance by the End of the Course		
1. Identifying the phenomenon to be investigated		
a. Students describe the phenomenon under investigation, which includes the following idea: a connection between the properties of water and its effects on Earth materials and surface processes.		

2. Identifying the evidence to answer this question

a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including:
    - Properties of water, including:
        - The heat capacity of water;
        - The density of water in its solid and liquid states; and
        - The polar nature of the water molecule due to its molecular structure.
    - The effect of the properties of water on energy transfer that causes the patterns of temperature, the movement of air, and the movement and availability of water at Earth's surface.
    - Mechanical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include:
        - Stream transportation and deposition using a stream table, which can be used to infer the ability of water to transport and deposit materials;
        - Erosion using variations in soil moisture content, which can be used to infer the ability of water to prevent or facilitate movement of Earth materials; and
        - The expansion of water as it freezes, which can be used to infer the ability of water to break rocks into smaller pieces.
    - Chemical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include:
        - The solubility of different materials in water, which can be used to infer chemical weathering and recrystallization;
        - The reaction of iron to rust in water, which can be used to infer the role of water in chemical weathering;
        - Data illustrating that water lowers the melting temperature of most solids, which can be used to infer melt generation; and
        - Data illustrating that water decreases the viscosity of melted rock, affecting the movement of magma and volcanic eruptions.

b. In their investigation plan, students describe how the data collected will be relevant to determining the effect of water on Earth materials and surface processes.

3. Planning for the Investigation

a. In their investigation plan, students include a means to indicate or measure the predicted effect of water on Earth's materials or surface processes. Examples include:
    - The role of the heat capacity of water to affect the temperature, movement of air and movement of water at the Earth's surface;
    - The role of flowing water to pick up, move and deposit sediment;
    - The role of the polarity of water (through cohesion) to prevent or facilitate erosion;
    - The role of the changing density of water (depending on physical state) to facilitate the breakdown of rock;
    - The role of the polarity of water in facilitating the dissolution of Earth materials;
    - Water as a component in chemical reactions that change Earth materials; and
    - The role of the polarity of water in changing the melting temperature and viscosity of rocks.

b. In the plan, students state whether the investigation will be conducted individually or collaboratively.

4. Collecting the data

a. Students collect and record measurements or indications of the predicted effect of a property of water on Earth's materials or surface.

5. Refining the design

a. Students evaluate the accuracy and precision of the collected data.

b. Students evaluate whether the data can be used to infer the effect of water on processes in the natural world.

c. If necessary, students refine the plan to produce more accurate and precise data.

Catholic Identity Connections

- Water is a vital part of the sacramental life of the church. This standard provides deeper insight into the versatility of water and its role in shaping the dynamics of the planet, thus enriching our understanding of the sacraments, as they draw us closer to God through creation. [SA]
- In ***Laudato Si'*** Pope Francis writes about "The Issue of Water" – paragraphs 27-31. Again, he demonstrates an "option for the poor and vulnerable" [CST] when he writes: "*access to safe drinkable water is a basic and universal human right, since it is essential to human survival and, as such, is a condition for the exercise of other human rights. Our world has a grave social debt towards the poor who lack access to drinking water, because they are denied the right to a life consistent with their inalienable dignity*" (para. 30).
- *"Today, however, we have to realize that a true ecological approach always becomes a social approach; it must integrate questions of justice in debates on the environment, so as to hear both the cry of the earth and the cry of the poor"* (Pope Francis, ***Laudato Si'***, para. 49). [M]
- This can be related to the 4th theme of Catholic Social Teaching – "Option for the Poor and Vulnerable" [CST]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Mathematics

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS1.A; HS.PS1.B; HS.PS3.B; HS.ESS3.C

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS3.A; MS.PS3.D; MS.PS4.B; MS.ESS2.A; MS.ESS2.C; MS.ESS2.D

HS-ESS2 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Components of the model

a. Students use evidence to develop a model in which they:
   - Identify the relative concentrations of carbon present in the hydrosphere, atmosphere, geosphere and biosphere; and
   - Represent carbon cycling from one sphere to another.

2. Relationships

a. In the model, students represent and describe the following relationships between components of the system, including:
   - The biogeochemical cycles that occur as carbon flows from one sphere to another;
   - The relative amount of and the rate at which carbon is transferred between spheres;
   - The capture of carbon dioxide by plants; and
   - The increase in carbon dioxide concentration in the atmosphere due to human activity and the effect on climate.

3. Connections

a. Students use the model to explicitly identify the conservation of matter as carbon cycles through various components of Earth's systems.
b. Students identify the limitations of the model in accounting for all of Earth's carbon.

Catholic Identity Connections

- God created the cycles, systems, and processes of Earth to maintain equilibrium and support life on the planet. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affected climate. Unchecked climate change threatens life on Earth. Thus, this standard relates to care of God's creation.
- Care for God's creation is the 7th theme of Catholic Social Teaching [CST] and has been added to the Corporal Works of Mercy and the Spiritual Works of Mercy. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
- Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. [CS S.712 DS2]
- Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
- Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- In ***Laudato Si'*** Pope Francis discusses climate as a common good, *"belonging to all and meant for all*" (#23). [MA] The poor suffer the most from climate change, thus we might address theme four of Catholic Social Teaching here: Option for the poor and vulnerable. All seven themes of Catholic Social Teaching relate in some way to climate change. [CST]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS1.A; HS.PS1.B; HS.PS3.D; HS.LS1.C; HS.LS2.B; HS.ESS3.C; HS.ESS3.D

Articulation to DCIs across Grade-Bands

MS.PS1.A; MS.PS3.D; MS.PS4.B; MS.LS2.B; MS.ESS2.A; MS.ESS2.B; MS.ESS2.C; MS.ESS3.C; MS.ESS3.D

HS-ESS2 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Clarification Statement: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.

Assessment Boundary: Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Construct an oral and written argument or counter-arguments based on data and evidence.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. **ESS2.E Biogeology** • The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.	**Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable

Examples of Observable Evidence of Student Performance by the End of the Course

1. Developing the claim

a. Students develop a claim, which includes the following idea: that there is simultaneous coevolution of Earth's systems and life on Earth. This claim is supported by generalizing from multiple sources of evidence.

2. Identifying scientific evidence

a. Students identify and describe evidence supporting the claim, including:
   - Scientific explanations about the composition of Earth's atmosphere shortly after its formation;
   - Current atmospheric composition;
   - Evidence for the emergence of photosynthetic organisms;
   - Evidence for the effect of the presence of free oxygen on evolution and processes in other Earth systems;
   - In the context of the selected example(s), other evidence that changes in the biosphere affect other Earth systems.

3. Evaluating and critiquing

a. Students evaluate the evidence and include the following in their evaluation:
   - A statement regarding how variation or uncertainty in the data (e.g., limitations, low signal-to-noise ratio, collection bias, etc.) may affect the usefulness of the data as sources of evidence; and
   - The ability of the data to be used to determine causal or correlational effects between changes in the biosphere and changes in Earth's other systems.

4. Reasoning and synthesis

a. Students use at least two examples to construct oral and written logical arguments. The examples:
   - Include that the evolution of photosynthetic organisms led to a drastic change in Earth's atmosphere and oceans in which the free oxygen produced caused worldwide deposition of iron oxide formations, increased weathering due to an oxidizing atmosphere and the evolution of animal life that depends on oxygen for respiration; and
   - Identify causal links and feedback mechanisms between changes in the biosphere and changes in Earth's other systems.

Catholic Identity Connections

- This speaks to the unity of creation. It is a one sacred whole. Human life is intimately bound up with the dynamics of the planet. We cannot have healthy humans on an unhealthy planet, whether it be due to climate change, scarcity of water, or other causes. Thus, this standard is connected to Care of God's Creation, which has been discussed in depth above.

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy
WHST.9-12.1 Write arguments focused on discipline-specific content.

Connections to Other DCIs

HS.LS2.A; HS.LS2.C; HS.LS4.A; HS.LS4.B; HS.LS4.C; HS.LS4.D

Articulation to DCIs across Grade-Bands

MS.LS2.A; MS.LS2.C; MS.LS4.A; MS.LS4.B; MS.LS4.C; MS.ESS1.C; MS.ESS2.A; MS.ESS2.C; MS.ESS2.D; MS.ESS3.C

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS3.A: Natural Resources** • Resource availability has guided the development of human society. **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Articulating the explanation of phenomena

a. Students construct an explanation that includes:
   - Specific cause and effect relationships between environmental factors (natural hazards, changes in climate, and the availability of natural resources) and features of human societies including population size and migration patterns; and
   - That technology in modern civilization has mitigated some of the effects of natural hazards, climate, and the availability of natural resources on human activity.

2. Evidence

a. Students identify and describe the evidence to construct their explanation, including:
   - Natural hazard occurrences that can affect human activity and have significantly altered the sizes and distributions of human populations in particular regions;
   - Changes in climate that affect human activity (e.g., agriculture) and human populations, and that can drive mass migrations;
   - Features of human societies that have been affected by the availability of natural resources; and
   - Evidence of the dependence of human populations on technological systems to acquire natural resources and to modify physical settings.

b. Students use a variety of valid and reliable sources for the evidence, potentially including theories, simulations, peer review, or students' own investigations.

3. Reasoning

a. Students use reasoning that connects the evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to describe:
   - The effect of natural hazards, changes in climate, and the availability of natural resources on features of human societies, including population size and migration patterns; and
   - How technology has changed the cause and effect relationship between the development of human society and natural hazards, climate, and natural resources.

b. Students describe reasoning for how the evidence allows for the distinction between causal and correlational relationships between environmental factors and human activity.

Catholic Identity Connections

- In ***Laudato Si'*** Pope Francis identifies fresh drinking water as "*an issue of primary importance*" and looks at "*water poverty*" and water quality (#28 and #29). He writes, "…*access to safe drinkable water is a basic and universal human right, since it is essential to human survival and, as such, is a condition for the exercise of other human rights*" (#30). [MA] The right to life is directly connected to the availability of water.
- The poor suffer the most from climate change, natural disasters, and environmental problems, therefore we should be especially mindful of the following themes of Catholic Social Teaching:
  - Life and Dignity of the Human Person
  - Option for the Poor and Vulnerable
  - Care for God's Creation

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Mathematics

MP.2 Reason abstractly and quantitatively.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

N/A

Articulation to DCIs across Grade-Bands

MS.LS2.A; MS.LS4.D; MS.ESS2.A; MS.ESS3.A.; MS.ESS3.B

HS-ESS3 Earth and Human Activity		
Students who demonstrate understanding can: **HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.** Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).	**ESS3.A: Natural Resources** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Analysis of costs and benefits is a critical aspect of decisions about technology. **Connections to Nature of Science** **Science Addresses Questions About the Natural and Material World** • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • Science knowledge indicates what can happen in natural systems — not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.
Examples of Observable Evidence of Student Performance by the End of the Course		
1. Supported claims		
a. Students describe the nature of the problem each design solution addresses. b. Students identify the solution that has the most preferred cost-benefit ratios.		
2. Identifying scientific evidence		
a. Students identify evidence for the design solutions, including: • Societal needs for that energy or mineral resource; • The cost of extracting or developing the energy reserve or mineral resource; • The costs and benefits of the given design solutions; and • The feasibility, costs, and benefits of recycling or reusing the mineral resource, if applicable.		

3. Evaluation and critique

a. Students evaluate the given design solutions, including:
   - The relative strengths of the given design solutions, based on associated economic, environmental, and geopolitical costs, risks, and benefits;
   - The reliability and validity of the evidence used to evaluate the design solutions; and
   - Constraints, including cost, safety, reliability, aesthetics, cultural effects environmental effects.

4. Reasoning/synthesis

a. Students use logical arguments based on their evaluation of the design solutions, costs and benefits, empirical evidence, and scientific ideas to support one design over the other(s) in their evaluation.
b. Students describe that a decision on the "best" solution may change over time as engineers and scientists work to increase the benefits of design solutions while decreasing costs and risks.

Catholic Identity Connections

- Care for God's creation is the 7th theme of Catholic Social Teaching [CST] and has been added to the Corporal Works of Mercy and the Spiritual Works of Mercy. It is also an important theme of the writings of the last three Popes, most recently Pope Francis' ***Laudato Si'***. [MA]
- Share how the beauty and goodness of God is reflected in nature and the study of the natural sciences. [CS S.712 GS4]
- Explain the processes of conservation, preservation, overconsumption, and stewardship as it relates to creation and to caring for that which God has given to sustain and delight us. [CS S.712 IS5]
- Evaluate the relationship between God, humans, and nature, and the proper role in the totality of being and creation. [CS S.712 IS6]
- Describe humanity's natural situation in, and dependence upon, physical reality and how humans carry out their role as a cooperator with God in the work of creation. [CS S.712 IS7]
- Display a deep sense of wonder and delight about the natural universe. [CS S.712 DS1]
- Share how natural phenomena have more than a utilitarian meaning and purpose and exemplify the handiwork of the Creator. (CS S.712 DS2)
- Subscribe to the premise that nature should not be manipulated at will, but should be respected for its natural purpose and end as destined by the creator God. [CS S.712 DS3]
- Share concern and care for the environment as part of God's creation. [CS S.712 DS4]
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics

MP.2 Reason abstractly and quantitatively.

Connections to Other DCIs

HS.PS3.B; HS.PS3.D; HS.LS2.A; HS.LS2.B; HS.LS4.D; HS.ESS2.A

Articulation to DCIs across Grade-Bands

MS.PS3.D; MS.LS2.A; MS.LS2.B; MS.LS4.D; MS.ESS3.A; MS.ESS3.C

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.

Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9– 12 builds on K–8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system.	**ESS3.C: Human Impacts on Earth Systems** • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Modern civilization depends on major technological systems. • New technologies can have deep impacts on society and the environment, including some that were not anticipated. **Connections to Nature of Science** **Science is a Human Endeavor** • Science is a result of human endeavors, imagination, and creativity.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students create a computational simulation (using a spreadsheet or a provided multi-parameter program) that contains representations of the relevant components, including:
   - A natural resource in a given ecosystem;
   - The sustainability of human populations in a given ecosystem;
   - Biodiversity in a given ecosystem; and
   - The effect of a technology on a given ecosystem.

2. Computational modeling

a. Students describe simplified realistic (corresponding to real-world data) relationships between simulation variables to indicate an understanding of the factors (e.g., costs, availability of technologies) that affect the management of natural resources, human sustainability, and biodiversity. (For example, a relationship could be described that the amount of a natural resource does not affect the sustainability of human populations in a given ecosystem without appropriate technology that makes use of the resource; or a relationship could be described that if a given ecosystem is not able to sustain biodiversity, its ability to sustain a human population is also small.)

b. Students create a simulation using a spreadsheet or provided multi-parameter program that models each component and its simplified mathematical relationship to other components. Examples could include:
   - S=C*B*R*T, where S is sustainability of human populations, C is a constant, B is biodiversity, R is the natural resource, and T is a technology used to extract the resource so that if there is zero natural resource, zero technology to extract the resource, or zero biodiversity, the sustainability of human populations is also zero; and
   - B=B1+C*T, where B is biodiversity, B1 is a constant baseline biodiversity, C is a constant that expresses the effect of technology, and T is a given technology, so that a given technology could either increase or decrease biodiversity depending on the value chosen for C.

c. The simulation contains user-controlled variables that can illustrate relationships among the components (e.g., technology having either a positive or negative effect on biodiversity).

3. Analysis

a. Students use the results of the simulation to:
   - Illustrate the effect on one component by altering other components in the system or the relationships between components;
   - Identify the effects of technology on the interactions between human populations, natural resources, and biodiversity; and
   - Identify feedbacks between the components and whether or not the feedback stabilizes or destabilizes the system.

b. Students compare the simulation results to a real world example(s) and determine if the simulation can be viewed as realistic.

c. Students identify the simulation's limitations relative to the phenomenon at hand.

Catholic Identity Connections

- Pope Francis discusses the "What is Happening to Our Common Home" in the first chapter of ***Laudato Si'***. He writes, "*There is an urgent need to develop policies so that, in the next few years, the emission of carbon dioxide and other highly polluting gases can be drastically reduced, for example, substituting for fossil fuels and developing sources of renewable energy. Worldwide there is minimal access to clean and renewable energy. There is still a need to develop adequate storage technologies. Some countries have made considerable progress, although it is far from constituting a significant proportion. Investments have also been made in means of production and transportation which consume less energy and require fewer raw materials, as well as in methods of construction and renovating buildings which improve their energy efficiency. But these good practices are still far from widespread*" (#26). [MA]
- Thomas Aquinas provides a beautiful argument in favor of biodiversity when he writes: "For He brought things into being in order that His goodness might be communicated to creatures, and be represented by them; and because His goodness could not be adequately represented by one creature alone, He produced many and diverse creatures, that what was wanting to one in the representation of the divine goodness might be supplied by another. For goodness, which in God is simple and uniform, in creatures is manifold and divided and hence the whole universe together participates the divine goodness more perfectly, and represents it better than any single creature whatever" (Summa Theologiae, First Part, Question 47). [TH]

Diocese of Owensboro ELA and Mathematics Standards Connections

Mathematics

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

Connections to Other DCIs

HS.PS1.B; HS.LS2.A; HS.LS2.B; HS.LS2.C; HS.LS4.D; HS.ESS2.A; HS.ESS2.E

Articulation to DCIs across Grade-Bands

MS.PS1.B; MS.LS2.A; MS.LS2.B; MS.LS2.C; MS.LS4.C; MS.LS4.D; MS.ESS2.A; MS.ESS2.E MS.ESS3.A; MS.ESS3.C

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific knowledge, principles and theories. • Design or refine a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ESS3.C: Human Impacts on Earth Systems** • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary)	**Stability and Change** • Feedback (negative or positive) can stabilize or destabilize a system. **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Using scientific knowledge to generate the design solution

a. Students use scientific information to generate a number of possible refinements to a given technological solution. Students:
- Describe the system being impacted and how the human activity is affecting that system;
- Identify the scientific knowledge and reasoning on which the solution is based;
- Describe how the technological solution functions and may be stabilizing or destabilizing the natural system;
- Refine a given technological solution that reduces human impacts on natural systems; and
- Describe that the solution being refined comes from scientists and engineers in the real world who develop technologies to solve problems of environmental degradation.

2. Describing criteria and constraints, including quantification when appropriate

a. Students describe and quantify (when appropriate):
- Criteria and constraints for the solution to the problem; and
- The tradeoffs in the solution, considering priorities and other kinds of research-driven tradeoffs in explaining why this particular solution is or is not needed.

3. Evaluating potential refinements

a. In their evaluation, students describe how the refinement will improve the solution to increase benefits and/or decrease costs or risks to people and the environment.
b. Students evaluate the proposed refinements for:
  - Their effects on the overall stability of and changes in natural systems; and
  - Cost, safety, aesthetics, and reliability, as well as cultural and environmental impacts.

Catholic Identity Connections

- In paragraphs #20-22 of ***Laudato Si'*** Pope Francis discusses pollution, waste and throwaway culture. [M]
  - "*Some forms of pollution are part of people's daily experience. Exposure to atmospheric pollutants produces a broad spectrum of health hazards, especially for the poor, and causes millions of premature deaths. People take sick, for example, from breathing high levels of smoke from fuels used in cooking or heating. There is also pollution that affects everyone, caused by transport, industrial fumes, substances which contribute to the acidification of soil and water, fertilizers, insecticides, fungicides, herbicides and agrotoxins in general"* (para. 20)
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "The Gospel of Creation" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

Mathematics

MP.2 Reason abstractly and quantitatively.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.LS2.C; HS.LS4.D

Articulation to DCIs across Grade-Bands

MS.LS2.C; MS.ESS2.A; MS.ESS2.E; MS.ESS3.B; MS.ESS3.C; MS.ESS3.D

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).

Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using computational models in order to make valid and reliable scientific claims. **Connections to Nature of Science** **Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS3.D: Global Climate Change** • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Organizing data

a. Students organize data (e.g., with graphs) from global climate models (e.g., computational simulations) and climate observations over time that relate to the effect of climate change on the physical parameters or chemical composition of the atmosphere, geosphere, hydrosphere, or cryosphere.

b. Students describe what each data set represents.

2. Identifying relationships

a. Students analyze the data and identify and describe relationships within the datasets, including:
   - Changes over time on multiple scales; and
   - Relationships between quantities in the given data.

3. Interpreting data

a. Students use their analysis of the data to describe a selected aspect of present or past climate and the associated physical parameters (e.g., temperature, precipitation, sea level) or chemical composition (e.g., ocean pH) of the atmosphere, geosphere, hydrosphere or cryosphere.
b. Students use their analysis of the data to predict the future effect of a selected aspect of climate change on the physical parameters (e.g., temperature, precipitation, sea level) or chemical composition (e.g., ocean pH) of the atmosphere, geosphere, hydrosphere or cryosphere.
c. Students describe whether the predicted effect on the system is reversible or irreversible.
d. Students identify one source of uncertainty in the prediction of the effect in the future of a selected aspect of climate change.
e. In their interpretation of the data, students:
   - Make a statement regarding how variation or uncertainty in the data (e.g., limitations, accuracy, any bias in the data resulting from choice of sample, scale, instrumentation, etc.) may affect the interpretation of the data; and
   - Identify the limitations of the models that provided the simulation data and ranges for their predictions.

Catholic Identity Connections

- Refer to ***Laudato Si'*** by Pope Francis – "*Climate as a common good*" -- paragraphs 23-26.
- Scripture: Refer to ***Laudato Si'***, Chapter 2 – "*The Gospel of Creation*" for scriptures related to care of God's creation. [S]

Diocese of Owensboro ELA and Mathematics Standards Connections

ELA/Literacy

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Mathematics

MP.2 Reason abstractly and quantitatively.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Connections to Other DCIs

HS.PS3.B; HS.PS3.D; HS.LS1.C; HS.ESS2.D

Articulation to DCIs across Grade-Bands

MS.PS3.B; MS.PS3.D; MS.ESS2.A; MS.ESS2.D; MS.ESS3.B; MS.ESS3.C; MS.ESS3.D

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9– 12 builds on K–8 experiences and progresses to using algebraic thinking and analysis; a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms; and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**ESS2.D: Weather and Climate** • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary) **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Examples of Observable Evidence of Student Performance by the End of the Course

1. Representation

a. Students identify and describe the relevant components of each of the Earth systems modeled in the given computational representation, including system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric CO_2 and production of photosynthetic biomass and ocean acidification).

2. Computational modeling

a. Students use the given computational representation of Earth systems to illustrate and describe relationships among at least two of Earth's systems, including how the relevant components in each individual Earth system can drive changes in another, interacting Earth system.

3. Analysis

a. Students use evidence from the computational representation to describe how human activity could affect the relationships between the Earth's systems under consideration.

Catholic Identity Connections	
• This standard is aligned with the 7th theme of Catholic Social Teaching: Care for God's Creation [CST] as well as the **Cardinal Newman Society** standards in the above section for HS-ESS3-2.	
Diocese of Owensboro ELA and Mathematics Standards Connections	
Mathematics	
MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
N.Q.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
N.Q.2	Define appropriate quantities for the purpose of descriptive modeling.
N.Q.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
Connections to Other DCIs	
HS.LS2.B; HS.LS2.C; HS.LS4.D; HS.ESS2.A	
Articulation to DCIs across Grade-Bands	
MS.LS2.C; MS.ESS2.A; MS.ESS2.C; MS.ESS3.C; MS.ESS3.D	

APPENDICES

SCIENCE INTERNET RESOURCES

2015-2016 Draft California Science Framework Chapters
The state education board in California approved a science curriculum framework to offer guidance for teaching the Next Generation Science Standards. The framework focuses, in part, on hands-on learning and problem-solving.
http://www.cde.ca.gov/

Action Plan to Respond to Climate Change in Kentucky
Resources to support the goals to conserve natural resources in Kentucky
http://climatechange.lta.org/wp-content/uploads/cct/2015/03/Climate_Change_ActionKY.pdf

Annenberg Video On Demand
Professional development videos for all content areas accessible for free
http://www.learner.org/resources/browse.html

CLEAN
Digital resources for teaching about climate and energy – resources are reviewed by educators and scientists, annotated, and aligned with standards and benchmarks
https://www.climate.gov/teaching/essential-principles-climate-literacy/about-clean-climate-literacy-and-energy-awareness
http://cleanet.org/clean/educational_resources/index.html

Catholic Climate Covenant's 2017 Earth Day program, "Know the Creator through Creation"
http://www.catholicclimatecovenant.org/earthday

Catholic Climate Covenant - Who's Under Your Carbon Footprint?
After decades of steady progress in reclaiming and advancing the Catholic Church's efforts to embrace an ethic of environmental stewardship, the Catholic Coalition on Climate Change is ready to launch an unprecedented and historical campaign to take responsibility for our contribution to climate change and do what we do best: be advocates for those who will be left out of the public policy debate on climate change.
https://www.youtube.com/watch?v=McdULlbg1_0
https://www3.epa.gov/carbon-footprint-calculator/

Catholic Health Association Earth Day Resources
On April 22, the world celebrates Earth Day. To help those who serve in Catholic health ministry make meaning of the connection between the environment, our health and our ministry's commitment to faithfully heal the earth, CHA offers resources for your use.
https://www.chausa.org/prayers/prayer-library/national-and-international-observances/global-and-international-prayers-and-reflections/earth-day-april-22/overview

Center for Ecoliteracy
Lessons, articles, principles and resources to further ecological teaching and learning.
https://www.ecoliteracy.org/ecological-education

Climate Adaptation Knowledge Exchange
Resources to support the goals to conserve natural resources in Kentucky
http://www.cakex.org/virtual-library/action-plan-respond-climate-change-kentucky-strategy-resilience

Climate Change Indicators in the United States
EPA partners with more than 40 data contributors from various government agencies, academic institutions, and other organizations to compile a key set of indicators related to the causes and effects of climate change. The indicators are published in EPA's report, Climate Change Indicators in the United States, available on this website and in print.
https://www.epa.gov/climate-indicators#explore
(Also see:
https://www.awwa.org/Portals/0/files/resources/water%20knowledge/rc%20climate%20change/EPA%202016%20Climate%20Change%20Indicators%20Report_%20webinar_8-4-16.pdf)

Climate Literacy: The Essential Principles of Climate Science
An interagency guide that provides a framework and essential principles for formal and informal education about climate change. It presents important information for individuals and communities to understand Earth's climate, impacts of climate change, and approaches for adapting and mitigating change. Principles in the guide can serve as discussion starters or launching points for scientific inquiry. The guide can also serve educators who teach climate science as part of their science curricula.
http://www.globalchange.gov/browse/educators
http://oceanservice.noaa.gov/education/literacy/climate_literacy.pdf

Curriki Resource Library
Curriki supports you with thousands of thoroughly vetted online learning activities in all major K-12 subject areas in many formats.
http://www.curriki.org/search/?type=Resource&phrase=Science&language=&start=0&partnerid=1&searchall=&viewer=&branding=common&sort=rank1+desc

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education
An interdisciplinary approach to teaching and learning about energy. The framework identifies seven Essential Principles and a set of Fundamental Concepts to support each principle. The guide does not seek to identify all areas of energy understanding, but rather to focus on those that are essential for all citizens K-Gray. It presents energy concepts that, if understood and applied, will help individuals and communities make informed energy decisions.
http://energy.gov/eere/education/energy-literacy-essential-principles-and-fundamental-concepts-energy-education

Engineering is Elementary
Curriculum and professional development resources that develop engineering literacy
http://www.eie.org/

Environmental Education in Kentucky
Environment education teaching resources
http://keec.ky.gov/Pages/default.aspx

Environmental Protection Agency Climate Change Indicators in the United States
EPA partners with more than 40 data contributors from various government agencies, academic institutions, and other organizations to compile a key set of indicators related to the causes and effects of climate change.
https://www.epa.gov/climate-indicators

Environmental Protection Agency Climate Change Information
Information about climate change
https://www.epa.gov/climatechange

Environmental Protection Agency Topics Index
An index that accesses information via links
https://www.epa.gov/environmental-topics/z-index

Environmental Protection Agency Environmental Information by Location
This will help you find information on environmental conditions and EPA activities relevant to specific locations of the United States.
https://www.epa.gov/environmental-topics/environmental-information-location

Explore Learning Gizmos
Online simulations that power inquiry and understanding. Gizmos are interactive math and science simulations for grades 3-12. Over 400 gizmos aligned to the latest standards help educators bring powerful new learning experiences to the classroom.
https://www.explorelearning.com/

Great Catholic Scientist Posters
https://bestcatholicposters.com/zencart/index.php?main_page=index&cPath=19_4&zenid=4d48935796b35b9c12e5a801a3433bc3

Guide to Implementing the Next Generation Science Standards
From: The National Academies Press
https://www.nap.edu/read/18802/chapter/1

Healing Earth
Healing Earth is a free, online environmental science textbook for upper level secondary school students, beginning college students, and adult learners. We invite teachers around the world to use this resource in their classrooms and share their experience with us.
Healing Earth adapts the basic Ignatian Pedagogy framework for use in studying environmental science. You are first invited to "see scientifically" and relate what you see to your own experience. Next, you are asked to reflect on the values ("evaluate ethically") and meaning ("reflect spiritually") that emerge in the study of environmental science. Finally, you are challenged to take the knowledge you have gained and act to heal the Earth ("act effectively"). Each chapter of *Healing Earth* is designed to help you build these four skills in sequence.
http://healingearth.ijep.net/

Hooked on Science
Monthly eScience newsletter that shares experiments and other science resources
www.hookedonscience.org.

IMAX Cosmic Voyage
Get ready for this fascinating cosmic ride....a cosmic zoom…in powers of ten...from tiny quarks to stupendously huge super clusters of galaxies....first, it starts on street and then zooms out to city then Earth, planets, solar system, galaxy and then to the known universe...then it starts at city again and starts to zoom into the molecules and atoms...it will give you an idea how big the universe is and how tiny a quark is.....by the end of it you will have a cosmic perspective....
https://www.youtube.com/watch?v=k-xcc2vGE7s

Kentucky Association for Environmental Education
Provides support, resources, and networking opportunities for environmental education to Kentucky's community of educators
http://www.kaee.org/

Knovation Science Resources
Sample science learning resources from the content collection
http://content.knovationlearning.com/science

***Laudato Si'* Resources for Teachers Grades: Pre-K through 12**
5 lesson plans for middle/high school with power points
http://www.catholicclimatecovenant.org/resource/laudato-si-resources-for-teachers

Lifelab Science Program
Life Lab cultivates children's love of learning, healthy food, and nature through garden-based education
http://www.lifelab.org/

Linking Environmental Literacy and the Next Generation Science Standards: A Tool for Mapping an Integrated Curriculum
https://naaee.org/sites/default/files/ngss_-_linking_environmental_literacy_and_the_next_generation_science_standards.pdf

Making Sense of the New Science and Engineering Standards with PBS LearningMedia
http://www.pbs.org/education/blog/making-sense-of-the-new-science-and-engineering-standards-with-pbs-learningmedia?utm_source=lmnews&utm_medium=email&utm_campaign=mktg_2016

Magis Center
"Led by Fr. Robert J. Spitzer, S.J., Ph.D. and his tireless work in putting out Rational Apologetics addressing four myths, Magis Center is intent on completely debunking the four myths listed below and rebuilding a faith centered society. Fr. Spitzer was President of Gonzaga University for 11 years. He noticed a marked decrease in the faith within the student body, and this at a Catholic University. His research showed that four popular secular myths were corroding faith and morals as well as undermining faith in God and Jesus Christ. The Myths are: **The Conflict between Faith and Science**, The Conflict between Suffering and Love, The Conflict between Christian Virtue and Freedom (and Moral Relativism), Skepticism about the Significance and Reality of Jesus."
https://www.magiscenter.org/

NAAEE Environmental Education Materials: Guidelines for Excellence
https://naaee.org/sites/default/files/gl_ee_materials_complete.pdf

NAAEE Excellence in Environmental Education: Guidelines for Learning (K-12)
http://resources.spaces3.com/89c197bf-e630-42b0-ad9a-91f0bc55c72d.pdf

NAAEE Guidelines for the Preparation and Professional Development of Environmental Educators
http://resources.spaces3.com/e42d12db-f327-46ca-94c2-647060d23e74.pdf

NASA for Educators
An aeronautics and space resource for education
http://www.nasa.gov/offices/education/about/index.html

Next Generation Science Standards (NGSS)
Information on the Next Generation Science Standards
http://www.nextgenscience.org/

NGSS Classroom Resources
Classroom resources that are "fully aligned" to the NGSS should meet the rigorous criteria of the EQuIP rubric developed by Achieve and NSTA. Full alignment means that the resources are three-dimensional in nature, have coherence across lessons and units, provide a number of important instructional supports, and provide methods to monitor student progress.
http://ngss.nsta.org/Classroom-Resources.aspx
http://ngss.nsta.org/DisplayStandard.aspx?view=topic&id=1

National Science Teachers Association: Access the Next Generation Science Standards by Topic
The topics are in tables by grade band, and then further broken down into columns of Life Science, Earth & Space Science, and Physical Science. The Engineering Design topic is located at the end of the respective grade band.
http://ngss.nsta.org/AccessStandardsByTopic.aspx
http://ngss.nsta.org/DisplayStandard.aspx?view=topic&id=3

North American Association for Environmental Education
Links to national standards in ELA, Math, Science and Social Studies
https://naaee.org/eepro/resources/linking-ee-and-national-standards

OER Physics Resource
http://www.curriki.org/oer/Curriki-High-School-Physics-Collection/

Open Educational Resources
OpenEd is the world's largest K-12 resource library! The website has over 1 million assessments, videos, homework, and games from top publishers like Pearson, Houghton Mifflin Harcourt, National Geographic, PBS Learning, and thousands more! The vast majority of the website is free.
https://www.opened.com

PBS Learning Media
LearningMediaContact@pbs.org

Project Learning Tree (PLT)
Project Learning Tree is an award-winning environmental education program designed for teachers and other educators, parents, and community leaders working with youth from preschool through grade 12.
https://www.plt.org/

PLT Southeastern Forests and Climate Change, Secondary Environmental Education Module
Project Learning Tree and the University of Florida have developed a new secondary module to help educators in the Southeast teach about climate change impacts on forest ecosystems, the role of forests in sequestering carbon, and strategies for reducing greenhouse gas emissions and adapting to changing climatic conditions. The module explores these concepts in 14 experiential activities by using research related to the goals of PINEMAP—a regional research, education, and extension program focused on southern pine management and climate change. (Download for free at this website.)
https://www.plt.org/curriculum/southeastern-forests-climate-change/

Project WET
Project WET's mission is to reach children, parents, teachers and community members of the world with water education that promotes awareness of water and empowers community action to solve complex water issues.
http://www.projectwet.org/

Project WET - WOW! The Wonders of Wetlands
With 70 pages of background material followed by more than 40 cross-referenced activities, this Guide is a valuable resource for K-12 teachers. Every page is thoughtfully laid out with informative text, stunning photography, along with easy-to-read sidebars, maps and illustrations. Activities are neatly organized into five sections: wetlands definitions, wetlands plants and animals, water quality and supply issues, soils and people. The appendix also provides instructions for planning and developing a schoolyard wetland habitat.
http://store.projectwet.org/educators-guides/wetlands-educators-guide.html

Project WILD
Project WILD is a wildlife-focused conservation education program for K-12 educators and their students. Project WILD is one of the most widely-used conservation and environmental education programs among educators of students in kindergarten through high school.
http://projectwild.org/

Pope Francis: On Care for Our Common Home
Power point explanation of encyclical with embedded video clips (for middle/high school)
https://docs.google.com/presentation/d/1_w4fPt_MmL-d0XY3reeChYUP1V7oLIHIYw6lXFCyVr0/present?slide=id.g74097742c_2_21

Powers of Ten
View the Milky Way at 10 million light years from the Earth. Then move through space towards the Earth in successive orders of magnitude.
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html

Project Learning Tree's New Online Units for Grades K-2, 3-5, and 6-8
PLT's e-units are self-contained units of instruction that are housed fully online. They are multi-disciplinary lessons designed to be easy for teachers to access and use. In addition to step-by-step

procedures, the e-units include a variety of teaching tools to enhance instruction, such as downloadable student pages, online quizzes, and links to videos.
https://www.plt.org/news/new-online-units-grades-k-8/

Science at NASA
A current online magazine of scientific research, events, and information for students and teachers
https://science.nasa.gov/

Science Buddies
A non-profit organization empowering students from all walks of life to help themselves and each other develop a love of science and an understanding of the scientific method.
http://www.sciencebuddies.org/

Science NetLinks
Science NetLinks' role is to provide a wealth of resources for K-12 science educators, including lesson plans and reviewed internet resources.
http://sciencenetlinks.com/

See the Change USA
A non-profit organization committed to student advancement in Science & Engineering. This is accomplished through introducing physics in middle schools, paralleling what is already in existence internationally.
http://seethechangeusa.org/

STEM Teaching Tools
http://stemteachingtools.org/

STREAM Resources
Presentations, articles, templates, tools and other resources to help you in your STREAM efforts
https://www.ncea.org/NCEA/Learn/Academic_Excellence/NCEA/Learn/Resource/Academic_Excellence_Resources.aspx?hkey=6bbdd3c7-436c-4265-95c1-40f57eba09ce

Ten Commandments for the Environment, Pope Benedict Speaks Out for Creation and Justice
A concise and compelling overview of Catholic environmentalism from the heart of the Church and from the Holy Father Newsweek is calling "the Green Pope." Seasoned author and journalist Woodeene Koenig-Bricker skillfully weaves together Pope Benedict's key statements on environmental justice into one volume. Additionally, she offers commentary that helps to unpack the Ten Commandments for the Environment, which were recently released by the Pontifical Council for Justice and Peace.
http://www.barnesandnoble.com/w/ten-commandments-for-the-environment-pope-benedict-xvi/1111385934?ean=9781594712111

Texas Instruments Education Technology in Science and Math
Engage in the most relevant topics in math, science and STEM education through participation in hands-on T³ webinars that are created and presented by teachers for teachers. Certificates of Attendance, which participants may submit with requests for continuing education credits, are awarded.
https://education.ti.com/en/professional-development/webinars-and-tutorials

TI Science Nspired
Lessons and tools to help you guide your students to understanding key science concepts with the power of TI-Nspire technology.
https://education.ti.com/en/tisciencenspired/us/home
https://www.youtube.com/watch?v=8skuagaoq4s

Teach Engineering
Engineering design process curriculum for K-12 teachers
https://www.teachengineering.org/k12engineering/designprocess
https://www.youtube.com/watch?v=fxJWin195kU

Teaching Channel Science Videos
https://www.teachingchannel.org/videos?page=1&categories=subjects_science&load=1

The Edible Schoolyard
The Edible Schoolyard Network connects educators around the world to build and share a K-12 edible education curriculum
www.edibleschoolyard.org

The Environment, Pope Benedict XVI
An unprecedented collection of excerpts from what Pope Benedict has had to say regarding the environment, this book is a treasure trove of insights and inspiration surrounding the Church and the world in which we live.
http://www.barnesandnoble.com/w/the-environment-pope-benedict-xvi/1109196878?ean=9781612786285&quickview=true

The Science Page
Comprehensive links to online science journals
http://sciencepage.org/mags.htm

You Can Make a Difference: Carbon Footprint
https://ket.pbslearningmedia.org/resource/35529f7e-1c9d-4544-8415-592b046ca254/35529f7e-1c9d-4544-8415-592b046ca254/?utm_source=lmnews&utm_medium=email&utm_campaign=mktg_2016

GLOSSARY

The purpose of this glossary is to help the user better understand and implement the science standards. It is not intended to be an exhaustive list of all scientific terms. The primary audience for this glossary are K-8 Science teachers.

Abiotic	nonliving
Absorb	to take up (e.g., plant roots absorb water)
Adaptation	hereditary features of organisms that allow them to live in a particular environment
Affect	to have an influence on
Affluence	plentiful supply of material goods; wealth
Analyze	to examine methodically by separating into parts and studying their interrelations
Applied science	research aimed at answering questions that have practical applications, e.g., determining the causes of diseases so that cures might be found
Asteroid	small rocky body orbiting the Sun
Atmosphere	gaseous envelope surrounding the Earth
Atom	smallest particle of an element that retains the chemical nature of the element
Barometric pressure	atmospheric pressure as indicated by a barometer, used especially in weather forecasting
Basic science	research designed to describe or explain nature to satisfy one's curiosity
Bias	statistical sampling or testing error caused by systematically favoring some outcomes over others
Biodiversity	1. number and variety of organisms found within a specified geographic region 2. variability among organisms, including the variability within and between species and within and between ecosystems
Biome	broad area of the Earth's surface characterized by distinctive vegetation and associated animal life; e.g., broad-leaf forest biome, grassland biome, desert biome
Biotic	relating to life or living organisms
Calorimetric	relating to the measurement of heat energy by means of temperature measurements
Camouflage	concealment by disguise or protective coloring
Carrying capacity	maximum number of individuals that a given environment can support for a sustained period of time
Catalyst	substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the process
Celestial	of or in the sky or universe, as planets or stars
Cell membrane	the thin membrane that forms the outer surface of the protoplasm of a cell and regulates the passage of materials in and out of the cell. It is made up of proteins and lipids and often contains molecular receptors

Cell wall	the definition of a cell wall is the protective coating for a plant cell.
Cellular respiration	metabolic processes which break down nutrients into usable energy
Circuit	1. closed path followed or capable of being followed by an electric current 2. configuration of electrically or electromagnetically connected components or devices
Cirrus	high-altitude cloud composed of narrow bands or patches of thin, generally white, fleecy parts
Characteristic	distinguishing trait, feature, quality, or property
Chloroplasts	a plastid in the cells of green plants and green algae that contains chlorophylls and carotenoid pigments and creates glucose through photosynthesis
Communicate	about; make known; express oneself in such a way that one is readily and clearly understood
Community	group of plants and animals living and interacting with one another in a specific region under relatively similar environmental conditions
Compare	to examine in order to note the similarities or differences of
Compound	substance formed from two or more elements chemically united in fixed proportions
Conclusion	statement, or statements, that summarize the extent to which hypotheses have been supported or not supported
Conduction	process by which heat or electrical energy is transmitted through a material or body without gross motion of the medium itself
Conifer	any of various mostly needle-leaved or scale-leaved, chiefly evergreen, cone-bearing gymnosperm trees or shrubs such as pines, spruces, and firs
Conservation	life science: the protection, preservation, management, or restoration of wildlife and of natural resources such as forests, soil, and water, to prevent exploitation, destruction or neglect physical science: a unifying principle of constancy of a quantity under specified conditions
Constellation	formation of stars perceived as a figure or design, especially one of 88 recognized groups named after characters from classical mythology and various common animals and objects
Consumer	organisms requiring complex organic compounds for food, which is obtained by preying on other organisms or by eating particles of organic matter
Contrail	artificial cloud created by an aircraft, caused either by condensation due to the reduction in air pressure above the wing surface, or by water vapor in the engine exhaust
Controlled investigation	investigation in which all but one variable remain constant
Convection	transfer of heat energy in a gas or liquid by the circulation of currents of matter from one region to another
Crystallization	to cause to form crystals or take on a crystalline structure
Cumulus	dense, white, fluffy, flat-based cloud with a multiple rounded top and a well-defined outline, usually formed by the ascent of thermally unstable air masses
Data	factual information, from observations, organized for analysis

Decomposer	organisms such as bacteria and fungi that feed and break down dead organisms, returning constituents of organic substances to the environment
Deformation	alteration of shape, as by pressure or stress
Demonstrate	to prove or make evident by reasoning or adducing evidence
Deposition	act of depositing, especially the laying down of matter by a natural process something deposited; a deposit
Describe	to transmit a mental image or impression with words
Distinguish	to perceive or indicate differences; discriminate
Dominant	of, relating to, or being an allele that produces the same phenotypic effect whether inherited with a homozygous or heterozygous allele
DNA	(deoxyribonucleic acid) double strand of nucleotides that is a self-replicating molecule present in living organisms as the main constituent of chromosomes; contains the genetic code and transmits the heredity pattern
Ecology	study of the interactions and relationships between and among organisms and their environment
Ecosystem	all the organisms in a given area and the abiotic factors with which they interact
Eclipse	partial or complete obscuring, relative to a designated observer, of one celestial body by another
Electron	negatively charged fundamental particle in an atom
Element	any of more than 100 fundamental substances that consist of atoms of only one atomic number and that singly or in combination constitute all matter
Environment	sum of all external conditions affecting the life, development and survival of an organism, including the biotic (living) and abiotic (non-living) elements
Erosion	group of natural processes, including weathering, dissolution, abrasion, corrosion, and transportation, by which material is worn away from the Earth's surface
Eukaryotic	referring to a cell with a nucleus and other internal structure
Evaluate	to examine and judge carefully; appraise
Experimentation	act of conducting a controlled test or investigation
Extinct	no longer in existence
Fertilization	1. act or process of initiating biological reproduction by insemination or pollination; 2. union of male and female gametes to form a zygote
Food chain	arrangement of the organisms of an ecological community according to the order of predation in which each uses the next as a food source
Food web	totality of interacting food chains in an ecological community
Force	K-6: push or pull that change the motion or shape of an object 7-HS: vector quantity that tends to produce an acceleration of a body in the direction of its application
Formulate	to devise or invent
Frequency	ratio of the number of times an event occurs in a series of trials of a chance experiment to the number of trials of the experiment

	performed; the number of cycles an oscillating system executes in one second
Friction	force that resists relative motion between two bodies in contact
Front (weather)	interface between air masses of different temperatures or densities
Gas	state of matter that does not have a definite shape or volume and is much less dense than a liquid because its molecules are far apart compared to their diameters
Genotype	particular combination of genes in an organism
Geoscience	the geological sciences as a whole; geology
Gravitation	universal force by which everybody in the universe attracts every other body
Gravity	attraction of the mass of the Earth, the Moon or a planet for bodies at or near its surface
Greenhouse gas	atmospheric gas such as carbon dioxide, water vapor, and methane that allows incoming sunlight to pass through but absorbs infrared radiation radiated back from the Earth's surface, leading to the phenomenon whereby the Earth's atmosphere traps solar radiation
Guided investigation	teacher-directed investigation
Habitat	place or environment where a plant or animal naturally or normally lives and grows
Hazardous waste	substance, such as nuclear waste or an industrial byproduct, that is potentially damaging to the environment and harmful to humans and other organisms
Heredity	genetic transmission of characteristics from parent to offspring
Heterogeneous	consisting of dissimilar elements or parts
Homogeneous	uniform in structure or composition throughout
Hydrosphere	aqueous envelope of the Earth, including the oceans, all lakes, streams, and underground waters, ice, and the aqueous vapor in the atmosphere
Hydrologic	the science dealing with the waters of the earth, their distribution on the surface and underground, and the cycle involving evaporation, precipitation, flow to the seas, etc.
Hypothesis	statement of an anticipated result of an investigation proposed relationship among observable phenomena or an inferred explanation for those phenomena
Identify	to find out the origin, nature, or definitive elements of
Infer	to conclude from evidence or premises
Igneous	relating to, resulting from, or suggestive of the intrusion or extrusion of magma or volcanic activity; rock formed from molten magma
Inorganic	involving neither organic life nor the products of organic life of or relating to compounds not containing carbon
Interdependence	state of organisms depending on each other and the environment for survival
Interpretation	explanation – explain the meaning of
Interrelationships	interactions between two or more objects or organisms
Invertebrate	animal, such as an insect or mollusk, that lacks a backbone or

	spinal column
Investigation	inquiry, research, or systematic examination
Involuntary	not under the influence or control of the will; not voluntary; as, the involuntary movements of the body (involuntary muscle fibers)
Isotope	any of two or more species of atoms of a chemical element with the same atomic number and nearly identical chemical behavior, but with differing atomic mass and mass number and different physical properties
Justify	to demonstrate or prove to be just, right, or valid
Law	statement that summarizes, identifies, or describes a relationship among observable phenomena
Lever	simple machine consisting of a rigid bar pivoted on a fixed point and used to transmit force, as in raising or moving a weight at one end by pushing down on the other
Limiting factor	conditions or resources that control the size of a population
Liquid	state of matter that does not hold a definite shape but occupies a definite volume because its molecules are in close contact
Lithosphere	outer part of the Earth, consisting of the crust and upper mantle, approximately 100 km (62 mi.) thick
Lunar	of, involving, caused by, or affecting the Moon lunar phase
Macroscopic	large enough to be perceived or examined by the unaided eye; large compared to a microscopic object
Mass	property of a body that is a measure of its inertia and causes it to have weight in a gravitational field, that is commonly taken as a measure of the amount of material it contains
Matter	anything that possesses mass and occupies volume
Mean	average value of a set of number
Measure	to ascertain the dimensions, quantity, or capacity of
Meiosis	type of cell division that occurs during the reproduction of diploid organisms to produce the gametes. The double set of genes and chromosomes of the normal diploid cells is reduced during meiosis to a single haploid set in the gametes. Crossing-over and, therefore, recombination occur during a phase of meiosis
Metamorphic	change in the constitution of rock; specifically, a pronounced change affected by pressure, heat and water that results in a more compact and more highly crystalline condition; a rock produced by these processes
Meteor	bright trail or streak that appears in the sky when a meteoroid is heated to incandescence by friction with the Earth's atmosphere; also called falling star, meteor burst, shooting star
Microscopic	too small to be seen by the unaided eye but large enough to be studied under a microscope; small compared to a macroscopic object
Mimicry	resemblance of one organism to another or to an object in its surroundings for concealment and protection from predators
Mitosis	cell division; cell division in multicellular organisms occurs by

	mitosis except for the special division called meiosis that generates the gametes
Mixture	portion of matter consisting of two or more components in varying proportions that retain their own properties
Model	schematic description or representation of a system, theory, or phenomenon that accounts for at least some of its known or inferred properties and may be used for further study of its characteristics
Molecule	smallest particle of a chemical substance that retains all the properties of the substance and is composed of one or more atoms
Mutation	change of the DNA sequence within a gene or chromosome of an organism
Mutualism	close, prolonged association between organisms of two different species in which each member benefits; type of symbiotic relationship natural resource
Natural selection	process by which, in a given environment, individuals having characteristics that aid survival will produce more offspring, so the proportion of individuals having such characteristics will increase with each succeeding generation. Two mechanisms of natural selection include: • gradualism- slow genetic modification (evolution) of a population over long periods of time • punctuated equilibrium- relatively rapid evolution at a speciation event
Neutron	uncharged elementary particle that has a mass a little greater than that of the proton and is present in most atomic nuclei
Nonliving	objects that don’t reproduce, grow, react, or use food
Nonstandard units of measure	units of measurement based on everyday items (e.g., hands, feet, pace, candy, potato, paper clip) used as a precursor to learning and using standard units of measurement
Mitochondria	are the structures within cells that produce energy.
Mutualism	close, prolonged association between organisms of two different species in which each member benefits
Nucleus	physical science: central region of an atom, which contains more than 99% of the atom's mass. life science: cellular organelle in eukaryotes that contains most of the genetic material
Observe	to be or become aware of, through one’s senses, and may include qualitative or quantitative data
Observation	event that is experienced personally or enhanced through measurement or instruments
Opaque	not capable of having light pass through or hard to understand.
Openness	mindset that allows a person to consider explanations of a phenomena
Organic	of, relating to, or derived from living organisms Chemistry: having to do with carbon compounds
Organism	living individual, such as a plant, animal, bacterium, protist, or fungus; a body made up of organs organelles, or other parts that work together to carry on the various processes of life

Periodic table	arrangement of the chemical elements by atomic number, starting with hydrogen in the upper left-hand corner and continuing in ascending order from left to right, arranged in columns according to similar chemical properties
pH	numerical measure of the acidity or alkalinity of a chemical solution; the negative of the logarithm of the hydrogen ion concentration
Phenotype	physical or visible characteristics of an organism that are determined by its genotype
Photosynthesis	chemical process by which chlorophyll-containing plants use light to convert carbon dioxide and water into carbohydrates, releasing oxygen as a byproduct
Pitch	aurally perceived property of a sound, especially a musical tone that is determined by the frequency of the waves producing it; highness or lowness of sound
Plane	flat or level surface
Plate tectonics	theory that explains the global distribution of geological phenomena such as seismicity, volcanism, continental drift, and mountain building in terms of the formation, destruction, movement, and interaction of the Earth's lithospheric plates; the theory that the earth's crust is broken into fragments (plates) which move in relation to one another, shifting continents, forming new crust, and causing volcanic eruptions
Population	group of organisms of the same species living and reproducing in a particular habitat or geographic region
Population density	number of organisms per unit area
Precipitation	any form of water, such as rain, snow, sleet, or hail, which falls to the Earth's surface
Predict	to forecast a future occurrence based on past observations or the extension of an idea
Prediction	statement of an expected (future) outcome of a planned test assuming that the hypothesis being tested is correct; to be compared with observed result to test the hypothesis
Preservation	to keep in perfect or unaltered condition; maintain unchanged
Probability	measure of the likelihood of an event occurring
Procedures	series of steps taken to accomplish an end
Prokaryotic	referring to a cell with no nucleus (e.g., a bacterium)
Property	characteristic attribute possessed by all members of a class
Propose	to put forward for consideration, discussion, or adoption
Proton	stable subatomic particle occurring in all atomic nuclei, with a positive electric charge equal in magnitude to that of an electron
Pulley	simple machine consisting of a wheel with a grooved rim in which a pulled rope or chain can run to change the direction of the pull and thereby lift a load
Pure science	science for the pursuit of scientific knowledge
Qualitative	involving quality or kind
Quantitative	involving the measurement of quantity or amount

Radiation	transfer of energy by electromagnetic radiation; process of emitting energy in the form of waves or particles (e.g., visible light, X-rays, alpha and beta radiation).the geographic spreading of a species reaction
Recessive	of, relating to, or designating an allele that does not produce a characteristic effect when present with a dominant allele
Reduce, **reuse**, **recycle**	help you, your community, and the environment by saving money, energy, and natural resources. Recycling programs are managed at the state and local level
Reflect	to throw or bend back (light, for example) from a surface
Refract	to deflect from a straight path undergone by light or other wave in passing obliquely from one medium (e.g., air) into another (e.g., glass) in which its speed is different
Reliability	to yield the same or compatible results in different clinical experiments or statistical trials
Respiration	physical and chemical processes by which an organism supplies its cells and tissues with the oxygen needed for metabolism and relieves them of the carbon dioxide formed in energy-producing reactions
Result	quantity or expression obtained by calculation
Revolution	orbital motion about a point, especially as distinguished from axial rotation
RNA	(ribonucleic acid) nucleic acids that contains ribose and uracil as structural components and is associated with the control of cellular chemical activities
Rotation	act or process of turning around a center or an axis; the turning of a body part about its long axis as if on a pivot
Sedimentary	of or relating to rocks formed by the deposition of sediment
Sedimentation	the act or process of depositing or forming a sediment.
Sexual	relating to, produced by, or involving reproduction characterized by the union of male and female gametes
Simple investigation	investigation involving a single variable
Solid	body of definite shape and volume; not liquid or gaseous
Solute	the dissolved matter in a solution; the compound of a solution that changes its state
Solution	a homogeneous mixture of two or more substances
Solvent	a liquid substance capable of dissolving other substances
Species	class of individuals or objects grouped by virtue of their common attributes and their ability to mate and produce fertile offspring, and assigned a common name; a division subordinate to a genus
Spectrophotometer	instrument used to determine the intensity of various wavelengths in a spectrum of light
Stimulus	object or event that causes a response
Strata	a section, level, or division, as of the atmosphere or ocean, regarded as like a stratum
Stratus	low-altitude cloud formation consisting of a horizontal layer of clouds
Structures	way in which parts are arranged or put together to form a whole; makeup arrangement or formation of the tissues, organs, or other parts of an organism; an organ or other part of an organism

Substrate	the substance that is acted upon by an enzyme or ferment; a surface on which an organism grow or is attached
Subsystem	component of a system (e.g., a solar system is a subsystem of a galaxy)
Symbiotic relationship	close, prolonged association between organisms of two different species that may, but does not necessarily, benefit each member; includes mutualism, commensalisms, and parasitism
Synthetic system	1. group of body organs that together perform one or more vital functions 2. organized group of devices, parts or factors that together perform a function or drive a process (e.g., weather system, mechanical system)
Technology	application of science, especially to industrial or commercial objectives; tools and techniques
Temperature	degree of hotness or coldness of a body or environment
Theory	collection of statements (conditions, components, claims, postulates, propositions) that when taken together attempt to explain a broad class of related phenomena; inferred explanations for observable phenomena
Tissues	a large mass of similar cells that make up a part of an organism and perform a specific function.
Transient	not regular or permanent
Transparent	something clear, see through or obvious.
Translucent	allowing light to pass through but not showing the distinct images on the other side.
Tsunami	large sea wave caused by an earthquake, landslide or other disturbance under the ocean.
U.S. customary units	measuring system used most often in the United States (e.g., inches, pounds, gallons)
Valid	correctly inferred or deduced from a premise
Variable	a factor or condition that is subject to change, especially one that is allowed to change in a scientific experiment to test a hypothesis.
Vibrate	to shake or move with or as if with a slight quivering or trembling motion

From *California Catholic School Superintendents Curriculum Committee*; https://www.spellingcity.com Science vocabulary words in grade and topic levels were obtained in part from this site.

SCIENCE BOOKS BIBLIOGRAPHY
OHIO SCIENCE FUSION
ARCHDIOCESE OF CINCINNATI

<u>Kindergarten:</u>

Alexander Graham Bell by Lola M. Schaefer (Capstone Press, 2003) provides biographical information about this famous inventor through simple text, photographs with captions and timelines. award-winning author

Animal Camouflage in the Snow by Martha E. H. Rustad (Capstone Press, 2009) offers easy-to-read text and striking photographs of various Arctic animals blending into their snowy environment to help them stay safe for predators.

Armadillos Sleep n Dugouts: And Other Places Animals Live by Pam Munoz Ryan (Hyperion Books for Children, 1997) introduces children to homes and habitats for almost 30 different animals in rhyming text.

Biggest, Strongest, Fastest by Steve Jenkins (Sandpiper, 1997) provides information about fourteen different animals and the “world records” of which they own the title. NSTA Trade Book; Outstanding Science Trade Book; Booklist Editors’ Choice

The Earth and I by Frank Asch (Sandpiper, 2008) A story from a child’s point-of view about how he and the Earth dance and sing together and take turns listening to each other. award-winning author

The Earth Book by Todd Parr (Little, Brown Books for Young Readers, 2010) offers ideas of little things children can do to make a big difference in caring and protecting our planet.

Fast and Slow by Sue Barraclough (Heinemann-Raintree, 2005) Introduces children to the world of motion by comparing things that move quickly and other things that move slowly.

The Great Kapok Tree: A Tale of the Amazon Rain Forest by Lynne Cherry (Houghton Mifflin Harcourt, 2000) When a man enters the forest to cut down a giant Kapok tree he is lulled to sleep by the heat and hum of the forest. As if in a dream, he is visited by creatures large and small, who educate him about what is at risk by the damage he intends. Sense of community, interdependency, oxygenation, and harmony are some of the balances that are made precarious by his intention.

Heating by Patricia Whitehouse (Raintree Publishers, 2005) Presents simple experiments that demonstrate the states of matter, and how different materials change and when heat is applied to them.

Henry Hikes to Fitchburg by D. B. Johnson (Sandpiper, 2006) The story of two friends who meet in a town halfway between them. One works along the way to earn money for train fare. The other walks through the woods and fields, enjoying nature along the way. SLI Best Book; New York Times Best Illustrated Book; Boston Globe-Horn Book Award; Notable Social Studies Trade Book; Notable Children’s Book in the Language Arts

Is it Hard or Soft? by Victoria Parker (Heinemann-Raintree, 2005) Takes children on a scavenger hunt to find a variety of items with contrasting properties, and allows children to investigate the texture, shape and form of these materials. award-winning author

Let's Look at a Garden by Angela Royston (Heinemann-Raintree, 2005) Provides information about plants and soil and includes vivid photographs, too. award-winning author

Like a Windy Day by Frank Asch (Sandpiper, 2008) The story of a young girl who discovers all the things the world can do by playing and dancing with it. award-winning author

Little Gorilla by Ruth Ornstein (Houghton Mifflin Harcourt, 2009) The story of a gorilla whose family and friends help him overcome his growing pains by reassuring him that they love him the way he is.

The Lorax by Dr. Seuss (Random House Children's Books, 1971) In this classic story, the Once-ler describes how his greedy actions destroyed a beautiful and thriving environment. Children will enjoy the colorful characters and rhyming verse and adults will appreciate the subtle messages about the negative effects of deforestation, habitat destruction, and air and water pollution.

Make Sense! by Jean Haddon (Lerner Publishing Group, 2006) helps children make sense of the 5 senses and what each might or might not be used for.

Matter by Christine Webster (Capstone Press, 2004) introduces the concept of matter and provides instructions for an activity to demonstrate some of its characteristics.

The Moon by Martha E. H. Rustad (Capstone Press, 2008) discusses features of the moon – Earth's only natural satellite – through the use of simple text, photographs, and diagrams.

Neil Armstrong by Dana Meachen Rau (Children's Press, 2003) provides biographical information about the astronaut, who was the first man on the moon. award-winning author

Oscar and the Bat: A Book About Sounds by Geoff Waring (Candlewick, 2009) tells the story of a curious kitten that learns what different noises sound like, how animals make sounds, and what the listeners can find out by using their ears.

Push and Pull by Hollie J. Endres (Capstone Press, 2004) teaches children about the concepts of force and energy and how various objects can be moved by pushing or pulling them.

Roll, Slope, and Slide: A Book about Ramps by Michael Dahl (Picture Window Books, 2006) offers information about this simple machine and discusses the ways that ramps help people do their work.

Seasons of the Year by Jilly Attwood (Heinemann-Raintree, 2005) explains the 4 seasons and the weather, clothing, food and activities associated with each season.

Seeds by Vijaya Khisty Bodach (Capstone Press, 2007) provides colorful photographs and basic information about the seed of plants, how the grow, and their uses.

Snow by Marion Dane Bauer (Aladdin, 2003) explores the wonders of snow, including how it forms and the characteristics of snowflakes. award-winning author

Someday a Tree by Eve Bunting (Clarion/Houghton Mifflin, 1993) The story of a young girl, her parents, and their neighbors whotry to save an old oak tree that has been poisoned by pollution. award-winning author

The Sun is My Favorite Star by Frank Asch (Voyager/Harcourt, 2008) Celebrates a child's love of the sun and the wondrous ways in which it helps the Earth and the life upon it. award-winning author

Sunshine, Moonshine by Jennifer Armstrong (Random House, 1997) provides rhyming text and follows the sun and the moon as they shine on a young boy's day. award-winning author

Wag! by Patrick McDonnell (Little, Brown Books for Young Readers, 2009) describes the different things in life that make Earl the dog's tail way, as told to the reader my Mooch the cat.

Walking through the Jungle by Debbie Harter (Barefoot Books, 2007) follows a young explorer who discovers the different animals and terrains of the world on her way home for dinner.

What is Science? by Rebecca Kai Dotlich (Henry Holt and Company, 2006) introduces children to the exciting world of science, covering a wide range of topics, including planets, rocks and soil, hurricanes, and airplanes. award-winning author

Winter: An Alphabet Acrostic by Steven Schnur (Clarion Books, 2002) presents poems that revolve around winter, from freezing snow to a crackling fire and fun wintertime activities, too. award-winning author

Grades 1-2:

Altoona Baboona by Janie Bynum (Voyager/Harcourt, 2002) This lovable character travels the world in her hot-air balloon.

Animal Dads by Sneed B. Collard III (Houghton Mifflin, 1997) Male parents of different species help take care of their young. award-winning author

Autumn: An Alphabet Acrostic by Steven Schnur (Clarion/Houghton Mifflin, 1997) Poems that revolve around autumn, with animals, rain, cold winds, and harvested foods, arranged alphabetically. award-winning author

Bear on a Bike by Stella Blackstone (Bareffot Books, 2007) Methods of transportation and motion in a fun format.

Biggest Strongest, Fastest by Steve Jenkins (Houghton Mifflin, 1995) Information on fourteen different animals and the "world records" of which they own the title. NSTA trade book; outstanding science trade book; booklist editors' choice

Broken Bones by Jason Glaser (Capstone, 2007) How and why broken bones occur as well as how to treat and prevent them.

The Circulatory System by Helen Frost (Capstone, 2001) Introduces the circulatory system and its purpose, parts, and functions. award-winning author

Day Light, Night Light by Franklyn M. Branley (Harper Collins, 1975) Discusses the properties of light, particularly its source in heat. award-winning author

Does a Kangaroo Have a Mother, Too? by Eric Carle (Harper Collins, 2005) Presents the names of animal babies, parents, and groups. For example: baby kangaroo is a joey, mother is a flyer, father is a boomer and the group is a troop, mob or herd. award-winning author

Ducky by Even Bunting (Clarion/Houghton Mifflin, 1997) The story of a yellow plastic duck that makes a long perilous journey when washed overboard with a crate full of bathtub toys during a storm. award-winning author

Everything is Matter! by David Bauer (Yellow Umbrella, 2004) Introduces the 3 states of matter.

Floating and Sinking by Ellen Sturm Niz (Capstone, 2006) Introduces the concepts of floating and sinking. Includes an activity to demonstrate these concepts and their characteristics.

Giant Panda by Michelle Levine (Lerner, 2006) Describes the physical features, habitat, diet and social activities of panda bears.

Gregory, the Terrible Eater by Mitchell Sharmat (Scholastic, 2009) The story of a finicky goat who refuses to eat the usual goat diet staples of shoes and tin cans in favor of fruits, vegetables, eggs and orange juice.

(Children's Choice) Growing Vegetable Soup by Lois Ehlert (Harcourt, 1987) The story of a father and child who grow vegetables and use them to make soup. award-winning author and illustrator

The Healthy Body by Angela Royston (Heinemann, 2000) Explains the importance of exercise in maintaining good health, and the roles of the muscles, joints, heart and lungs in this process. award-winning author

Henry Hikes to Fitchburg by D. B. Johnson (Houghton Mifflin, 2000) The story of two friends who meet in a town halfway between them. One works along the way to earn money for train fare. The other walks through woods and fields, enjoying nature along the way. SLI Best Book; New York Times Best Illustrated Book; Boston Globe- Horn Book Award, Notable Social Studies Trade Book; Notable Children's Book in the Language Arts

Here is the African Savanna by Madeleine Dunphy (Web of Life, 2006) Describes the interdependence among the plants and animals that make up the African savanna. NSTA Trade Book; Outstanding Science Trade Book

I Know the River Loves Me / Yo se que el rio me ama by Maya Christina Gonzalez (Children's Book Press, 2009) The story of a girl who expresses her love of the river that she visits, plays in, and cares for. award-winning author and illustrator

In the Trees, Honey Bees by Lori Mortensen (Dawn, 2009) An up-close view of the members of a bee colony and their contributions to the colony.

Is it Slippery or Sticky? by Vic Parker (Raintree, 2005) Children go on a scavenger hunt to find a variety of items with contrasting properties. Students investigate texture, shape, and form of the materials. award-winning author

Let's Look at Pebbles by Angela Royston (Heinemann, 2006) Offers fascinating facts and information about pebbles as well as vivid photographs. award-winning author

Let's Look at Rocks by Jeri Cipriano (Yellow Umbrella, 2004) Lists the various places people find rocks and describes the different ways people use rocks.

Living and Nonliving by Carol K. Lindeen (Capstone, 2008) Informative text and rich photographs explain the differences between living and nonliving things.

The Longest Night by Marion Dane Bauer (Holiday House, 2009) The story of a crow, moose, and fox who all claim to be able to bring back the sun when it disappears at night. But the wind knows that only one little creature has what is needed to end the darkness. award-winning author

The Lorax by Dr. Seuss (Random House Children's Books, 1971) In this classic story, the Once-ler describes how his greedy actions destroyed a beautiful and thriving environment. Children will enjoy the colorful characters and rhyming verse and adults will appreciate the subtle messages about the negative effects of deforestation, habitat destruction, and air and water pollution.

Make it Move! by Jennifer VanVoorst (Yellow Umbrella, 2004) Introduces simple machines and gives examples of everyday use.

Mammals by Susan Ring (Yellow Umbrella, 2004) A basic introduction to various mammals and discusses some of their features and habits.

Matter by Christine Webster (Capstone, 2005) Introduces the concept of matter. Provides an activity to demonstrate some of matter's characteristics.

Motion by Rebecca Olien (Capstone, 2005) Introduces the concept of motion. Provides an activity to demonstrate some of motion's characteristics.

My Mother is Mine by Marion Dane Bauer (Simon & Schuster, 2004) Focuses on the relationship between various animal babies and their mothers. award-winning author

On Sand Island by Jacqueline Briggs Martin (Houghton Mifflin, 2003) The story of a young boy on an island in Lake Superior I 1916. He builds himself a boat by bartering with other islanders for parts and labor. Golden Kite Honor

Oscar and the Bird: A Book About Electricity by Geoff Waring J (Candlewick, 2009) The story of a curious kitten that presses a switch by mistake, which prompts an array of questions about electricity.

Oscar and the Snail: A Book About Things We Use by Geoff Waring (Candlewick, 2009) The story of a curious kitten that wonders about the different materials we use daily , and the wise snail that answers his questions.

Pop! A Book about Bubbles by Kimberly Brubaker Bradley (HarperCollins, 2001) Explains how bubbles are made, why their shape is always round, and why they pop. NSTA Trade Book; Outstanding Science Trade Book

Precious Water: A Book of Thanks by Brigitte Weninger (North-South, 2000) Describes the souces of water, and water's importance to all living things. award-winning author

Pumpkin Circle: The Story of a Garden by George Levenson (Tricycle, 2004) Captures each phase of the pumpkin's life cycle, with time-lapse photography. NSTA Trade Book; Outstanding Science Trade Book

Rain by Manya Stojic (Dragonfly, 2009) The story of animals on and African savanna that use their senses to predict and enjoy the rain. New York Times Best Illustrated Book

Science with Magnets by Helen Edom (Useborne, 2008) Reveals properties and basic principles relation to magnetism. Provides safe, fun and simple experiments designed to teach through personal experience and observation.

Show Us Your Wings by Susan Ring (Yellow Umbrella, 2004) Presents some of the birds and insects that have wings and the different ways they use them.

Snakes and Lizards by Ellen Catala (Yellow Umbrella, 2004) Describes the features and characteristics of these slithery, scaly reptiles.

Snow by Marian Dane Bauer (Aladdin, 2003) Explores the wonders of snow, including how it forms and the characteristics of snowflakes. award-winning author

Someday a Tree by Eve Bunting (Clarion/Houghton Mifflin, 1993) The story of a young girl, her parents, and their neighbors who try to save an old oak tree that has been poisoned by pollution. award-winning author

The Sun is My Favorite Star by Frank Asch (Voyager/Harcourt, 2008) Celebrates a child's love of the sun and the wondrous ways in which it helps the Earth and the life upon it. award-winning author

Water by Frank Asch J (Harcourt, 2000) Details the many forms of water. Encourages readers to appreciate this precious resource. award-winning author

Weather Patterns by Monica Hughes (Heinemann, 2004) Describes the different types of climate in various places and the weather that occurs during the seasons. award-winning author

What is Water? by Rebecca Olien (Capstone, 2005) Introduces the basic elements of water. Describes water as a liquid, solid, and gas.

What Makes Day and Night by Franklyn m. Branley (HarperCollins, 1986) Offers a simple explanation of how the rotation of the earth causes night and day. award-winning author

What's This? by Caroline Mockford (Barefoot Books, 2007) Recounts a small girl's discovery of a seed. Illustrates how it grown into a sunflower.

Who Builds? by Jennifer VanVoorst (Yellow Umbrella, 2004) Compares some of the structures that people build with structures by animals

Grades 3-5:

A Project Guide to Light and Optics by Colleen Kessler (Mitchell Lane Publishers, 2011) examines light, optics, and how they are used in our everyday lives through hands-on experiments that develop deeper understanding of the subject.

Adaptation and Survival by Robert Sneeden (Raintree, 2012) shows how animals adapt to different environments and how those adaptations and the fitness of an organism are often important to an organism's quality of life.

Animal Tongues by Dawn Cusick (EarlyLight Books, 2012) uses full color and often silly photographs to illustrate the different tongues found in different types of animals and highlights how this physical adaptation helps them overcome different environments.

The Apollo Mission and Other Adventures in Space by Chris Oxlade(Rosen Central, 2011) introduces kids to the brave astronauts and space program employees who inspire and educate others through their efforts to learn about space.

Bones: Skeletons and How They Work by Steve Jenkins (Scholastic, 2010) compares the skeletons of humans with the skeletons of other species through wonderful, to scale illustrations and shows how different bones benefit different types of bodies. award-winning author

Cool Stuff 2.0: And How It Works by Chris Woodford, Jon Woodcock (DK Publishing,2010) introduces young readers to the engineering and invention that went into the things that they see every day, as well as outlining the inventions that happened along the way to make the technology we have possible.

Day & Night by Teddy Newton (Chronicle Books, 2010) fancifully illustrates the concepts of day and night and allows children to explore their differences and similarities as Day and Night meet and learn about each other.

Deformed Frogs by Kathy Allen (Capstone Press, 2010) examines what happens when the genetic traits passed down to an animal are different than those of their parents and discusses how these differences might be the cause of changing environments and a need to adapt.

Design It!: The Ordinary Things We Use Every Day and the Not-So-Ordinary Ways They Came To Be by Rona Arato (Tundra Books, 2010) provides the stories and pictures behind the way every day products were designed to be solutions to problems that people were having and introduces young readers to careers in industrial design.

Earth Cycles: Water by Sally Morgan (Wayland, 2011) teaches young readers about the water cycle and the ways that this cycle helps create life all over the planet.

Hide and Seek Moon: The Moon Phases by Robin Koontz (Capstone Press, 2011) uses a graphic novel format to illustrate the phases of the moon in a dynamic way. award-winning author

How Do My Muscles Get Strong? Muscles and Exercise by Steve Parker (Heinemann-Raintree, 2011) teaches children how their muscles work and how exercise is important to the normal function of their body.

How to Raise Monarch Butterflies by Carol Pasternak (Firefly Books, 2012) includes gorgeous, detailed photographs that illustrate the life cycle of monarch butterflies, teaching children how to care for butterflies and to understand each phase of their lives.

Illustrated Timeline of Space Exploration by Patricia Louise Wooster (Picture Window Books, 2011) gives a graphic, exciting look at what we've learned from space exploration and when and how we learned it.

Inside Lightning by Melissa Stewart (Sterling Children's Books, 2011) explains how lightning forms and why it strikes where it does and uses first hand experiences to describe what it feels like to be struck by lightning. award-winning author

Investigating Light by Sally M. Walker (Lerner Classroom, 2011) explores the properties of light, light's rays, how they move, and why they react differently when they encounter different objects.

Investigating Science: What Is Force? by Jacqui Bailey (Franklin Watts, 2010) introduces young readers to the concept of forces and uses photographs to illustrate how they act on objects.

The Lorax by Dr. Seuss (Random House Children's Books, 1971) In this classic story, the Once-ler describes how his greedy actions destroyed a beautiful and thriving environment. Children will enjoy the colorful characters and rhyming verse and adults will appreciate the subtle messages about the negative effects of deforestation, habitat destruction, and air and water pollution.

The Manatee Scientists: Saving Vulnerable Species by Peter Lourie (Houghton Mifflin Harcourt, 2011) discusses animal activism and what people can do to protect a species that is endangered because of the ways in which their environments are being altered by humans.

National Geographic Kids Everything Rocks and Minerals: Dazzling Gems of Photos and Info That Will Rock Your World by Steve Tomecek (National Geographic Children's Books, 2011) uses colorful photographs and exciting facts to teach children about geology and the types of rocks that geologists encounter by explaining how they're formed, where they come from, and why they're different from one another.

National Geographic Kids Everything Weather: Facts, Photos, and Fun That Will Blow You Away by Kathy Furgang (National Geographic Children's Books, 2012) studies different types of weather and what causes it with the help of bold photographs, facts, and trivia.

Physics: Why Matter Matters! by Dan Green, Simon Basher (Kingfisher, 2010) uses visual, kid-friendly explanations of the ways we use properties to classify matter and how we identify the building blocks of physics. Plants: Flowering

Plants, Ferns, Mosses, and Other Plants by Shar Levine (Crabtree Publishing Company, 2010) profiles the many kinds of plants and illustrates their differences and how they interact with their environments.

Rachel Carson: Clearing the Way for Environmental Protection by Mike Venezia (Children's Press, 2010) introduces young readers to Rachel Carson and her early efforts to help protect the environment through the use of entertaining illustrations and easy-to-read text.

The Science of a Racecar: Reactions in Action by Heather E. Schwartz (Capstone Press, 2010) takes a look at how forces like friction and gravity affect the motion of a racecar.

The Science of Hitting a Home Run: Forces and Motion in Action by Jim Whiting (Capstone Press, 2010) offers a look the way the principles of motion and our understanding of physics affects the game of baseball and how it is played.

The Secret Life of a Snowflake: An Up-Close Look at the Art and Science of Snowflakes by Kenneth Libbrecht (Voyageur Press, 2010) explains how snowflakes are formed and illustrates their unique differences through concise text and a series of beautiful photographs.

The Secret Lives of Plants! by Janet Slingerland (Capstone Press, 2012) explores the processes plants use to grow and procreate through colorful illustrations, as well as showing the ways they defend themselves from their surroundings.

Seed, Sprout, Fruit: An Apple Tree Life Cycle by Shannon Barefield (Capstone Press, 2011) illustrates, in a graphic novel format, the life cycle of an apple tree and the different processes it goes through as it grows.

Sight by Louise Spilsbury (Heinemann-Raintree, 2012) examines the sense of sight in both humans and animals, and explains how the eye works and the ways poor vision is corrected.

Stars by Ker Than (Children's Press, 2010) provides rich photographs and an indepth look at what stars are made of, how they're formed, how they sustain themselves, and what happens when they die.

Using Electricity by Chris Oxlade (Heinemann-Raintree, 2012) explains the basic concepts of electricity while examining what it is, how we use it, and how it's created.

The Watcher: Jane Goodall's Life with the Chimps by Jeanette Winter (Schwartz & Wade, 2011) uses colorful illustrations and simple text to introduce young readers to Jane Goodall's early life and the animals that she studied and loved.

Weird & Wacky Inventions by Jim Murphy (Sky Pony Press, 2011) discusses a number of fun and creative inventions sure to pique a young reader's curiosity while teaching them the importance of using imagination to solve problems.

What Do You Know About States of Matter? by Tilda Monroe (Powerkids Press, 2010) uses a question and answer format to introduce young readers to the physical properties of the different states of matter and why it is important to understand them.

What If There Were No Sea Otters?: A Book About the Ocean Ecosystem by Suzanne Buckingham Slade (Picture Window Books, 2010) teaches young readers about how important every organism is to a delicate ecosystem. award-winning author

What to Expect When You're Expecting Joeys by Bridget Heos (MillbrookPress, 2011) offers a fun, light-hearted look at marsupial reproduction and how they care for their young.

What's the Problem? How to Start Your Scientific Investigation by Kylie Burns (Crabtree Publishing Company, 2010) depicts how scientists investigate questions, where they start, and how they apply the scientific method.

Why Does Water Evaporate?: All About Heat and Temperature by Rob Moore (PowerKids Press, 2010) shows young readers how temperature is measured and how it affects the physical world around us.

Grades 6-8:

Acids and Bases (Material Matters/Express Edition) by Carol Baldwin (Heinemann-Raintree, 2005) focuses on the properties of acids and bases with photographs and facts.

Acids and Bases by Eurona Earl Tilley (Chelsea House, 2008) provides a thorough basic understanding of acid and base chemistry, including such topics as naming compounds, writing formulas, and physical and chemical properties.

Across the Wide Ocean: The Why, How, and Where of Navigation for Humans and Animals at Sea by Karen Romano Young (Greenwillow, 2007) focuses on navigational tools, maps, and charts that researchers and explorers use to learn more about oceanography. award-winning author

Adventures in the South with Max Axiom, Super Scientist (Graphic Science Series) by Emily Sohn (Capstone, 2007) provides information about sound through a fun graphic novel

Air: A Resource Our World Depends on (Managing Our Resources) by Ian Graham (Heinemann-Raintree, 2005) examines this valuable natural resource and answers questions such as "How much does Earth's air weigh?" And "Why do plants need wind?"

The Alkaline Earth Metals: Beryllium, Magnesium, Calcium, Strontium, Barium, Radium (Understanding the Elements of the Periodic Table) by Bridget Heos (Rosen Central, 2009) Describes the characteristics of these metals, including their similar physical and molecular properties.

All About Light and Sound (Mission Science) by Connie Jankrowski (Compass Point 2010) Focuses on the importance of light and sound and how without them we could not survive.

Alternative Energy: Beyond Fossil Fuels by Dana Meachen Rau (Compass Point, 2010) Discusses the ways that water, wind, and sun provide a promising solution to our energy crisis and encourages readers to help the planet by conserving energy. award-winning author

Amazing Biome Projects You can Build Yourself (Build it Yourself Series) by Donna Latham (Nomad, 2009) provides an overview of eight terrestrial biomes, including characteristics about climate, soil, animals, and plants.

Archaea: Salt-Lovers, Methane-Makers, Thermophiles, and Other Archaeans (A class of their own) by David M. Baker (Crabtree, 2010) provides interesting facts about different types of archaeans.

The Art of Construction: Projects and Principals for Beginning Engineers and Architects by Mario Salvadori (Chicago Review 2000) Explains how tents, houses, stadiums, and bridges are built, and how to build models of such structures using materials found around the house. award-winning author

Astronomy: Out of this world! by Simon Basher and Dan Green (Kingfisher, 2009), takes readers on a journey of the universe and provides information about the planets, stars, galaxies, telescopes, space missions, and discoveries.

At the Sea Floor Café: Odd Ocean Critter Poems by Leslie Bulion (Peachtree, 2011) provides poetry to educate students about how ocean creatures search for food, capture prey, protect their young, and trick predators.

Battery Science: Make Widgets that work and Gadgets that Go by Doug Stillinger (Klutz, 2003) offers an array of activities and gadgets to get students excited about electricity.

The Biggest Explosions in the Universe by Sara Howard (BookSurge, 2009) tells the story of stars in our universe through fun text and captivating photographs.

Biology: Life as We Know It! by Simon Basher and Dan Green (Kingfisher, 2008) Offers information about all aspects of life from the animals and plants to the minuscule cells, proteins, and DNA that bring them to life.

Birds of a Feather by Jane Yolen (Boyds Mills Press, 2011) Offers facts and information about birds through fun poetry and beautiful photographs. award-winning author

Blackout!: Electricity and Circuits (Fusion) by Anna Claybourne (HeinemannRaintree 2005) provides an array of facts about electricity and how we rely on it for so many things in everyday life. award-winning author

Cell Division and Genetics by Robert Snedden (Heineman, 2007) explains various aspects of cells and the living world, including what happens when cells divide and how characteristics are passed on from one generation to another. award-winning author

Chemistry: Getting a Big Reaction by Dan Green and Simon Basher (Kingfisher, 2010) acts as a guide about the chemical “characters” that fizz, react, and combine to make up everything around us.

Cool Stuff Exploded by Chris Woodford (Dorling Kindersley, 2008) focuses on today’s technological marvels and tomorrows jaw-dropping devices. Outstanding Science Trade Book

Disaster Deferred: How new Science is Changing Our View of Earthquake Hazards in the Midwest by Seth Stein, (Columbia University, 2010) discusses technological innovations that make earthquake prediction possible.

The Diversity of Species (Timeline: Life on Earth) by Michael Bright (Heinemann, 2008) explains how and why things on earth have genetic and physical differences and how they have had and continue to have an impact on Earth.

Drip! Drop!: How Water Gets to Your Tap by Barbara Seuling (Holiday House, 2000) introduces students to JoJo and her Dog, Willy, who explain the water cycle and introduce fun experiments about filtration, evaporation, and condensation. award-winning author

Eat Fresh Food: Awesome recipes for Teen Chefs by Rozanne Gold (Bloomsbury, 2009) includes more than 80 recipes and places a strong emphasis on fresh foods throughout the book.

Eco-Tracking: On the Trail of Habitat Change (Worlds of Wonder) by Daniel Shaw (University of New Mexico, 2010) recounts success stories of young people involved in citizen science efforts and encourages others to join in to preserve natures ecosystems.

Electric Mischief: Battery-Powered Gadgets Kids Can Build by Alan Bartholomew (Kids Can Press, 2002) Offers a variety of fun projects that include making battery connections and switches and building gadgets such as electric dice and a bumper car.

Electricity (Why it Works) by Anna Claybourne (QED Publishing, 2008) provides information about electricity in an easy to follow manner. award-winning author

Electricity and Magnetism (Usborne Understand Science) by Peter Adamczyk (Usborne, 2008) explains the basics about electricity and magnetism, including information about static electricity, electric circuits, and electromagnetism.

Energy Transfers (Energy Essentials) by Nigel Saunders and Steven Chapman (Raintree, 2005) explains the different types of energy, how they can change, and how different forms of energy help us in our everyday lives.

The Everything Machine by Matt Novak (Roaring Brook, 2009) tells the silly story of a machine that does everything for a group of people until they wake up one day ad discover that the machine has stopped working. award-winning author

Experiments with Plants and Other Living Things by Trevor Cook (PowerKids, 2009) Provies fun, hands-on experiments to teach students about flowers, plants, and biology.

Exploring the Oceans: Seafloor by John Woodward (Heinemann, 2004) takes readers on a virtual tour through the bottom part of the ocean, highlighting the plants and animals that thrive in this environment.

Extreme Structures: Mega Constructions of the 21st Century (Science Frontiers) by David Jefferies (Crabtree, 2006) takes a look at how some of the coolest buildings in the world were built and what other kinds of structures are being planned for the future. award-winning author

Fascinating Science Projects: Electricity and Magnetism by Bobbi Searle (Aladdin, 2002) Teaches the concepts of electricity and magnetism though dozens of projects and experiments and color illustrations.

Fizz, Bubble, and Flash!: Element Explorations and Atom Adventures for Hands on Science Fun by Anita Brandolini, Ph.D. (Williamson, 2003) introduces chemistry to students in a non-intimidating way and focuses on the elements and the periodic table. Parents' Choice

Floods: Hazards of Surface and Groundwater Systems (The Hazardous Earth) by Timothy M. Kusky (Facts on File, 2008) explores the processes that control the development and flow in river and stream systems and when these processes become dangerous.

Fossils (Geology Rocks!) by Rebecca Faulkner (Raintree, 2008) educates students about rock formation and processes and characteristics of rocks and fossils.

Friends: True Stories of Extrodinary Animal Friendships by Catherine Thimmesh (Houghton Mifflin Harcourt, 2011) Depicts true stories of unlikely animal friendships, including a wild polar bear and a sled dog as well as a camel and a Vietnamese pig. award-winning author

The Frog Scientist (Scientists in the Field) by Pamela S. Turner (Houghton Mifflin Harcourt, 2009) follows a scientist and his protégés as they research the effects of atrazine-contaminated water on vulnerable amphibians. Booklist Editors' Choice

From Steam Engines to Nuclear Fusion: Discovering Energy (Chain reactions) by Carol Ballard (Heinemann-Raintree, 2007) tells the fascinating story of energy, from the heat produced by a simple fire to the extrodinary power contained in an atom.

Fully Charged (Everyday Science) by Steve Parker (Heinemann-Raintree, 2005) explains how electricity is harnessed, and used and also the difference between electricity, including static electricity and electronics. award-winning author

Galileo for Kids: His Life and Ideas by Richard Panchyk (Chicago Review, 2005) includes experiments that demonstrate scientific principals developed by the astronomer Galileo.

Genes and DNA by Richard Walker (Kingfisher, 2003) offers and abundance of information about characteristics of genes, gene function, DNA technology and genetic engineering, as well as other fascinating topics. NSTA Trade Book; Outstanding Science Trade Book

Hands-on Science Series: Simple Machines by Steven Souza and Joseph Shortell (Walch, 2001) investigates the concepts of work, force, power, efficiency, and mechanical advantage.

How Animals Work by David Burnie (Dorling Kindersley, 2010) provides vivid photographs and intriguing text to describe various animals and their characteristics, diets, and families. award-winning author

How Does an Earthquake Become a Tsunami? (How does it Happen?) by Linda Tagliaferro (Heinemann-Raintree, 2009) Describes the changes in water, waves, and tides that occur between an earthquake and a tsunami. award-winning author

How the Future Began: Machines by Clive Gifford (Kingfisher, 1999) acts as a guide to historical and current developments in the field of machinery, including mass production, computers, robots, micro-engineering, and communications technology.

How Scientists Work (Simply Science) by Natalie M. Rosinsky (Compass Point, 2003) Discusses the scientific method, equipment, and procedures and also describes how scientists compile information and answer questions.

How to Clean a Hippopotamus: A look at Unusual Animal Partnerships by Steve Jenkins and Robin Page (Houghton Mifflin Harcourt, 2010) explores animal symbiosis with fun illustrations and close up step by step view of some of nature's most fascinating animal partnerships. ALA Notable Book

Human Spaceflight (Frontiers in Space) by Joseph A. Angelo (Facts on File, 2007) examines the history of space exploration and the evolution of space technology from the dawn of the space age to the present.

The Hydrosphere: Agent of Change by Gregory L. Vogt, Ed. D. (Twenty-First Century, 2006) discusses the impact this 20-mile thick sphere has had on the surface of the planet and the processes that go on there, including the ability of Earth to sustain life. award-winning author

In Rivers, Lakes, and Ponds (Under the Microscope) by Sabrina Crewe (Chelsea Clubhouse, 2010) educates readers about the various microscopic critters that live in these various bodies of water.

A Kid's Guide to Climate Change and Global Warming: How to Take Action! by Cathryn Berger Kaye, M.A. (Free Spirit, 2009) Encourages students to learn about the climate changes happening around the world and to get involved to help save our planet.

Lasers (Lucent Library of Science and Technology) by Don Nardo (Lucent, 2003) discusses the scientific discovered and development of lasers high intensity light and their use in our daily lives. award-winning author

Leonardo's Horse by Jean Fritz (Putman, 2001) tells the story of Leonardo Da Vinci the curious and inquisitive artist, engineer and astronomer who created a detailed horse sculpture for the city of Milan. ALA Notable Book; Notable Social Studies Trade Book; Notable Children's Book in the Language Arts

Light: From Sun to Bulbs by Christopher Cooper (Heinmann, 2003) invites students to investigate the dazzling world of physical science and light through fun experiments. award-winning author

Magnetism and Electromagnets (Sci-Hi: Physical Science) by Eve Harman (Raintree, 2008) offers colorful illustrations, photographs, quizzes, charts, graphs, and text to teach students about magnetism.

Making Good Choices About Non Renewable Resources (Green Matters) by Paula Johanson (Rose Central, 2009) focuses on the different types of nonrenewable natural resources, alternative resources, conservation, and making positive consumer choices.

Making Waves: Sound (Everyday Science) by Steve Parker (Heinemann-Raintree, 2005) describes what sound is, how it is formed and used, and properties associated with sound, such as pitch, speed, and volume. award-winning author

The Manatee Scientists: Saving Species (Scientists in the Field Series) by Peter Lourie (Houghton Mifflin Harcourt, 2011) discusses three species of manatees and the importance of preserving these mammals. award-winning author

The Man Who Named the Clouds by Julie Hannah and Joan Holub (Albert Whitman, 2006) tells the story of the 18th Century English meteorologist Luke Howard and also discusses the ten classifications of clouds.

Medicine in the News (Science New Flash) by Brian R. Shmaefsky, Ph. D. (Chelsea House, 2007) focuses on medical advancements that are in the news today and the innovative tools that are used for diagnosis and treatment.

Metals and Metalloids (Periodic Table of Elements) by Monica Halka, Ph. D. and Brian Nordstrom, Ed. D. (Facts on File 2010) offers information about the physics, chemistry, geology, and biology of metals and metalloids.

Meteorology: Ferguson's Careers in Focus by Ferguson (Ferguson, 2011) profiles 18 different careers pertaining to the science of the atmosphere and its phenomena.

The Microscope (Great Medical Discoveries) by Adam Woog (Lucent, 2003) recounts how the microscope has had an impact on the history of medicine.

Microscopes and Telescopes: Great Inventions by Rebecca Stefoff (Marshall Cavendish Benchmark, 2007) describes the origin, history, development and societal impact of the Telescope and microscope. Outstanding Science Trade Book

Mighty Animal Cells by Rebecca L. Johnson (Millbrook, 2007) takes readers on a journey to discover how people and animals grown from just one cell. award-winning author

Moon (Eye Witness Books) by Jacqueline Mitton (Dorling Kindersley, 2009) offers information about our planets mysterious nearest neighbor, from the moon's waterless seas and massive craters to its effects on the Earths ocean, tides and its role in solar eclipses. award-winning author

MP3 Players (Let's Explore Technology Communications) by Jeanne Sturm (Rourke, 2010) discusses the technology advances in music in our society.

Nanotechnologist (cool Science Careers) by Anne Heinrichs (Cherry Lake, 2009) provides information about nanotechnologists scientists who work with material on a subatomic or atomic level.

Ocean: An Illustrated Atlas by Sylvia A. Earle (National Geographic, 2008) provides an overview on the ocean as a whole each of the major ocean basins, and the future of the oceans. award-winning author

Oceans (Insiders) by Beverly McMillan and John A. Musick (Simon and Schuster, 2007) takes readers on a 3-D journey of the aquatic universe exploring the formation of waves and tsunamis as well as the plant and animal species that live beneath the ocean's surface.

Organic Chemistry and Biochemistry (Facts at Your Fingertips) by Graham Batemen (Brown Bear, 2011) provides diagrams, experiments, and testing aids to teach students the basics about organic chemistry and biochemistry.

An Overcrowded World? Our Impact on the Planet (21st Century Debates) by Rob Bowden (Heinemann, 2002) investigates how and why the world's population is growing so fast, the effects of this growth on wildlife and habitats and the pressure and resources, and suggests the ways of controlling growth.

The Pebble in My Pocket: A History of Our Earth by Meredith Hooper (Viking, 1996) follows the course of a pebble, beginning 480 million years ago, through a firery volcano and primordial forest and along the icy bottom of a glacier and how it looks today as the result of its journey. award-winning author

The Periodic Table: Elements with Style! by Simon Basher and Adrian Dingle (Kingfisher, 2007) offers information about different elements that make up the periodic table and their features and characteristics.

Phenomena: Secrets of the Senses by Donna M. Jackson (Little Brown, 2008) focuses on the senses and how to interpret them and discusses ways that technology is changing how we experience the world around us. award-winning author

Pioneers of Light and Sound (Mission: Science) by Connie Jankowski (Compass Point, 2010) focuses on various scientists and their accomplishments and achievements.

Planet Animal: Saving Earths Disappearing Animals by B. Taylor (Barron's, 2009) focuses on the planet's most endangered animals, their relationships to the environment, and steps that are being taken to try to save the animals from extinction.

Plant and Animal Science Fair Projects (Biology Science Projects Using the Scientific Method) by Yael Calhoun (Enslow, 2010) provides an array of experiments about plants and animals and describes the importance of the scientific method, forming a hypothesis and recording data for any given project.

Plant Secrets: Plant Life Processes by Anna Claybourne (Heinemann-Raintree, 2005) includes informative text, vivid photographs, and detailed charts about characteristics of various plants. award-winning author

Polar Regions: Human Impacts (Our Fragile Planet) by Dana Desonie (Chelsea House, 2009) focuses on pollutants and global warming in the artic and antarctic and future dangers that will occur if our planet continues on its current path.

Potato Clocks and Solar Cars: Renewable and Non-Renewable Energy by Elizabeth Raum (Raintree, 2007), explores various topics, including alternative energy sources, fossil fuels, and sustainable energy.

The Power of Pressure (How Things Work) by Andrew Dunn (Thomson Learning, 1993) explains how water pressure and air work and how they are used in machines.

Protists and Fungi (Discovery Channel School Science) by Katie King and Jacqueline A. Ball (Gareth Stevens, 2003) focuses on the appearance, behavior, and characteristics of various protists and fungi, using examples of algae, mold, and mushrooms.

Protozoans, Algae and Other Protists by Steve Parker (Compass Point, 2010) Introduces readers to the parts, life cycles, and reproduction of various types of protists, from microscopic protozoans to seaweed like algae, and some of the harmful effects protists have on humans. award-winning author

Sally Ride: The First American Woman in Space by Tom Riddolls (Crabtree, 2010) focuses on the growth and the impact of Sally Ride Science, an educational program founded by the astronaut to encourage girls to pursue hobbies and careers in science.

Science and Technology in 20th Century American Life by Christopher Cumo (Greenwood, 2008) takes readers on a history of technology from agricultural implements through modern computers, telecommunications and skateboards.

Sedimentary Rock (Geology Rocks) by Rebecca Faulkner (Raintree, 2008) educates students about rock formation and the processes and characteristics of sedimentary rock.

Shaping the Earth by Dorothy Hinshaw Patent (Clarion/Houghton Mifflin, 2000) combines vivid photographs with informative text to explain the forces that have created the geological features on Earth’s surface. award-winning author

Silent Spring by Rachel Carson (Houghton Mifflin Harcourt, 2002) Celebrates marine biologist and environmental activist Rachel Carson’s contribution to Earth through an array of essays.

Skywalkers: Mohawk Ironworkers Build the City by David Weitzman (Flash Point, 2010) focuses on the ironworkers who constructed bridges and skyscrapers in New York and Canada. award-winning author

Sustaining Earth’s Energy Resources (Environment at Risk) by Ann Heinrichs (Marshall Cavendish, 2010) offers information on Earths sources of nonrenewable and renewable energy, how they are used, and their disadvantages and benefits.

Team Moon: How 400,000 People Landed Apollo 11 on the Moon by Catherine Thimmesh (Houghton Mifflin Harcourt, 2006) tells the story of the first moon landing and celebrates the dedication, ingenuity, and perseverance of the people who make this event happen. ALA Notable Book; Orbis Pictus Honor; Notable Children’s Book in the Language Arts; ALA Best Book for Young Adults; Golden Kite Honor

The Top of the World: Climbing Mount Everest by Steve Jenkins (Houghton Mifflin Harcourt, 1999) describes the conditions and terrain of Mount Everest, attempts that have been made to scale this peak, and information about the equipment and techniques of mountain climbing. ALA Notable Book; SLI Best Book; Boston Globe – Horn Book Award; Orbis Pictus Honor

Transmission of Power by Fluid Pressure: Air and Water by William Donaldson (Nabu, 2010) describes the transmission of fluid pressure as it pertains to the elements of air and water in the world of motion forces and energy.

Tsunami: The True Story of an April Fools Day Disaster by Gail Langer Karwoski (Darby Creek, 2006) offers a variety of viewpoints about the wave that struck Hawaii in 1946. Notable Social Studies Trade Book

Vapor, Rain, and Snow: The Science of Clouds and Precipitation (Weatherwise) by Paul Fleisher (Lerner, 2010) answers and array of questions about water such as "How does a cloud form?" and "Why do ice cubes shrink in the freezer?" award-winning author

Water Supplies in Crisis (Planet in Crisis) by Russ Parker (Rosen Central, 2009) describes a world where safe drinking water is not readily available, polluted water brings disease and lakes are disappearing.

Weird Meat-Eating Plants (Bizarre Science) by Nathan Aaseng (Enslow, 2011 provides information about a variety of carnivorous plants, reversing the food chains usual order. award-winning author

What are Igneous Rocks? (Let's Rock!) by Molly Aloian (Crabtree, 2010) explains how granite, basalt, lava, silica, and quartz are formed after hot molten rock cools.

What's Living Inside Your Body? by Andrew Solway (Heinemann, 2004) offers information about an array of viruses, germs, and parasites that thrive inside the human body.

Why Should I Bother to Keep Fit? (What's Happening?) by Kate Knighton and Susan Meredith (Usborne, 2009) motivates students to get and stay fit.

The World of Microbes: Bacteria, Viruses, and Other Microorganisms (Understanding Genetics) by Janey Levy (Rosen Classroom, 2019) describes the world of microbes, a history of microbiology, and the characteristics of both harmful and beneficial bacteria.

Written in Bone: Buried Lives of Jamestown and Colonial Maryland by Sally M. Walker (Carolrhoda, 2009) describes the way scientists used forensic anthropology to investigate colonial-era graves near Jamestown, VA. ALA Notable Bok; Outstanding Science Trade Book; Notable Social Studies Trade Book

You Blink Twelve Times a Minute, and Other Freaky Facts about the Human Body by Barbara Seuling (Picture Window, 2009) provides fun and unusual facts about various ailments, medical marvels, and body parts and their functions. award-winning author

EVOLUTION

- The Catholic Church embraces a theistic theory of evolution, which involves a Creator.
- Intelligent design is neither Catholic teaching nor is it good science, thus it is not included in the science standards for Catholic schools in the Diocese of Owensboro.
- Evolution, as the Church understands it, is not one theory (ie: Darwin), but rather a compilation of theories of several scientists spanning over a century. (Darwin's little-known later writings talk about love and nurturance as part of the evolutionary process.) Thus, the idea that the Catholic schools are only teaching one theory of evolution is incorrect.
- It is important that we make distinctions between the "Big Bang Theory" and biological evolution. They are different theories with different methodologies that can be combined to create a grand, sacred evolutionary narrative.
- More on the Catholic Church's position is below, with talking points highlighted.

From Catholic Encyclopedia (excerpts)

(http://www.newadvent.org/cathen/05654a.htm)

Theistic vs. atheistic theories of evolution

The theory of evolution just stated rests on a theistic foundation. In contradistinction to this is another theory resting on a materialistic and atheistic basis, the first principle of which is the denial of a personal Creator. This atheistic theory of evolution is ineffectual to account for the first beginning of the cosmos or for the law of its evolution, since it acknowledges neither creator nor lawgiver. Natural science, moreover, has proved that spontaneous generation—i.e. the independent genesis of a living being from non-living matter—contradicts the facts of observation. For this reason the theistic theory of evolution postulates an intervention on the part of the Creator in the production of the first organisms. When and how the first seeds of life were implanted in matter, we, indeed, do not know. The Christian theory of evolution also demands a creative act for the origin of the human soul, since the soul cannot have its origin in matter. The atheistic theory of evolution, on the contrary, rejects the assumption of a soul separate from matter, and thereby sinks into blank materialism.

From US Catholic.org (excerpts)

(http://www.uscatholic.org/articles/201508/do-catholics-believe-evolution-30288)

Imagine if we were able to see evolution as a sign of the unlimited potential of God's creation, rather than a threat to our limited point of view.

For the biblical literalist, the theory of evolution is problematic because it appears to contradict the stories found in the earliest chapters of Genesis. But is literalism the best approach to understanding scripture? The Catechism of the Catholic Church discourages literalism when it encourages believers to recognize the various literary genres found in the Bible.

Another issue is that science and religion are each a distinct tool for the discovery and explanation of truth. The realm of science is concerned with data that can be empirically demonstrated or proven. The realm of religion has to do with the meaning of life and existence in a way that surpasses the physical world. The religious believer and scientist both make the same mistake when they wrongly attempt to use their own tools to judge the other. Theology and science each have their own methodologies, their own instruments, for the discovery of their particular areas of truth.

For the most part, the church has resolved any tensions between religion and science. In 1950, in his encyclical *Humani Generis* (On the Human Person), Pope Pius XII expressed concern that the theory of evolution not be embraced uncritically. He called for more research, but did not condemn the theory. In 1996 Pope John Paul II addressed the issue before the Pontifical Academy of Sciences. He sanctioned the acceptance of evolution, but reminded his listeners that spiritual questions like the nature of the soul and its relationship to God are beyond the realm of science.

Two years later John Paul issued his encyclical *Fides et Ratio* (On Faith and Reason), reminding the church that while faith is superior to reason, "there can never be a true divergence between faith and reason, since the same God who reveals the mysteries and bestows the gift of faith has also placed in the human spirit the light of reason." This is reminiscent of St. Augustine of Hippo, who wrote that "truth, wherever it is to be found, belongs to our God."

This article appeared in the August 2015 issue of U.S. Catholic *(Vol. 80, No. 8, page 46).*

From Catholic.com (excerpts)

(https://www.catholic.com/tract/adam-eve-and-evolution)

People usually take three basic positions on the origins of the cosmos, life, and man:
(1) special or instantaneous creation, (2) developmental creation or theistic evolution, (3) and atheistic evolution. The first holds that a given thing did not develop, but was instantaneously and directly created by God. The second position holds that a given thing did develop from a previous state or form, but that this process was under God's guidance. The third position claims that a thing developed due to random forces alone.

Concerning biological evolution, the Church does not have an official position on whether various life forms developed over the course of time. However, it says that, if they did develop, then they did so under the impetus and guidance of God, and their ultimate creation must be ascribed to him.

Concerning human evolution, the Church has a more definite teaching. It allows for the possibility that man's *body* developed from previous biological forms, under God's guidance, but it insists on the *special creation* of his *soul*. Pope Pius XII declared that "the teaching authority of the Church does not forbid that, in conformity with the present state of human sciences and sacred theology, research and discussions . . . take place with regard to the doctrine of evolution, in as far as it inquires into the origin of the human body as coming from pre-existent and living matter—[but] the Catholic faith obliges us to hold that souls are immediately created by God" (Pius XII, *Humani Generis* 36). So whether the human body was specially created or developed, we are required to hold as a matter of Catholic faith that the human soul is specially created; it did not evolve, and it is not inherited from our parents, as our bodies are.

While the Church permits belief in either special creation or developmental creation on certain questions, it in no circumstances permits belief in atheistic evolution. …

…The *Catechism* explains that "Scripture presents the work of the Creator symbolically as a succession of six days of divine 'work,' concluded by the 'rest' of the seventh day" (CCC 337), but "nothing exists that does not owe its existence to God the Creator. The world began when God's word drew it out of nothingness; all existent beings, all of nature, and all human history is rooted in this primordial event, the very genesis by which the world was constituted and time begun" (CCC 338).

NIHIL OBSTAT: I have concluded that the materials
presented in this work are free of doctrinal or moral errors.
Bernadeane Carr, STL, Censor Librorum, August 10, 2004

IMPRIMATUR: In accord with 1983 CIC 827
permission to publish this work is hereby granted.
+*Robert H. Brom, Bishop of San Diego, August 10, 2004*

U.S. News and World Report

https://www.usnews.com/news/articles/2014/10/28/pope-francis-comments-on-evolution-and-the-catholic-church

Word that Pope Francis on Monday said that faith and creationism aren't at odds with one another may have shocked many Americans, but the comments don't actually reflect any deviation from long-standing church teaching.

"The Big-Bang, that is placed today at the origin of the world, does not contradict the divine intervention but exacts it," Francis said, speaking at a ceremony in the Vatican Gardens inaugurating a bronze bust in honor of his successor, Pope Benedict XVI. "The evolution in nature is not opposed to the notion of Creation, because evolution presupposes the creation of beings that evolve." Catholics often "risk imagining that God was a magician, with such a magic wand as to be able to do everything" when they think of the creation story, Francis said.

"God is not a demiurge or a magician, but the Creator who gives being to all entities," he said. Catholics have long accepted that the creation story as written in the book of Genesis in the Bible can stand along the scientific theory of evolution and that the two are not mutually exclusive. …

Modern Catholic teaching on evolution stems from the papal encyclical Humani generis of *Pope Pius XII* in 1950, a letter on Catholic doctrine dictating that evolution and Catholic faith are not necessarily at odds. "The teaching authority of the Church does not forbid that, in conformity with the present state of human sciences and sacred theology, research and discussions, on the part of men experienced in both fields, take place with regard to the doctrine of evolution, in as far as it inquires into the origin of the human body as coming from pre-existent and living matter – for the Catholic faith obliges us to hold that souls are immediately created by God," the document states. …

…The Supreme Court has banned the teaching of creationism in public schools and several states require students to "crucially analyze key aspects of evolutionary theory." The ability to teach intelligent design theory in public schools was also struck down by the courts.

Pope John Paul II – Message to the Pontifical Academy of Sciences: On Evolution (excerpts)
(October 22, 1996)
(https://www.ewtn.com/library/PAPALDOC/JP961022.HTM)

3. In his encyclical *Humani Generis* (1950), my predecessor *Pius XII* has already affirmed that there is *no conflict between evolution and the doctrine of the faith* regarding man and his vocation, provided that we do not lose sight of certain fixed points.

4. …Today, more than a half-century after the appearance of that encyclical, some new findings lead us toward the recognition of evolution as more than an hypothesis.* In fact it is remarkable that this theory has had progressively greater influence on the spirit of researchers, following a series of discoveries in different scholarly disciplines. The convergence in the results of these independent studies—which was neither planned nor sought—constitutes in itself a significant argument in favor of the theory.

…And to tell the truth, rather than speaking about the theory of evolution, *it is more accurate to speak of the theories of evolution. The use of the plural is required here—in part because of the diversity of explanations regarding the mechanism of evolution, and in part because of the diversity of philosophies involved.* There are materialist and reductionist theories, as well as spiritualist theories. Here the final judgment is within the competence of philosophy and, beyond that, of theology…

5. The magisterium of the Church takes a direct interest in the question of evolution, because it touches on the conception of man, whom Revelation tells us is created in the image and likeness of God. The conciliar constitution Gaudium et Spes has given us a magnificent exposition of this doctrine, which is one of the essential elements of Christian thought. The Council recalled that "man is the only creature on earth that God wanted for its own sake." In other words, the human person cannot be subordinated as a means to an end, or as an instrument of either the species or the society; he has a value of his own. He is a person. By this intelligence and his will, he is capable of entering into relationship, of communion, of solidarity, of the gift of himself to others like himself. St. Thomas observed that man's resemblance to God resides especially in his speculative intellect, because his relationship with the object of his knowledge is like God's relationship with his creation. (*Summa Theologica* I-II, q 3, a 5, ad 1) But even beyond that, man is called to enter into a loving relationship with God himself, a relationship which will find its full expression at the end of time, in eternity. Within the mystery of the risen Christ the full grandeur of this vocation is revealed to us. (*Gaudium et Spes,* 22) It is by virtue of his eternal soul that the whole person, including his body, possesses such great dignity. Pius XII underlined the essential point: *if the origin of the human body comes through living matter which existed previously, the spiritual soul is created directly by God* ("animas enim a Deo immediate creari catholica fides non retimere iubet"). (*Humani Generis*)

As a result, the theories of evolution which, because of the philosophies which inspire them, regard the spirit either as emerging from the forces of living matter, or as a simple epiphenomenon of that matter, are incompatible with the truth about man. They are therefore unable to serve as the basis for the dignity of the human person.

6. *With man, we find ourselves facing a different ontological order—an ontological leap,* we could say. But in posing such a great ontological discontinuity, are we not breaking up the physical continuity which seems to be the main line of research about evolution in the fields of physics and chemistry? An appreciation for *the different methods used in different fields of scholarship allows us to bring together two points of view which at first might seem irreconcilable.* The sciences of observation describe and measure, with ever greater precision, the many manifestations of life, and write them down along the

time-line. The moment of passage into the spiritual realm is not something that can be observed in this way—although we can nevertheless discern, through experimental research, a series of very valuable signs of what is specifically human life. But the experience of metaphysical knowledge, of self-consciousness and self-awareness, of moral conscience, of liberty, or of aesthetic and religious experience—these must be analyzed through philosophical reflection, while theology seeks to clarify the ultimate meaning of the Creator's designs.

Pope Benedict XVI (excerpts from article)

(http://www.integratedcatholiclife.org/2015/03/trasancos-pope-benedict-creation-evolution/)

In 1981, Pope Emeritus Benedict XVI, then Cardinal Ratzinger, developed a catechesis for adults on the creation narratives because, he noted, creation catechesis was nearly absent from teaching, preaching, and theology. His catechesis was in the form of four Lenten homilies given in the cathedral of Munich. Later in 1986, and at the request of many people, he published the homilies in a short book, *In the Beginning: A Catholic Understanding of the Story of Creation and the Fall*. (Full text here.)

In the third homily, he explored the creation of the human being, taken from the earth and made in the image of God. The homilies are theological, but a discussion of creation cannot be complete without a discussion of scientific progress in the twentieth century. Thus, the last section of this homily turns to evolution. Here he proposes *the "inner unity" of creation and evolution and of faith and reason.*

The truth of creation and the theory of evolution do not represent two different realities, he wrote, as is often portrayed by the perception that faith and science operate in mutually exclusive spheres. Pope Benedict instead called *creation and evolution "complementary realities"* in that they are different, but they go together. This seems to be key to understanding science in the light of faith. Science tells a literal story, but faith pulls science up into a richer, fuller, *real* story. …

…Similarly, the creation story, *the "story of the dust of the earth and the breath of God" explains what humans are in a fuller truth than evolution can provide, but neither does the creation story mean we must reject advances in evolutionary science if it is not readily obvious how they complement each other.* Creation is a story of our "inmost origin," wrote Pope Benedict. The theory of evolution can only search for biological explanations in physical terms.

On the other extreme of biblical literalism is the extreme of atheistic materialism. A materialist who lacks belief in God might say that life on earth and the existence of our species is the result of chemical and biological mechanics. A materialist might propose that chance and randomness are responsible for our origin. Such an outlook is even more dismal than only giving a child a list of facts and numbers about his birthday. It is like giving a boy a literal record of his birth *and* telling him there was no father who loved and willed him, no father in whom he could ever find faith, hope, and love. The boy might well conclude his existence was merely mechanical, the result of, as Pope Benedict put it, "blind chance that threw us into the ocean of nothingness …."

…Here it is important to note that *even for scientists "chance" and "randomness" do not refer to philosophical absolutes.* Those two concepts refer to the limits of human ability to measure a process or know a physical law. Scientists generally agree that there are laws and processes governing the properties and behavior of physical matter even in situations that are deemed "chance" or "random." The expectation of order and predictability are the basis of the scientific method. …

The view proposed by Pope Benedict is one of balance, an "inner unity" that considers faith and science, and hence creation and evolution, as "complementary realities." *We do not read Genesis as a science or history book because we do not believe a single chapter or a single narrative was intended to be sundered from the whole Bible nor do we believe that a literal account is all God intends to communicate in Genesis.* Likewise, we also "have the audacity to say that the great projects of the living creation are not the products of chance." *Joyfully, we say that our existence—that human beings—are a "divine project," willed and loved by a creating Intelligence. …*

…Catholics see all of the natural world as intelligently designed, everything from the deoxyribonucleic acid (DNA) that codes our genome to the cells that make up dandelions and the dirt beneath our bare feet, to the stars from which the elements may have sprung, to the remotest cosmic bodies we will never observe, to every water molecule that makes up every rain drop and ocean wave and every path each water molecule wanders and every spin, orbit, excitation, and relaxation of every electron in every atom that makes up all that water, to the materials with which we build our homes and computers, to the tears of a widow and the laughter of every child. It is all part of one universe created by God. We are from that universe. We are one race. *Evolution is no more and no less theistic than chemistry or physics or cooking or wood-splitting. …*

…In Christ, we can learn what it means to be human, that even in our smallest and most humiliating moments just as in the entire human history of sin, hatred, and suffering, we can see that the human is "loved by God to the very dust." The dust, the love—complementary realities.

Pope Francis on Evolution – see quotes in articles above. Also see excerpts from *Laudato Si'* in science standards/Catholic ID.

Washington Post article on teaching "intelligent design" (excerpt)

(https://www.washingtonpost.com/news/worldviews/wp/2014/10/28/pope-francis-backs-theory-of-evolution-says-god-is-no-wizard/?utm_term=.74603114d6f2)

A 2006 article in the Vatican's main newspaper also distanced the Catholic Church from the idea of "intelligent design," which it said should not be taught in schools as science. The Catholic News Service, which summarizes the article here, explains what distinguishes the Vatican's thinking from more secular understandings of evolution.

> What the church does insist upon is that the emergence of the human supposes a willful act of God, and that man cannot be seen as only the product of evolutionary processes, it said. The spiritual element of man is not something that could have developed from natural selection but required an "ontological leap."

Barbara Brown Taylor – *The Luminous Web, Essays on Science and Religion*

Barbara Brown Taylor, in *The Luminous Web* (2000), explains, that there lies a third alternative between Genesis and Darwin: "a creation dependent neither on a literal reading of the Bible nor on the random variations of genes, but on laws of complexity we are only beginning to understand" (p. 24). She continues, "Instead of a collection of genetic accidents, there are patterns more like blueprints that tend to organize cells the same basic way every time. These patterns explain why something as biologically complex as an eyeball can evolve in forty separate lineages" (p. 24). Water, for example, has its own dynamic of self-organization; "Stir the water and you get waves. Stir the gene pool and you get eyes, kidneys, spinal cords, and brains. Stir it again and the details may change, but the patterns will remain familiar…" (p. 24)

The Newman Society Standards that connect to the Catholic Church's view on evolution.

- Explain what it means to say that God created the world and all matter out of nothing at a certain point in time; how it manifests His wisdom, glory, and purpose; and how He holds everything in existence according to His plan. (CS S.K6 IS1)
- Describe the relationships, elements, underlying order, harmony, and meaning in God's creation. (CS S.K6 IS2)
- Explain how creation is an outward sign of God's love and goodness and, therefore, is "sacramental" in nature. (CS S.K6 IS3)
- Explain how science properly limits its focus to "how" things physically exist and is not designed to answer issues of meaning, the value of things, or the mysteries of the human person. (CS S.K6 IS8)
- Describe how the use of the scientific method to explore and understand nature differs, yet complements, the theological and philosophical questions one asks in order to understand God and His works. (CS S.K6 IS9)
- Analyze and articulate the Church's approach to the theory of evolution. (CS S.712 IS12)
- Relate how the human soul is specifically created by God for each human being, does not evolve from lesser matter, and is not inherited from our parents. (CS S.712 IS13)
- Explain how understanding the physiological properties of a human being does not address the existence of the transcendent spirit of the human person (see Appendix E). (CS S.712 IS14)
- Explain the supernatural design hypothesis in terms of the Borde-Vilenkin-Guth Proof, the Second Law of Thermodynamics, entropy, and anthropic coincidences (fine tuning of initial conditions and universal constants) (see Appendix E). (CS S.712 IS15)

ASSESSMENT

Assessment is a means of measuring performance. It illustrates how well we are accomplishing our stated mission, goals, and objectives to educate and form the whole person. Through an integrated system of standards and of multiple forms of evaluation, assessment measures:

- beliefs, attitudes and behaviors, which are expressions of our Catholic identity;
- content knowledge
- student achievement (individual and group) ; and the
- learning and teaching environment

(NCEA'S Statement on Accountability and Assessment in Catholic Education)

Assessments of students should match the learning outcome or goal. In all classrooms, a variety of assessments, both objective and subjective, should be used to enhance learning and measure progress. Assessments are both instructional tools for students while they are learning and accountability tools to determine if learning has occurred. Many forms of assessment should be used including summative, formative and informal assessments.

Summative assessments are designed initially by a teacher for each course and reflect where you want your students to be at end of unit. It is a measure OF learning designed to determine degree of mastery of each student…it judges the success of the process/product at the end.

Formative assessments are designed to prepare students for the summative assessment; these direct instruction and ensure students have the appropriate practice opportunities before the summative assessment. The formative assessments are stops along the way. Results are used to direct instruction and/or to plan corrective activities.

	FORMATIVE	**SUMMATIVE**
PURPOSE	To monitor and guide process product while still in progress	To judge the success of process/product at the end (however arbitrarily defined)
TIME OF ASSESSMENT	During the process or development of the product	At the end of the process or when the product is completed
TYPES OF ASSESSMENT	Informal observation, quizzes, homework, teacher questions, worksheets	Formal observation, tests, projects, term papers, exhibitions
USE OF ASSESSMENT INFORMATION	To improve or change a process/product while it is still going on or being developed	Judge the quality of a process/product; grade, rank, promote

Forms of Assessment

Performance Assessments (PA):

Student formal and informal presentations across the curriculum using rubrics, checklists, rating scales, anecdotal records:

- Recitations, reading, retellings, speeches, debates, discussions, video or audio performances
- Written work across the curriculum
- Cooperative group work (students are assessed individually, not as a group)
- Story, play, poem, paragraph(s), essay, research paper
- Spelling bees
- Poetry recitals
- Oratorical Competitions
- Classroom performance/demonstration (live or taped)
- Parent/Teacher/Student conferences
- Presentations (live or taped)
- Oral, dance, visual (photos or video)
- Seminars
- Projects
- Anecdotal records
- Application of standard English grammar skills in daily written and oral work across the curriculum (*including notebooks, journals, blogs, responses to questions*)
- Teacher observation of student activities across the curriculum
- Oral reading (literature, expository/informational in addition to the text)
- Informal and formal inventories and formative/summative assessments
- Daily work
- Student spelling in written work
- Notebook checks
- Running records
- Application and evaluation of skills across the curriculum
- Portfolios

Criterion Referenced Assessments (CRA):

(Paper/Pencil Tests/Quizzes)

- Multiple Choice
- Matching Items
- Completion Items
- Short Answer
- Essay Visual Representation
- Standardized Tests
- Teacher/text created tests (Written or oral)
- Fluency tests
- Teacher or text generated check-lists of skills

Independent Assessments (IA)

- Teacher observation
- Teacher-student conference
- Student self-correction and reflection on learning and performance
- Student self-assessment of goals
- On-line programs that allow students to self-assess
- Instructional questions
- Questionnaires
- Response Journals
- Learning Logs
- Oral tests/exams

From: *California Catholic School Superintendents Curriculum Committee*

RESOURCES

ACT Aspire Performance Level Descriptors
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-3.pdf,
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-4.pdf,
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-5.pdf,
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-6.pdf,
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-7.pdf,
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-8.pdf,
https://www.discoveractaspire.org/wp-content/uploads/2016/08/science-pld-ehs.pdf

ACT College and Career Ready Science Standards
http://www.act.org/content/dam/act/unsecured/documents/CCRS-ScienceStandards.pdf

Archdiocese of Kansas Science Curriculum
https://www.archkck.org/schools/2015/schools7-science

Archdiocese of Louisville, KY Science Curriculum Framework, 2016
https://www.archlou.org/wp-content/uploads/2015/07/Science-Framework.pdf

Archdiocese of Portland, Oregon Science curriculum
https://schools.archdpdx.org/curriculum

Cardinal Newman Society Catholic School Curriculum Science Standards
https://cardinalnewmansociety.org/catholic-curriculum-standards/scientific-topics-standards/

Catechism of the Catholic Church
http://www.vatican.va/archive/ccc_css/archive/catechism/p2s2.htm

Catholic Identity for Science Standards, DeMoor, Emily, Ph. D., Brescia University
emily.demoor@brescia.edu

Center for Theology and the Natural Science, The
http://www.ctns.org

Diocese of Knoxville, TN Science Standards
https://dioknox.org/schools/curriculum/

Diocese of Phoenix. AZ Science Standards
https://catholicschoolsphx.org/en/science-curriculum-standards/

Diocese of San Bernadino, CA Science Standards
https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxzYmRjYXRob2xpY3NjaG9vbHN8Z3g6MWZkZGUxM2M3ODUyMDExNw

Indiana Department of Education Science Standards
http://www.doe.in.gov/standards/science-computer-science

Interdisciplinary Encyclopedia of Religion and Science
http://inters.org/reflection-on-John-Paul-II-science-religion

Kentucky Department of Ed Core Standards for Science
http://education.ky.gov/curriculum/standards/kyacadstand/Documents/Kentucky_Academic_Standards_Science.pdf

Letter of His Holiness John Paul II To Reverend George V. Coyne, S.J.
https://w2.vatican.va/content/john-paul-ii/en/letters/1988/documents/hf_jp-ii_let_19880601_padre-coyne.html

National Academies Press, A Framework for K-12 Science Education
https://www.nap.edu/read/13165/chapter/1

National Science Teachers Association
http://www.nsta.org

National Standards and Benchmarks for Effective Catholic Elementary and Secondary Schools
http://www.catholicschoolstandards.org/the-standards/2014-07-13-13-36-30/download-the-standards

New Advent, Plants in the Bible
http://www.newadvent.org/cathen/12149a.htm

Next Generation Science Standards
http://www.nextgenscience.org/

Northwest Evaluation Association (NWEA) Measures of Academic Progress (MAP) Science Goal Structure, pp. 33-36
https://community.nwea.org/docs/DOC-2037

Old Dominion University, Bible Plats
http://ww2.odu.edu/~lmusselm/plant/bible/allbibleplantslist.php

United States Conference of Catholic Bishops
http://www.usccb.org/issues-and-action/human-life-and-dignity/environment/renewing-the-earth.cfm

http://www.usccb.org/beliefs-and-teachings/what-we-believe/catholic-social-teaching/seven-themes-of-catholic-social-teaching.cfm

Vatican Observatory
http://www.vaticanobservatory.va/content/specolavaticana/en/science--religion--society/faq-science-religion.html