Science
Course of Study
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Science Course of Study Introduction and Philosophy

Introduction

Following is the revised Science Course of Study for the Catholic Diocese of Columbus. This course of study reflects the Science Academic Content Standards set forth by the Ohio Department of Education.

Philosophy

We believe the purpose of science education in Catholic Schools is to facilitate learning so students will actively apply scientific knowledge and skills to contemporary, technological, moral, and social issues. This will be accomplished by recognizing God's design and promoting personal responsibility.

We believe the science curriculum will provide minds-on, as well as hands on, opportunities for students to practice scientific literacy, critical thinking and problem solving skills. It will also build a foundation for life-long discovery in sciences that will carry over into other disciplines.

We believe that students have a natural curiosity and appreciation of science. Teachers will encourage students by using the many scientific methods, providing a variety of learning experiences and assessment strategies, and utilizing various materials, technologies, and community resources as well as Catholic values.

Program Goals

Students, utilizing a broad-based curriculum, will acquire higher-level thinking skills and in-depth knowledge necessary to solve problems in creative and productive ways.

Students will be able to engage intelligently in public discourse and to debate matters of scientific and technological concern.

Students will use their scientific knowledge and Catholic values to lead well-balanced and ethical lives.

Students will use scientific literacy to enhance life and career opportunities.

Philosophy of Assessment

Based on educational research, the following is a set of grading practices organized into guidelines. These guidelines should provide a framework of effective grading practices. The goal is to support student learning and encourage student success.

It is important to be aware that the quality of any grading guidelines are directly dependant on the quality of diagnostic, formative, and summative assessments used in the classroom. They are not meant to be so specific when a teacher is not afforded flexibility in the classroom. Instead, these are suggestions and explanations of grading techniques that have been proven to increase the level of student achievement.

Relate grades to the achievement based on the standards.

Use the standards in the Diocesan Courses of Study as the basis of determining grades. Specific learning targets should be used to figure grades

Use agreed-on performance standards as reference points when determining grades.

Whether we use symbols, letters, or numbers the students' scores should reflect whether or not the students have mastered the material. If the student has mastered the material, the student has earned the grade.

Separate achievement from other non-academic items such as effort, behavior, and participation.

Grades should only indicate what a student knows, understands, and can do. Effort, behavior, participation should be reported separately from achievement. Individual achievement, not group achievement should be the basis for the grade.

Sample student performance. Don't score everything and don't include all scores in grades.

Everything does not need to be scored and include in a grade. Formative assessments are tools to guide future instruction. You can assess these with rubrics, checklists, scoring guides and a variety of other methods. Scores at the end of the grading period, after the learning has taken place, should be the determining factor when figuring grades.

Use care when using numbers or points to determine grades.

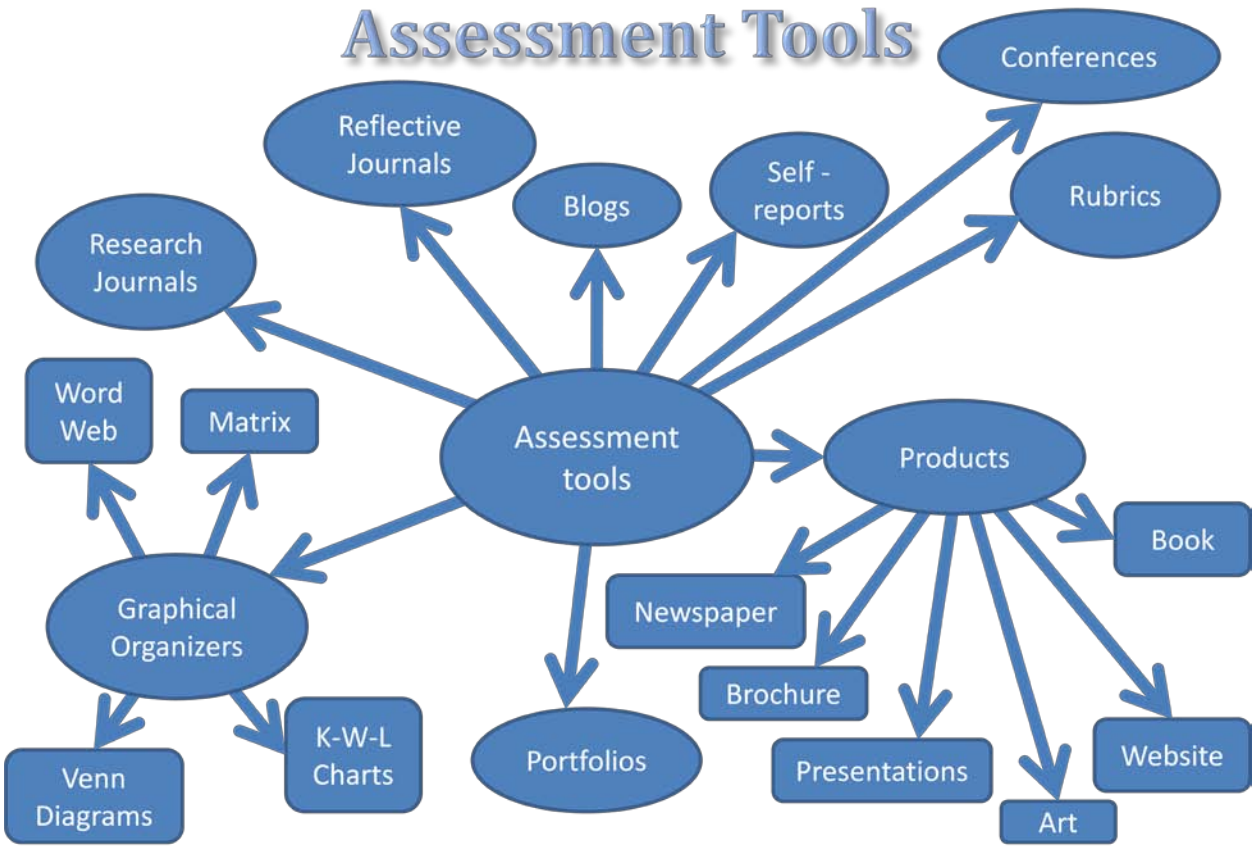
When determining grades, consider the "body of evidence" and use professional judgment. When averaging scores, consider using the median or mode. The mean is not always the best measure

Use quality assessments and properly record evidence of achievement.

Assessments should match what the student is expected to learn. There are many tools (e.g. portfolios, rubrics, interviews) other than the standard paper and pencil tests to assess a student's understanding of the material.

Discuss and involve students in the assessment and grading processes throughout the learning cycle.

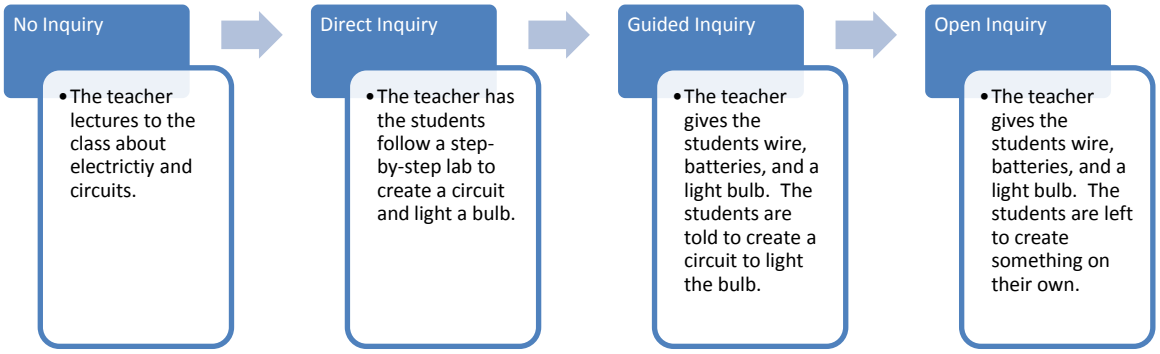
One method that has continued to increase student achievement is involving them in the assessment process. Students should be involved in all steps of this process. At the most basic level, students can simply understand how their grades will be determined. As assessment becomes more student-centered, the students can develop rubrics, maintain their own assessment records, self- assess, and communicate their achievement to others (student-led conferences).



Inquiry Based Science

One of the biggest differences between this Course of Study and previous Science Courses of Study is the focus on inquiry based learning. Inquiry based learning is based on the philosophy of constructivist learning. That is the idea that students must be able to create their own understanding of concepts.

There are several levels to inquiry based learning. These range from no inquiry to open inquiry. When there is no inquiry, teachers tell the students the facts and expected to repeat these facts to prove their knowledge. In open inquiry, students are given the materials to learn. The students are expected to create their own knowledge. This will lead them to a greater understanding and long-term retention of the material.



Think of a time when you learned something new or wanted to understand something in greater depth. It is rare that the learning process is a linear one. Often, you will be intrigued by something you see. Imagine trying to figure out why ice melts in the sun. In trying to understand this, you make judgments based on both previous knowledge and personal experiences. You begin to inquire about why does this happen. You explore and this become less of a mystery. Through this process, you know that the sun and melting ice fit together, but you are not exactly sure how that happens. Sometimes, it does not fit together nicely and old ideas must be broken down and reconstructed. (The ice still melted at night; why?) It is through these experiences that understandings are extended. An idea is tested and if it does not work, we go back and retest it. If we go back to the ice example, you realize that the ice will melt on a warm night just as it will during a warm day. You realize that it is not the sun by itself that melts the ice. Instead, it is the heat that causes ice to melt.

Though this entire process, you have gained much more knowledge than heat causes matter to change form. You have learned how to take your previous knowledge and apply it in a specific situation. You have made observations, tested your ideas, reflected on what did not work, and gathered additional information. Learning is not a linear process. Learning is a continuous and individual process. As a student, you facilitated your own learning. This is exactly what inquiry based learning is. It is taking old skills and knowledge and applying them in new situations. It is learning by doing.

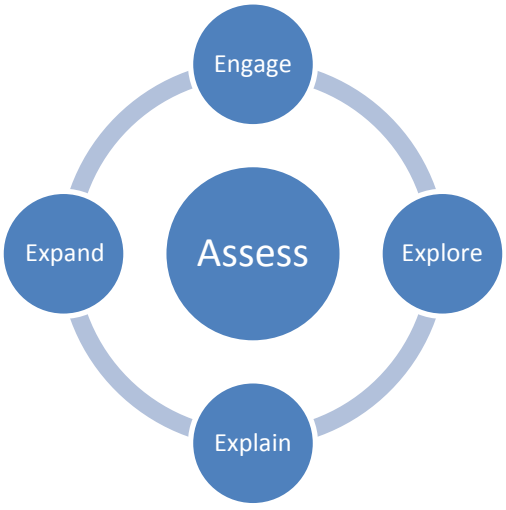
The teacher still has a very important role in all of this. While students are naturally curious about the world around them, it is still important for the teacher to lay the groundwork for the class. A question or a problem can get the students **engaged** in the instructional task. If we think about marketing, a company needs your attention before you will buy their product. It does not matter if it is the best product in the world. If you do not know it exists, you will not purchase it.

When students **explore**, they are directly involved with the material. This is where they develop the experiences to build their knowledge. The classroom teacher is necessary at this point to provide the materials and guided focus.

After the students have completed their explorations, it is time for them to **explain** what they have learned. During the explanation process, teachers have a vital role of correcting misconceptions or introducing formal vocabulary. A student who learned that a ball will continue rolling until friction and gravity act upon it will have something concrete to think of when Newton's First Law of Motion is mentioned.

The teacher is also essential in **elaboration** of the topic. The teacher can raise questions that were not brought up in the exploration stage. If the students were working with the laws of motion, they can be asked about which balls will go further on a given surface. It is not possible to explore every situation, but the knowledge the students gained during the exploration stage will help them in these areas.

Finally, there is the **assessment** piece. This should be an on-going piece throughout this entire process. This will allow the teacher to determine whether the student understands the material. Some tools to help you with this are rubrics, observations, checklists, interviews, and portfolios. Assessment must guide future lesson planning and may even be cause for modification in the future. For example, if you notice there is a misconception with many students, you can revisit the concept. If you notice great student interest in a specific area, the class can be refocused to take advantage of this high level of interest.



Definitions

Standards

Strands: *These are the science disciplines: Earth and space sciences, physical sciences; life science. Overlaying all the content standards and embedded in each discipline are science inquiry and applications.*

Themes: *These are the overarching ideas that connect the strands and the topics within the grades. Themes illustrate a progression of increasing complexity from grade to grade that is applicable to all the strands.*

Connections*: Overarching ideas that connect the strands and topics within a grade. Connections help illustrate the integration of the content statements from the different strands.*

Topics: *The Topics are the main focus for content for each strand at that particular grade level. The Topics are the foundation for the specific content statements.*

Content Statements: *The science content to be learned. These are the "what" of science that should be accessible to students at each grade level to prepare them to learn about and use scientific knowledge, principles, and processes with increasing complexity in subsequent grades.*

Model Curriculum

The Model Curriculum is a web-based resource that will incorporate information on "how" the material in the Content Statement may be taught. It is not included in this document, but it is highly suggested that all science teachers have an understanding of at least the Content Elaboration and the Expectations for learning. You can find the model curriculum at the Ohio Department of Education's website.

Content Elaboration: *This piece will provide more in-depth information and detail about the "what" that should be taught in the classroom and what is eligible for assessment*.

Expectations for Learning: *This section will provide recommendations for how students may be assessed. It will provide a range of examples of the various cognitive levels and depth of learning that students can be expected to demonstrate at grade level for a particular science content statement. The Expectations for Learning will provide guidance for developing assessments***.**

Connections to the *Catechism of the Catholic Church*

This is a teacher reference for topics, issues, and/or questions that may arise while teacher science class at any grade level.

Topic	Section
Science and Faith	**159**
The Natural Moral Law	**1954-1960**
Abortion	**2270-2275**
Suicide	**2280-2283**
Respect for the person and scientific research	**2292-2296**
Research aimed at reducing human sterility	**2375-2379**
Care for Creation and Ethical Use	**2415**
Scientific experiments using animals	**2417-2418**
Evolution	**279-289**

Kindergarten Science Standards

<table>
<tr><td colspan="3">Theme: Observations of the Environment

This theme focuses on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry.</td></tr>
<tr><td colspan="3">Science Inquiry and Application

During the years of K-4 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:
• Observe and ask questions about the natural environment;
• Plan and conduct simple investigations;
• Employ simple equipment and tools to gather data and extend the senses;
• Use appropriate mathematics with data to construct reasonable explanations;
• Communicate about observations, investigations and explanations; and
• Review and ask questions about the observations and explanations of others.
• Apply Catholic values to development and application of science concepts.</td></tr>
<tr><td colspan="3">Strands
Strand Connections: Observations of both living and nonliving things in local surroundings. This includes water, the sun, rocks and soil, human-made materials and living organisms. This encourages the examination and exploration of the environment.</td></tr>
<tr><td>Earth and Space Science</td><td>Physical Science</td><td>Life Science</td></tr>
<tr><td>Topic: Observations of Nature

This topic focuses on observing, exploring and describing the local natural environment.</td><td>Topic: Observations of Objects and Materials

This topic focuses on making sound and observing, exploring and describing properties of objects and materials that can be found in nature, classrooms and homes.</td><td>Topic: Observations of Living Things

This topic focuses on observing, exploring and describing external, physically observable characteristics and behaviors of plants and animals found in their local natural environment, in classrooms and homes.</td></tr>
</table>

Content Statements		
Weather changes are long term and short term. Weather changes occur throughout the day and from day to day. Air is a nonliving substance that surrounds Earth, wind is moving air. Wind, temperature and precipitation document short-term weather changes. Yearly weather changes (seasons) are observable patterns in the daily weather changes. **Note:** The focus is on observing the weather patterns of seasons. The reason for changing seasons is not appropriate for this grade level; this is found in grade 5.	**Objects and materials can be sorted and described by their properties.** Objects can be sorted and described by the properties of the materials from which they are made. Some of the properties can include color, size or texture.	**Living things are different from nonliving things.** Living things include anything that is alive or has ever been alive. Living things have specific traits. Living things grow and reproduce. Living things are found almost everywhere in the world. There are somewhat different kinds in different places.
The moon, sun and stars are visible at different times of the day or night. The moon, sun and stars are in different positions at different times of the day or night. Sometimes the moon is visible during the night, sometimes the moon is visible during the day and at other times the moon is not visible at all. The observable shape of the moon changes in size very slowly throughout each day of every month. The sun is visible only during the day. The sun's position in the sky changes in a single day and from season to season. Stars are visible at night, some are visible in the evening or morning, and some are brighter than others.	**Some objects and materials produce sound.** Sound is produced by touching, blowing or tapping objects. The sounds that are produced vary depending on the properties of objects. Sound is produced when objects vibrate.	**Living things have physical traits and behaviors, which influence their survival.** Living things are made up of a variety of structures. Some of these structures and behaviors influence their survival. **Note:** This concept is addressed in Pre-K, but is included here for schools that do not have a Pre-K program.

First Grade Science Standards

Theme: Observations of the Environment

This theme focuses on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry.

Science Inquiry and Application

During the years of K-4 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Observe and ask questions about the natural environment;*
- *Plan and conduct simple investigations;*
- *Employ simple equipment and tools to gather data and extend the senses;*
- *Use appropriate mathematics with data to construct reasonable explanations;*
- *Communicate about observations, investigations and explanations; and*
- *Review and ask questions about the observations and explanations of others.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Energy is observed through movement, heating, cooling and the needs of living organisms.*

Earth and Space Science	Physical Science	Life Science
Topic: Sun, Energy and Weather *This topic focuses on the sun as a source of energy and energy changes that occur to land, air and water.*	**Topic: Motion and Materials** *This topic focuses on the changes in properties that occur in objects and materials. Changes of position of an object are a result of pushing or pulling.*	**Topic: Basic Needs of Living Things** *This topic focuses on the physical needs of living things in Ohio. Energy from the sun or food, nutrients, water, shelter and air are some of the physical needs of living things.*

Content Statements		
The sun is the principal source of energy. Sunlight warms Earth's land, air and water. The amount of exposure to sunlight affects the amount of warming or cooling of air, water and land.	**Properties of objects and materials change.** Objects and materials change when exposed to various conditions, such as heating or freezing. Not all materials change in the same way. **Note 1:** Changes in temperature are a result of changes in energy. **Note 2:** Water changing from liquid to solid and from a solid to a liquid is found in ESS grade 1.	**Living things have basic needs, which are met by obtaining materials from the physical environment.** Living things require energy, water and a particular range of temperatures in their environments. Plants get energy from sunlight. Animals get energy from plants and other animals. Living things acquire resources from the living and nonliving components of the environment.
The physical properties of water change. Water can change from a liquid to a solid and from a solid to a liquid. Weather observations can be used to examine the property changes of water. **Note**: Water as a vapor is not introduced until grade 2; only solid and liquid water should be discussed at this level. A broader coverage of states of matter is found in grade 4. This concept builds on the PS grade K strand pertaining to properties (liquids and solids).	**Objects can be moved in a variety of ways, such as straight, zigzag, circular, and back and forth.** The position of an object can be described by locating it relative to another object or to the object's surroundings. An object is in motion when its position is changing. The motion of an object can be affected by pushing or pulling. A push or pull is a force that can make an object move faster, slower or go in a different direction. **Note**: Changes in position are a result of changes in energy.	**Living things survive only in environments that meet their needs.** Resources are necessary to meet the needs of an individual and populations of individuals. Living things interact with their physical environments as they meet those needs. Effects of seasonal changes within the local environment directly impact the availability of resources. **Note:** The Catholic Social Teaching of Care for God's Creation may be taught here at a grade appropriate level.

Second Grade Science Standards

Theme: Observations of the Environment

This theme focuses on helping students develop the skills for systematic discovery to understand the science of the physical world around them in greater depth by using scientific inquiry.

Science Inquiry and Application

During the years of K-4 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Observe and ask questions about the natural environment;*
- *Plan and conduct simple investigations;*
- *Employ simple equipment and tools to gather data and extend the senses;*
- *Use appropriate mathematics with data to construct reasonable explanations;*
- *Communicate about observations, investigations and explanations;*
- *Review and ask questions about the observations and explanations of others.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Living and nonliving things may move. A moving object has energy. Air moving is wind and wind can make a windmill turn. Changes in energy and movement can cause change to organisms and the environments in which they live.*

Earth and Space Science	Physical Science	Life Science
Topic: The Atmosphere *This topic focuses on air and water as they relate to weather and weather changes that can be observed and measured.*	**Topic: Changes in Motion** *This topic focuses on observing the relationship between forces and motion.*	**Topic: Interactions within Habitats** *This topic focuses on how ecosystems work by observations of simple interactions between the biotic/living and abiotic/nonliving parts of an ecosystem. Just as living things impact the environment in which they live, the environment also impacts living things.*

Content Statements		
The atmosphere is made up of air. Air has properties that can be observed and measured. The transfer of energy in the atmosphere causes air movement, which is felt as wind. Wind speed and direction can be measured. **Note**: Air is introduced in ESS kindergarten and can be linked to PS and LS. (Air has mass and takes up space. Air is a basic need for many living organisms.)	**Forces change the motion of an object.** Motion can increase, change direction or stop depending on the force applied. The change in motion of an object is related to the size of the force. Some forces act without touching, such as using a magnet to move an object or objects falling to the ground. Note: At this grade level, gravitational and magnetic forces should be introduced through observation and experimentation only. The definitions of these forces should not be the focus of the content statements.	**Living things cause changes on Earth.** Living things function and interact with their physical environments. Living things cause changes in the environments where they live; the changes can be very noticeable or slightly noticeable, fast or slow. **Note**: At this grade level, discussion is limited to changes that can be easily observed. The model curriculum will provide greater detail.
Water is present in the air. Water is present in the air as clouds, steam, fog, rain, ice, snow, sleet or hail. When water in the air cools (change of energy), it forms small droplets of water that can be seen as clouds. Water can change from liquid to vapor in the air and from vapor to liquid. The water droplets can form into raindrops. Water droplets can change to solid by freezing into snow, sleet or hail. Clouds are moved by flowing air. **Note:** This concept builds upon the changing properties of water from ESS grade 1.		**Some kinds of individuals that once lived on Earth have completely disappeared, although they were something like others that are alive today.** Living things that once lived on Earth no longer exist; their basic needs were no longer met.

Long- and short-term weather changes occur due to changes in energy. Changes in energy affect all aspects of weather, including temperature, precipitation amount and wind. **Note:** Discussion of energy at this grade level should be limited to observable changes		

Third Grade Science Standards

Theme: Interconnections within Systems

This theme focuses on helping students recognize the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

Science Inquiry and Application

During the years of PreK-4 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Observe and ask questions about the natural environment;*
- *Plan and conduct simple investigations;*
- *Employ simple equipment and tools to gather data and extend the senses;*
- *Use appropriate mathematics with data to construct reasonable explanations;*
- *Communicate about observations, investigations and explanations; and*
- *Review and ask questions about the observations and explanations of others.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Matter is what makes up all substances on Earth. Matter has specific properties and exists in different states. Earth's resources are made of matter, can be used by living things and can be used for the energy they contain. There are many different forms of energy. Each living component of an ecosystem is composed of matter and uses energy.*

Earth and Space Science	Physical Science	Life Science
Topic: Earth's Resources *This topic focuses on Earth's resources. While resources can be living and nonliving, within this strand, the emphasis is on Earth's nonliving resources, such as water, air, rock, soil and the energy resources they represent.*	**Topic: Matter and Forms of Energy** *This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the states of matter.*	**Topic: Behavior, Growth and Changes** *This topic explores life cycles of organisms and the relationship between the natural environment and an organism's (physical and behavioral) traits, which affect its ability to survive and reproduce.*

Content Statements		
Earth's nonliving resources have specific properties. Soil is composed of pieces of rock, organic material, water and air and has characteristics that can be measured and observed. Rocks have unique characteristics that allow them to be sorted and classified. Rocks form in different ways. Air and water are nonliving resources. **Note 1:** Rock classification is not the focus for this grade level; this is found in grade 6. At this grade, the actual characteristics of rocks can be used to sort or compare, rather than formal classification. **Note 2:** Properties of air and water have been addressed in PreK-2.	**All objects and substances in the natural world are composed of matter.** Matter takes up space and has weight. **Note:** Distinguishing between mass and weight is not appropriate for the elementary grades.	**Offspring resemble their parents and each other.** Individual organisms inherit many traits from their parents indicating a reliable way to transfer information from one generation to the next. Some behavioral traits are learned through interactions with the environment and are not inherited
Earth's resources can be used for energy. Many of Earth's resources can be used for the energy they contain. Renewable energy is an energy resource, such as wind, water or solar energy that is replenished within a short amount of time by natural processes. Nonrenewable energy is an energy resource, such as coal or oil that is a finite energy source that cannot be replenished in a short amount of time.	**Matter exists in different states, each of which has different properties.** The most common states of matter are solids, liquids and gases. Shape and compressibility are properties that can distinguish between the states of matter.	**Individuals of the same kind differ in their traits and sometimes the differences give individuals an advantage in surviving and reproducing.** Plants and animals have physical features that are associated with the environments where they live. Plants and animals have certain physical or behavioral characteristics that improve their chances of surviving in particular environments.

	The shape of a solid is independent of its container. Liquids and gases flow and take the shape of the container. One way to change matter from one state to another is by heating or cooling.	Individuals of the same kind have different characteristics that they have inherited. Sometimes these different characteristics give individuals an advantage in surviving and reproducing. **Note:** The focus is on the individual, not the population. Adaption is not the focus at this grade level.
Some of Earth's resources are limited. Some of Earth's resources become limited due to overuse and/or contamination. Reducing resource use, decreasing waste and/or pollution, recycling and reusing can help conserve these resources.	**Heat, electricity, light and sound are forms of energy.** There are many different forms of energy. Energy is the ability to cause motion or create change. **Note:** The different forms of energy that are outlined at this grade level should be limited to familiar forms of energy that a student is able to observe.	**Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.** Over the whole earth, organisms are growing, reproducing, dying and decaying. The details of the life cycle are different for different organisms affecting their ability to survive and reproduce in their natural environments. **Note 1:** The names of the stages within the life cycles are not the focus. **Note 2:** New organisms are produced by the old ones**.**
Catholic Social Teachings: Caring for God's Creation We show respect to our Creator by our stewardship of God's creation. We have a moral obligation to protect the planet on which we live.		

Fourth Grade Science Standards

Theme: Interconnections within Systems

This theme focuses on helping students recognize the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

Science Inquiry and Application

During the years of K-4 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Observe and ask questions about the natural environment;*
- *Plan and conduct simple investigations;*
- *Employ simple equipment and tools to gather data and extend the senses;*
- *Use appropriate mathematics with data to construct reasonable explanations;*
- *Communicate about observations, investigations and explanations; and*
- *Review and ask questions about the observations and explanations of others.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Heat and electricity are forms of energy that can be transferred from one location to another. Matter has properties that allow the transfer of heat and electricity. Heating and cooling affect the weathering of Earth's surface and Earth's past environments. The processes that shape Earth's surface and the fossil evidence found can help decode Earth's history.*

Earth and Space Science	Physical Science	Life Science
Topic: Earth's Surface *This topic focuses on the variety of processes that shape and reshape Earth's surface.*	**Topic: Electricity, Heat and Matter** *This topic focuses on the conservation of matter and physical properties of matter that allow the transfer of heat or electricity.*	**Topic: Earth's Living History** *This topic focuses on using fossil evidence and living organisms to observe that suitable habitats depend upon a combination of biotic and abiotic factors.*

Content Statements		
Earth's surface has specific characteristics and landforms that can be identified. About 70 percent of the Earth's surface is covered with water and most of that is the ocean. Only a small portion of the Earth's water is freshwater, which is found in rivers, lakes and groundwater. Earth's surface can change due to erosion and deposition of soil, rock or sediment. Catastrophic events such as flooding, volcanoes and earthquakes can create landforms.	**The total amount of matter is conserved when it undergoes a change.** When an object is broken into smaller pieces, when a solid is dissolved in a liquid or when matter changes state (solid, liquid, gas), the total amount of matter remains constant. **Note 1**: At this grade, the discussion of conservation of matter should be limited to a macroscopic, observable level. **Note 2**: States of matter are found in PS grade 3. Heating and cooling is one way to change the state of matter.	**Changes in an organism's environment are sometimes beneficial to its survival and sometimes harmful.** Ecosystems can change gradually or dramatically. When the environment changes, some plants and animals survive and reproduce and others die or move to new locations. An animal's patterns of behavior are related to the environment. This includes the kinds and numbers of other organisms present, the availability of food and resources, and the physical attributes of the environment.
The surface of Earth changes due to weathering. Rocks change shape, size and/or form due to water or ice movement, freeze and thaw, wind, plant growth, gases in the air, pollution and catastrophic events such as earthquakes, mass wasting, flooding and volcanic activity. **Note**: The ice movement (above) refers to large bodies of ice, such as glaciers that can break large rocks into small ones.	**Heat results when substances burn, when certain kinds of materials rub against each other, and when electricity flows through wires.** Metals are good conductors of heat and electricity. Electricity flowing through an electric circuit produces magnetic effects in the wire. Electrical energy in circuits can be changed to other forms of energy, including light, heat, sound and motion. Electric circuits require a complete loop through conducting materials in which an electric current can pass.	**Fossils can be compared to one another and to present day organisms according to their similarities and differences.** The concept of biodiversity is expanded to include different classification schemes based upon shared internal and external characteristics of organisms. Most species that have lived on Earth no longer exist. Fossils provide a point of comparison between the types of organisms that lived long ago and those existing today.

The surface of Earth changes due to erosion and deposition. Water, wind and ice physically remove and carry (erosion) rock, soil and sediment and deposit the material in a new location. Gravitational force affects movements of water, rock and soil.		

Fifth Grade Science Standards

Theme: Interconnections within Systems

This theme focuses on helping students recognize the components of various systems and then investigate dynamic and sustainable relationships within systems using scientific inquiry.

Science Inquiry and Application

During the years of grades 5-8 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions that can be answered through scientific investigations;*
- *Design and conduct a scientific investigation;*
- *Use appropriate mathematics, tools and techniques to gather data and information;*
- *Analyze and interpret data;*
- *Develop descriptions, models, explanations and predictions;*
- *Think critically and logically to connect evidence and explanations;*
- *Recognize and analyze alternative explanations and predictions; and*
- *Communicate scientific procedures and explanations.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Cycles on Earth, such as those occurring in ecosystems, in the solar system, and in the movement of light and sound result in describable patterns. Speed is a measurement of movement that is related to force and weight. The transfer of energy drives changes in systems, including ecosystems and physical systems.*

Earth and Space Science	Physical Science	Life Science
Topic: Cycles and Patterns in the Solar System *This topic focuses on the characteristics, cycles and patterns in the solar system and within the universe.*	**Topic: Light, Sound and Motion** *This topic focuses on the forces that affect motion. This includes the relationship between the speed of an object, the amount of force applied and the weight of the object. Light and sound are explored*	**Topic: Interactions within Ecosystems** *This topic focuses on foundational knowledge of the structures and functions of ecosystems.*

	as forms of energy that move in predictable ways, depending on the matter through which they move.	
Content Statements		
The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics. The distance from the sun, size, composition and movement of each planet are unique. Planets revolve around the sun in elliptical orbits. Some of the planets have moons and/or debris that orbit them. Comets, asteroids and meteoroids orbit the sun. **Note**: The shape of Earth's orbit is nearly circular (also true for other planets). Many graphics that illustrate the orbit overemphasize the elliptical shape, leading to the misconception regarding seasonal change being related to how "close" Earth is to the sun. The discussion of planet characteristics should be at an introductory level for this grade.	**The amount of change in movement of an object is based on the weight of the object and the amount of force exerted.** Movement can be measured by speed. The speed of an object is calculated by determining the distance (d) traveled in a period of time (t). Earth pulls down on all objects with gravitational force. Weight is a measure of the gravitational force between an object and the Earth. The weight of the object and amount of force applied affect the speed of the object. **Note 1:** Gravity and magnetism are introduced (through observation) in PS grade 2. **Note 2:** Mass is the amount of matter in an object or substance, but it is not appropriate in the elementary grades.	**Organisms perform a variety of roles in an ecosystem** Populations of organisms can be categorized by how they acquire energy. Food webs can be used to identify the relationships among producers, consumers and decomposers in an ecosystem.

The sun is one of many stars that exist in the universe. The sun appears to be the largest star in the sky because it is the closest star to Earth. Some stars are larger than the sun and some stars are smaller than the sun.	**Light and sound are forms of energy that behave in predicable ways.** Light travels and maintains its direction until it interacts with an object or when it moves from one medium to another, and then it can be reflected, refracted or absorbed. Sound is produced by vibrating objects and requires a medium through which to travel. The rate of vibration is related to the pitch of the sound. **Note:** At this grade level, the discussion of light and sound should be based on observable behavior. Waves are introduced at the middle school level.	**All of the processes that take place within organisms require energy.** **For ecosystems, the major source of energy is sunlight.** Energy entering ecosystems as sunlight is transferred and transformed by producers into energy that organisms use through the process of photosynthesis. That energy then passes from organism to organism as illustrated in food webs. In most ecosystems, energy derived from the sun is transferred and transformed into energy that organisms use by the process of photosynthesis in plants and other photosynthetic organisms.
Most of the cycles and patterns of motion between the Earth and sun are predictable. Earth's revolution around the sun takes approximately 365 days. Earth completes one rotation on its axis in a 24-hour period, producing day and night. This rotation makes the sun; stars and moon appear to change position in the sky. Earth's axis is tilted at an angle of 23.5°. This tilt, along with Earth's revolution around the sun, affects the amount of direct sunlight that the Earth receives in a single day and throughout the year. The average daily temperature is related to		

the amount of direct sunlight received. Changes in average temperature throughout the year are identified as seasons. **Note 1:** The amount of direct sunlight that Earth receives is related to the altitude of the sun, which affect the angle of the sun's rays, and the amount of time the sun is above the horizon each day. **Note 2**: Different regions around the world have seasonal changes that are not based solely on average temperature. Examples include rainy season, dry season, monsoon season, etc.		

Sixth Grade Science Standards

Theme: Order and Organization

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

Science Inquiry and Application

During the years of grades 5-8 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions that can be answered through scientific investigations;*
- *Design and conduct a scientific investigation;*
- *Use appropriate mathematics, tools and techniques to gather data and information;*
- *Analyze and interpret data;*
- *Develop descriptions, models, explanations and predictions;*
- *Think critically and logically to connect evidence and explanations;*
- *Recognize and analyze alternative explanations and predictions; and*
- *Communicate scientific procedures and explanations.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *All matter is made of small particles called atoms. The properties of matter are based on the order and organization of atoms and molecules. Cells, minerals, rocks and soil are all examples of matter.*

Earth and Space Science	Physical Science	Life Science
Topic: Rocks, Minerals and Soil *This topic focuses on the study of rocks, minerals and soil which make up the lithosphere. By classifying and identifying different types of rocks, minerals and soil, the past environment in which they formed can be decoded.*	**Topic: Matter and Motion** *This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy.*	**Topic: Cellular to Multicellular** *This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells.*

Content Statements		
Minerals have specific, quantifiable properties. Minerals are naturally occurring, inorganic solids that have a defined chemical composition. Minerals have properties that can be observed and measured. Minerals form in specific environments. **Note:** Specific information regarding the properties that can be used to identify minerals will be found in the model curriculum.	**All matter is made up of small particles called atoms.** Each atom takes up space, has mass and is in constant motion. Mass is the amount of matter in an object. Elements are a class of substances composed of a single kind of atom. Molecules are the combination of two or more atoms that are joined together chemically. Compounds are composed of two or more different elements. Each element and compound has properties, which are independent of the amount of the sample.	**Cells are the fundamental unit of life.** All living things are composed of cells. Different body tissues and organs are made of different kinds of cells. The ways cells function are similar in all living organisms. **Note 1**: Specific information about the organelles that need to be addressed at this grade level will be found in the model curriculum. **Note 2**: Emphasis should be placed on the function and coordination of these components, as well as on their roles in overall cell function.
Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification. Most rocks are composed of one or more minerals, but there are a few types of sedimentary rocks that contain organic material, such as coal. The composition of the rock, types of mineral present, mineral arrangement, and/or mineral shape and size can be used to identify the rock and to interpret its history of formation, breakdown (weathering) and transport (erosion).	**Changes of state are explained by a model of matter composed of atoms and/or molecules that are in motion.** Atoms and molecules are not changed in structure when a substance undergoes a change of state; the amount of motion of the atoms and molecules is changed. Thermal energy is a measure of the motion of the atoms and molecules in a substance. Mass is conserved when substances undergo changes of state.	**All cells come from pre-existing cells.** Cells repeatedly divide resulting in more cells and growth and repair in multicellular organisms. **Note 1**: This is not a detailed discussion of the phases of mitosis or meiosis. The focus should be on reproduction as a means of transmitting genetic information from one generation to the next, cellular growth and repair.

	Note: Thermal energy can be connected to kinetic energy at this grade level.	**Note 2:** Students may bring up topics such as stem cells, cloning, and/or genetic engineering. These topics should be addressed within the context of Catholic Social teachings.
Igneous, metamorphic and sedimentary rocks form in different ways. Magma or lava cools and crystallizes to form igneous rocks. Heat and pressure applied to existing rock forms metamorphic rocks. Sedimentary rock forms as existing rock weathers chemically and/or physically and the weathered material is compressed and then lithifies. Each rock type can provide information about the environment in which it was formed.	**There are two categories of energy: kinetic and potential.** Objects and substances in motion have kinetic energy. Objects and substances can store energy as a result of its position (potential energy). **Note:** Kinetic and potential energy should be introduced at the macroscopic level for this grade. Chemical and elastic potential energy should not be included at this grade; this is found in PS grade 8.	**Cells carry on specific functions that sustain life.** Many basic functions of organisms occur in cells. Cells take in nutrients and energy to perform work, like making various molecules required by that cell or an organism. Every cell is covered by a membrane that controls what can enter and leave the cell. Within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback and movement. **Note 1:** Emphasis should be placed on the function and coordination of cell components, as well as on their roles in overall cell function.
Soil is unconsolidated material that contains nutrient matter and weathered rock. Soil formation occurs at different rates and is based on environmental conditions, type of existing bedrock and rates of weathering. Soil forms in layers known as horizons. Soil horizons can be distinguished from one another based on properties that can be measured. **Note:** The introduction to soil is found in grade 3.	**An object's motion can be described by its speed and the direction in which it is moving.** An object's position and speed can be measured and graphed as a function of time. **Note 1:** This begins to quantify student observations using appropriate mathematical skills.	**Living systems at all levels of organization demonstrate the complementary nature of structure and function.** Level of organization within organisms includes cells, tissues, organs, organ systems and whole organisms. Whether the organism is single-celled or multicellular, all of its parts function as a whole to perform the tasks necessary for the survival of the organism.

	Note 2: Velocity and acceleration rates should not be included at this grade level; these terms are introduced in high school.	Organisms have diverse body plans, symmetry and internal structures that contribute to their being able to survive in their environments.
Rocks, minerals and soils have common and practical uses. Nearly all manufactured material requires some kind of geologic resource. Most geologic resources are considered nonrenewable. Rocks, minerals and soil are examples of geologic resources that are nonrenewable. **Note:** Nonrenewable energy sources should be included (such as fossil fuels).		

Seventh Grade Science Standards

Theme: Order and Organization

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

Science Inquiry and Application

During the years of grades 5-8 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions that can be answered through scientific investigations;*
- *Design and conduct a scientific investigation;*
- *Use appropriate mathematics, tools and techniques to gather data and information;*
- *Analyze and interpret data;*
- *Develop descriptions, models, explanations and predictions;*
- *Think critically and logically to connect evidence and explanations;*
- *Recognize and analyze alternative explanations and predictions; and*
- *Communicate scientific procedures and explanations.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Systems can exchange energy and/or matter when interactions occur within systems and between systems. Systems cycle matter and energy in observable and predictable patterns.*

Earth and Space Science	Science Physical Science	Life Science
Topic: Cycles and Patterns of Earth and the Moon *This topic focuses on Earth's hydrologic cycle, patterns that exist in atmospheric and oceanic currents, the relationship between thermal energy and the currents, and the relative position and movement of the Earth, sun and moon.*	**Topic: Conservation of Mass and Energy** *This topic focuses on the empirical evidence for the arrangements of atoms on the Periodic Table of Elements, conservation of mass and energy, transformation and transfer of energy.*	**Topic: Cycles of Matter and Flow of Energy** *This topic focuses on the impact of matter and energy transfer within the biotic component of ecosystems.*

Content Statements		
The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere and atmosphere. Thermal energy is transferred as water changes state throughout the cycle. The cycling of water in the atmosphere is an important part of weather patterns on Earth. The rate at which water flows through soil and rock is dependent upon the porosity and permeability of the soil or rock. **Note:** Contamination can occur within any step of the hydrologic cycle. Ground water is easily contaminated as pollution present in the soil or spilled on the ground surface moves into ground water and can impact numerous water sources.	**The properties of matter are determined by the arrangement of atoms.** Elements can be organized into families of elements with similar properties, such as highly reactive metals, less-reactive metals, highly reactive nonmetals and some almost-completely nonreactive gases. Substances are classified according to their properties, such as metals and acids. When substances are combined in a mixture, the new product may have different properties, but the amount of mass does not change. **Note 1:** This is the conceptual introduction of the Periodic Table of Elements. **Note 2:** Acids and bases are included in this topic; further detail will be provided in the Model Curriculum. **Note 3:** It is important to emphasize that most changes in the properties of matter have some combination of chemical and physical change (at different levels).	**Matter is transferred continuously between one organism to another and between organisms and their physical environments.** Plants use the energy in light to make sugars out of carbon dioxide and water (photosynthesis). These materials can be used immediately stored for later use. Organisms that eat plants break down plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms. Energy can transform from one form to another in living things. Animals get energy from oxidizing their food, releasing some of its energy as heat. The total amount of matter and energy remains constant, even though its form and location change. **Note 1**: Chemical reactions are presented as the rearrangement of atoms in molecules. **Note 2:** Chemical reactions in terms of subatomic structures of atoms are not appropriate.

Thermal energy transfers in the ocean and the atmosphere contribute to the formation of currents, which influence global climate patterns. The sun is the major source of energy for wind, air and ocean currents and the hydrologic cycle. As thermal energy transfers occur in the atmosphere and ocean, currents form. Large bodies of water can influence weather and climate. The jet stream is an example of an atmospheric current and the Gulf Stream is an example of an oceanic current. Ocean currents are influenced by factors other than thermal energy, such as water density, mineral content (such as salinity), ocean floor topography and Earth's rotation. All of these factors delineate global climate patterns on Earth. **Note:** This content statement is related to LS grade 7 (biomes). Regional temperature and precipitation contribute to the identification of climatic zones.	**Energy can be transformed from one form to another or can be transferred from one location to another, but is never lost.** When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. When energy is transformed from one form to another, the total amount of energy remains the same. **Note:** Further discussion of energy transformation is addressed at the high school level.	**In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors.** Biomes are regional ecosystems characterized by distinct types of organisms that have developed under specific soil and climatic conditions. The variety of physical (abiotic) conditions that exists on Earth gives rise to diverse environments (biomes) and allows for the existence of a wide variety of organisms (biodiversity). Ecosystems are dynamic in nature; the number and types of species fluctuate over time. Disruptions, deliberate or inadvertent, to the physical (abiotic) or biological (biotic) components of an ecosystem impact the composition of an ecosystem. **Note:** Predator-prey and producer-consumer relations are addressed in grade 5.
The atmosphere has different properties at different elevations and contains a mixture of gases that cycle through the lithosphere, biosphere, hydrosphere and atmosphere. The atmosphere is held to the Earth by the force of gravity. There are defined layers of the atmosphere that have specific properties, such	**Energy can be transferred through a variety of ways.** Thermal energy can be transferred through radiation, convection and conduction. Mechanical energy can be	

as temperature, chemical composition and physical characteristics. Gases in the atmosphere include nitrogen, oxygen, water vapor, carbon dioxide and other trace gases. Biogeochemical cycles illustrate the movement of specific elements or molecules (such as carbon or nitrogen) through the lithosphere, biosphere, hydrosphere and atmosphere. **Note:** The emphasis is on why the atmosphere has defined layers, not on naming the layers.	transferred when objects push or pull on each other over a distance. Electromagnetic waves transfer energy when they interact with matter. Electrical energy transfers when an electrical source is connected in a complete electrical circuit to an electrical device. **Note 1:** Energy transfers should be experiential and observable. This builds upon PS grade 4 and is directly connected to ESS grade 7 (thermal energy transfers in the hydrologic cycle). **Note 2:** Electricity can be measured through current, voltage and resistance. In addition, renewable energy systems should be included (such as wind, geothermal, water or solar). **Note 3:** The types of waves used within this topic include seismic, oceanic, sound and light. Seismic waves also are found in ESS grade 8.	
The relative patterns of motion and positions of the Earth, moon and sun cause solar and lunar eclipses, tides and phases of the moon. The moon's orbit and its change of position relative to the Earth and sun result in different parts of the moon being visible from Earth (phases of the moon). A solar eclipse is when Earth moves into the shadow of the moon (during a new moon). A lunar eclipse is when the moon moves into the shadow of Earth (during a full moon). Gravitational force between the Earth and the moon causes daily oceanic tides. When the gravitational forces from the sun and moon align (at new and full moons) spring tides occur. When the		

gravitational forces of the sun and moon are perpendicular (at first and last quarter moons), neap tides occur.		

Eighth Grade Science Standards

Theme: Order and Organization

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be described by simple principles. These principles are related to the properties or interactions within and between systems.

Science Inquiry and Application

During the years of grades 5-8 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions that can be answered through scientific investigations;*
- *Design and conduct a scientific investigation;*
- *Use appropriate mathematics, tools and techniques to gather data and information;*
- *Analyze and interpret data;*
- *Develop descriptions, models, explanations and predictions;*
- *Think critically and logically to connect evidence and explanations;*
- *Recognize and analyze alternative explanations and predictions; and*
- *Communicate scientific procedures and explanations.*
- *Apply Catholic values to development and application of science concepts.*

Strands

Strand Connections: *Systems can be described and understood by analysis of the interaction of their components. Energy, forces and motion combine to change the physical features of the Earth. The changes of the physical Earth and the species that have lived on Earth are found in the rock record. For species to continue, reproduction must be successful.*

Earth and Space Science	Physical Science	Life Science
Topic: Physical Earth *This topic focuses on the physical features of Earth and how they formed. This includes the interior of Earth, the rock record, plate tectonics and landforms.*	**Topic: Forces and Motion** *This topic focuses on forces and motion within, on and around the Earth and within the universe.*	**Topic: Species and Reproduction** *This topic focuses on continuation of the species.*

Content Statements		
The composition and properties of Earth's interior are identified by the behavior of seismic waves.	**Some forces between objects act when the objects are in direct contact or when they are not touching.**	**Diversity of species occurs through gradual processes over many generations. Fossil records provide evidence that changes have occurred in number and types of species.**
The refraction and reflection of seismic waves as they move through one type of material to another is used to differentiate the layers of Earth's interior. Earth has an inner and outer core, an upper and lower mantle, and a crust. The formation of the planet generated heat from gravitational energy and the decay of radioactive elements, which is still present today. Heat released from Earth's core drives convection currents throughout the mantle and the crust. **Note:** The thicknesses of each layer of Earth can vary and be transitional, rather than uniform and distinct as often depicted in textbooks.	Magnetic, electrical and gravitational forces can act at a distance. **Note:** Direct contact forces were addressed in the elementary grades.	Fossils provide important evidence of how life and environmental conditions have changed. Changes in environmental conditions can affect how beneficial a trait will be for the survival and reproductive success of an organism or an entire species. Throughout Earth's history, extinction of a species has occurred when the environment changes and the individual organisms of that species do not have the traits necessary to survive and reproduce in the changed environment. Most species (approximately 99 percent) that have lived on Earth are now extinct. **Note:** Population genetics and the ability to use statistical mathematics to predict changes in a gene pool are reserved for grade 10.

Earth's crust consists of major and minor tectonic plates that move relative to each other. Historical data and observations such as fossil distribution, paleomagnetism, continental drift and sea-floor spreading contributed to the theory of plate tectonics. The rigid tectonic plates move with the molten rock and magma beneath them in the upper mantle. Convection currents in the crust and upper mantle cause the movement of the plates. The energy that forms convection currents comes from deep within the Earth. There are three main types of plate boundaries: divergent, convergent and transform. Each type of boundary results in specific motion and causes events (such as earthquakes or volcanic activity) or features (such as mountains or trenches) that are indicative of that type of boundary.	**Forces have magnitude and direction.** The motion of an object is always measured with respect to a reference point. Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The net force acting on an object can change the object's direction and/or speed. When the net force is greater than zero, the object's speed and/or direction will change. When the net force is zero, the object remains at rest or continues to move at a constant speed in a straight line.	**Reproduction is necessary for the continuation of every species.** Every organism alive today comes from a long line of ancestors who reproduced successfully every generation. Reproduction is the transfer of genetic information from one generation to the next. It can occur with mixing of genes from two individuals (sexual reproduction). It can occur with the transfer of genes from one individual to the next generation (asexual reproduction). The ability to reproduce defines living things.
A combination of constructive and destructive geologic processes formed Earth's surface. Earth's surface is formed from a variety of different geologic processes, including but not limited to plate tectonics. **Note:** The introduction of Earth's surface is found in ESS grade 4.	**There are different types of potential energy.** Gravitational potential energy changes in a system as the masses or relative position(s) of objects are changed. Objects can have elastic potential energy due to their compression, or chemical potential energy due to the nature and arrangement of the atoms that make up the object.	**The characteristics of an organism are a result of inherited traits received from parent(s).** Expression of all traits is determined by genes and environmental factors to varying degrees. Many genes influence more than one trait, and many traits are influenced by more than one gene. During reproduction, genetic information (DNA) is transmitted between parent and

		offspring. In asexual reproduction, the lone parent contributes DNA to the offspring. In sexual reproduction, both parents contribute DNA to the offspring. **Note 1:** The focus should be the link between DNA and traits without being explicit about the mechanisms involved. **Note 2:** Students are not expected to know any of the ways in which bacteria reproduce. **Note 3:** The molecular structure of DNA is not appropriate at this grade level.
Evidence of the dynamic changes of Earth's surface through time is found in the geologic record. Earth is approximately 4.6 billion years old. Earth history is based on observations of the geologic record and the understanding that processes observed at present day are similar to those that occurred in the past (uniformitarianism). There are different methods to determine relative and absolute age of some rock layers in the geologic record. Within a sequence of undisturbed sedimentary rocks, the oldest rocks are at the bottom (superposition). The geologic record can help identify past environmental and climate conditions. **Note:** Environmental and climate conditions also can be documented through the cryosphere as seen through ice cores.		

High School Science Course Syllabi

The high school standards are organized by courses and course syllabi. The courses that were chosen meet the criteria of the Ohio Core (ORC § 3313.603 C:) for science:

> *Beginning with students who enter ninth grade for the first time on or after July 1, 2010, except as provided in divisions (D) to (F) of this section, the requirements for graduation from every public and chartered nonpublic high school shall include twenty units that are designed to prepare students for the workforce and college. The units shall be distributed as follows:*
>
> *Science, three units with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information, which shall include the following, or their equivalent:*
>
> *(a) Physical sciences, one unit;*
> *(b) Life sciences, one unit;*
> *(c) Advanced study in one or more of the following sciences, one unit:*
> *(i) Chemistry, physics, or other physical science;*
> *(ii) Advanced biology or other life science;*
> *(iii) Astronomy, physical geology, or other earth or space science.*

These are not the only courses that can be taught at the high school level, they are a sampling of courses that can be offered. The courses that would typically be introductory (grades 9 or 10) include Biology and Physical Science (a combination of Chemistry and Physics, including some Astronomy). The courses that would be considered advanced (grades 11 or 12) include: Environmental Science, Physical Geology, Chemistry, and Physics. The syllabi for the advanced science courses do not contain the same level of detail as the introductory courses. The high school courses will also have a Model Curriculum section which is where technological design, scientific inquiry and applications, and 21st century skills will be housed. All high school courses are required to be taught with inquiry and provide laboratory experiences for the students of Ohio.

Biology – Unit Overview and Outline

Biology is a high school level course which satisfies Ohio Core science graduation requirements as required by section 3313.603 of the Ohio Revised Code that requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

This course investigates the composition, diversity, complexity and interconnectedness of life on Earth. Fundamental concepts of heredity and evolution provide a framework through inquiry-based instruction to explore the living world, the physical environment and the interactions within and between them.

Students engage in investigations to understand and explain the behavior of living things in a variety of scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

The following information may be taught in any order. The sequence provided here does not represent a recommended sequence; there is no recommended sequence.

Heredity

- Cellular Genetics
- Structure and function of DNA in cells
- Genetic mechanisms and inheritance
- Mutations

Evolution

- Natural Selection and other mechanisms of biological evolution
    - Undirected variation and environmental change
    - Genetic drift, immigration, emigration and mutation
    - History of life on Earth
- Evolution and Diversity of Life
    - Speciation and biological classification based on molecular evidence
    - Variation of organisms within a species due to population genetics and gene frequency

Diversity and Interdependence of Life

- Classification systems are frameworks created by scientists for describing the vast diversity of organisms, indicating the degree of relatedness between organisms.
- Ecosystems
    - Homeostasis
        - Carrying capacity
        - Equilibrium and disequilibrium

Cells

- Cell Structure and Function
    - Structure, function and interrelatedness of cell organelles
    - Eukaryotic cells and prokaryotic cells

- Cellular Processes
    - Characteristics of life regulated by cellular processes
    - Photosynthesis, chemosynthesis, cellular respiration
    - Cell division and differentiation

Biology – Detailed Course Outline

Science Inquiry and Application

During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions and concepts that guide scientific investigations;*
- *Design and conduct scientific investigations;*
- *Use technology and mathematics to improve investigations and communications;*
- *Formulate and revise explanations and models using logic and evidence (critical thinking);*
- *Recognize and analyze explanations and models; and*
- *Communicate and defend a scientific argument.*
- *Apply Catholic values to development and application of science concepts.*

Course Content

The following information may be taught in any order. The sequence provided here does not represent a-recommended sequence as there is no recommended sequence.

Heredity

Elaboration for Instruction

Building on knowledge from elementary school (plants and animals have life cycles and offspring resemble their parents) and knowledge from middle school (reproduction, inherited traits and diversity of species), this topic focuses on the explanation of genetic mechanisms and the molecular basis of inheritance. Important concepts include:

- The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different parts of the instructions are used in different types of cells, influenced by the cell's environment and past history.
- The information passed from parents to offspring is coded in DNA molecules.
- The genetic information in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms.
- Genes are segments of DNA molecules. Inserting, deleting or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm or have little or no as-of-yet observable effect on the offspring's success in its environment.
- Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious.
- The sorting and recombination of genes in sexual reproduction, and meiosis specifically, result in a great variety of possible gene combinations from the offspring of any two parents.
- Gene mutations can be caused by such things as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring. If they occur in other cells, they can be passed on to descendant cells only. The experiences an organism has during its lifetime can affect its offspring only if the genes in its own sex cells are changed by the experience.

Evolution
Elaboration for Instruction

Building on knowledge from elementary school (living things can only survive when their basic needs are met and comparing fossils to current life forms) and from middle school (diversity of species through gradual process), this topic focuses on evolutionary mechanisms and the unity and diversity of life. Evolution is not an explanation for the origin of life, but the accepted science-based explanation for the origin of the diversity of life. Emphasis shifts from thinking in terms of selection of individuals with a particular trait to changing proportions of a trait in populations. This evolutionary theme can use the Modern Synthesis Theory, historical perspectives as represented by study of the theory's development from the time of Darwin and his contemporaries, deoxyribonucleic acid (DNA), phenotypic and genetic variability in populations brought about by random mutations, independent assortment and genetic recombination that occur as gametes are produced, speciation, natural selection and genetic drift. Important concepts include:

- The basic idea of biological evolution is that the Earth's present-day species developed from earlier, distinctly different species. Modern ideas about evolution provide a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing species. Evolution builds on what already exists, so the more variety there is, the more there can be in the future. Evolution does not necessitate long-term progress in a set direction.
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations.
- From about 4 billion years ago to about 2 billion years ago, only simple, single-celled microorganisms are found in the rock record. Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.
- Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descent branched off from one another.
- New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells. Changes in other cells of an organism cannot be passed on to the next generation. New heritable characteristics do not necessarily result in reproductive or survival advantage or disadvantage.
- There are a variety of mechanisms for evolution including but not limited to mutation, gene flow, recombination, genetic drift and natural selection. Some variation in heritable characteristics exists within every species. Some of these characteristics give individuals an advantage over others in surviving and reproducing in particular environments. Advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase. The continuing operation of natural selection on new characteristics and in changing environments, over and over again for millions of years, has produced a succession of diverse new species.
- Species evolve over time. Evolution is the consequence of the interactions of: (1) the potential for a species to increase its numbers; (2) the genetic variability of offspring due to mutation and recombination of genes; (3) a finite supply of the resources required for life; and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

- The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities, patterns of development, similarity of their chemical processes and the evidence of common ancestry.
- Heritable characteristics can be observed at molecular and whole-organism levels – in structure, chemistry and/or behavior.
- Heritable characteristics influence how likely an organism is to survive and reproduce.
- When an environment and organisms that inhabit it change, the survival value of inherited characteristics may change.

Diversity and Interdependence of Life
Elaboration for Instruction

Building on knowledge from elementary school (interactions of organisms within their environment) and from middle school (cycles of matter and the flow of energy), this topic focuses on the study of diversity and similarity at the molecular level, why diversity within and among species is important, and coherence to the complex array of relationships among organisms and environments studied in prior grades.

The concept of an ecosystem should bring coherence to the complex array of relationships among organisms and environments that students have encountered. Students' growing understanding of systems in general can suggest and reinforce characteristics of ecosystems – interdependence of parts, feedback, oscillation, inputs and outputs. Variables such as population size, number and kinds of species, and productivity can be considered along with stability and change in ecosystems.

Organisms must process energy (flow of energy) and matter (cycles of matter) to survive and reproduce. The cycling of matter and flow of energy can be found at many levels of biological organization, from molecules to ecosystems. The study of food webs starts in the elementary grades with the transfer of matter, continues in the middle grades with the flow of energy through organisms, and then can be integrated in high school as students' understanding of energy storage in molecular configurations develops. Important concepts include:

- The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classifications based on anatomical similarities.
- The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled niches with life forms.
- Disturbances in an ecosystem, such as flood, fire or the addition or loss of species, may cause the affected ecosystem to return to a system similar to its original one, or it may take a new direction, leading to a very different type of ecosystem. Climate changes can produce very large changes in an ecosystem.
- Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, its size is limited by one or more environmental factors: availability of food; availability of nesting sites; or number of predators.

- Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution.
- The amount of life any environment can support is limited by available energy, water, oxygen and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials.
- A classification system is a framework created by scientists for describing the vast diversity of organisms, indicating the degree of relatedness between organisms, and framing research questions.

Note: As food webs, food chains and interactions between organisms within ecosystems are covered in upper elementary school and middle school, they are not appropriate at this grade level.

Cells
Elaboration for Instruction

Building on knowledge from middle school (cell theory), this topic focuses on the cell as a system itself (single-celled organism) and as part of larger systems, sometimes as part of a multicellular organism, always as part of an ecosystem. The cell is a system that conducts a variety of functions associated with life. Materials enter and leave the cell as these functions occur through a cell membrane, which serves as a boundary between the cell and its environment. Important concepts include:

- Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape and, for animal cells, movement.
- A living cell is composed of a small number of chemical elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules.
- Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact. Both single cells and multicellular organisms have molecules that help keep the cell's acidity within a narrow range.
- Within the cell are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, information feedback and movement. In addition to these basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not.
- The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes.
- The genetic information in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms.

- Cell functions are regulated. Regulation occurs through changes in the activity of the functions performed by proteins and through the selective expression of individual genes. This regulation allows cells to respond to their environments and to control and coordinate the synthesis and breakdown of specific molecules, cell growth and cell division.
- Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior also can be affected by molecules from other parts of the organism or other organisms.

Note 1: The idea that protein molecules assembled by cells conduct the work that goes on inside and outside the cells in an organism can be learned without going into the biochemical details. It is sufficient for students to know that the molecules involved are different configurations of a few amino acids and that the different shapes of the molecules influence what they do.

Note 2: Discussion of what occurs in the cell is much more important than memorizing parts of the cell.

Physical Science – Unit Overview and Outline

Physical Science is a high school introductory-level course which satisfies Ohio Core requirements, as required by section 3313.603 of the Ohio Revised Code that requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

This course introduces students to key concepts and theories that provide a foundation for further study in other sciences and advanced science disciplines. Physical Science comprises the systematic study of the physical world, as related to chemistry, physics and space science.

Course Content

The following information may be taught in any order. The sequence provided here does not represent a recommended sequence; there is no recommended sequence.

Study of Matter

- Properties of Matter
    - Classification of Matter
        - Heterogeneous vs. homogeneous
        - Pure substances vs. mixtures
        - Compounds and elements
    - Atoms and molecules
        - Ions
        - Isotopes
- Periodic Trends of the Elements
    - Atomic structure
    - Reactivity
- Reactions of Matter
    - Bonding
    - Chemical reactions
    - Nuclear reactions

Forces, Motion and Energy

- Dynamics (cause of motion)
    - Newton's Laws
        - Constant velocity
        - Objects accelerating
        - Opposing, but equal forces – related to momentum
- Waves
    - Energy transfer and conservation
    - Behavior
        - Refraction, Reflection, Diffraction
        - Doppler shift

The Universe

- Stars
  - Formation; stages of evolution
  - Fusion in stars
- Origin of the Universe
  - Composition of Galaxies
  - Redshift
  - Theoretical Support

Physical Science – Detailed Course Outline

Science Inquiry and Application

During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions and concepts that guide scientific investigations;*
- *Design and conduct scientific investigations;*
- *Use technology and mathematics to improve investigations and communications;*
- *Formulate and revise explanations and models using logic and evidence (critical thinking);*
- *Recognize and analyze explanations and models; and*
- *Communicate and defend a scientific argument.*
- *Apply Catholic values to development and application of science concepts.*

Course Content

The following information may be taught in any order. The sequence provided here does not represent a recommended sequence; there is no recommended sequence.

Study of Matter

Elaboration for Instruction

Building upon observation, exploration and analytical skills developed at the elementary level and middle school levels and foundational knowledge about matter (its basic particle composition and behavior under various conditions), an extensive understanding of matter, its composition and the changes it undergoes are further constructed. Substances within a closed system interact with one another in a variety of ways; however, the total mass and energy of the system remains the same. Instructional concepts include:

- Matter can be classified in different ways depending upon characteristics that are observable and characteristics that can be observed with magnification.
- Particulate nature of matter is represented by models because it is too small to see with the naked eye or with traditional visible-light microscopes.
- Atomic structure determines the properties of an element and how the atom (of the element) will interact with other atoms. Neutrons have little effect on how an atom interacts with other atoms, but they do affect the mass and stability of the nucleus.
- When elements are listed in order of increasing number of protons, the same sequence of properties appears over and over again. At times the masses do not correspond with periodic order, but the atomic number always does.
- Bonding describes how atoms are arranged in molecules and rearrange in chemical reactions. Atoms may be bonded together by losing, gaining or sharing electrons.
- Matter is conserved in all chemical/nonchemical analysis of mixtures. In a chemical reaction, the number, type of atoms and total mass are the same before and after the reaction.
- Radioactive substances are unstable nuclei that undergo spontaneous nuclear decay emitting particles and/or high-energy wave-like radiation.
- Nuclear fission involves the decay of large nuclei into smaller nuclei. Nuclear fusion is the joining of nuclei into a larger nucleus accompanied by the release of large quantities of energy. Nuclear fusion in the stars creates all the elements in the universe beyond helium.

Forces, Motion and Energy
Elaboration for Instruction

Building upon the knowledge that energy is transformed and transferred all the while being conserved, an understanding of the relative strength of the forces within an atom, the nature of motion and forces and how motion is affected by forces, and wave behavior, including the Doppler effect and its applications to understanding the movement of galaxies in the universe is developed. Mathematics, including graphing, should be used when describing these phenomena, moving from qualitative understanding to one that is more quantitative. Instructional concepts include:

- Motion of an object is a measurable quantity that depends on the observer's frame of reference and is described in terms of position, speed, velocity, acceleration and time.
- An object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced net force acts on it. The rate at which motion changes (speed or direction) is proportional to applied force and inversely proportional to the mass. A force is an interaction between two objects; both objects in the interaction experience an equal amount of force, but in opposite directions.
- Waves can be refracted, reflected, absorbed and superposed on one another. As waves enter a different medium, they can be reflected back into the original medium, absorbed by the new medium as energy. The waves may also be transmitted into the new medium which may result in bending the waves.
- The wavelength of a wave depends upon the relative motion of the source and the observer. If either is moving toward the other, the wavelength is shorter; if either is moving away, the wavelength is longer.

The Universe
Elaboration for Instruction

Building a unified understanding of the universe from elementary and middle school science, insights from history, and mathematical ways of thinking, provides a basis for knowing the nature of the universe. Concepts from the previous section, Forces, Motion and Energy, are also used as foundational knowledge. The role of gravity in forming and maintaining the organization of the universe becomes clearer at this level, as well as the scale of billions and speed of light used to express relative distances. Instructional content includes:

- The stars differ from each other in size, temperature and age.
- Stars transform matter into energy in nuclear reactions. These and other processes in stars have led to the formation of all elements. The process of star formation and destruction continues.
- Early in the history of the universe, gravitational attraction caused matter to clump together to form countless trillions of stars and billions of galaxies.
- The red shift provides evidence that the universe is and has been expanding. Data from measurements of this expansion have been used in calculations that estimate the age of the universe to be over ten billion years old.

Environmental Science – Unit Overview and Outline

Environmental Science is a high school level course which satisfies Ohio Core science graduation requirements as required by section 3313.603 of the Ohio Revised Code that requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Environmental Science incorporates biology, chemistry, physics and physical geology and introduces students to key concepts, principles and theories within environmental science.

Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Science Inquiry and Application

During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions and concepts that guide scientific investigations;*
- *Design and conduct scientific investigations;*
- *Use technology and mathematics to improve investigations and communications;*
- *Formulate and revise explanations and models using logic and evidence (critical thinking);*
- *Recognize and analyze explanations and models; and*
- *Communicate and defend a scientific argument.*
- *Apply Catholic values to development and application of science concepts.*

Course Content

The following information may be taught in any order. The sequence provided here does not represent a-recommended sequence as there is no recommended sequence.

Historical Environmental Issues and Information

This topic explores the background and history of environmental actions and laws. This includes investigations on a local, national and global level.

- Resource use and conservation
- Environmental issues through time
    - Population changes
    - Waste management: sewage, hazardous and solid waste
    - Land use: development, zoning and agriculture (point source and non-point source contamination, thermal pollution)
    - Water: surface and ground water protection, Clean Water Act
    - Air: primary and secondary contamination, greenhouse gases, Clean Air Act
    - Industry changes, permits and regulations (point source and non-point source contamination, thermal pollution)
- Changes in Environmental Law and Regulation in the United States

Patterns and Cycles on Earth

This topic focuses on biogeochemical cycles and the connection to Earth's spheres (hydrosphere, atmosphere, biosphere and lithosphere). This includes an understanding of the cause and effect of climate change.

- Conservation of matter, physical and chemical changes that impact the environment
- Movement of matter and energy through the lithosphere, atmosphere, hydrosphere and biosphere
- Ocean and atmospheric currents, transfer of energy, global climate (including el Niño, la Niña trends)

Concepts and Principles of Environmental Science

The principles of Environmental Science include principles from other science disciplines (such as biology), but are applied to environmental issues.

- Abiotic factors that influence ecosystems
- Ecosystem equilibrium
- Energy transfer and transformation
- Climate and populations
- Evolution, natural selection, adaptation and sustainability
- Human risk factors

Global Issues

This topic adds to the historical perspective at the beginning of the course, by applying current issues and laws. Developing and using population models, collecting and analyzing water quality data, connecting to real-world, on-going issues (can be local, national or global) students will understand firsthand the issues listed below.

- Human population
- Drinking water quality and availability
- Climate change
- Deforestation
- Waste disposal (solid and hazardous)

Earth's Resources

This topic goes beyond what was part of earlier renewable and nonrenewable energy resources to learn about the effectiveness and efficiency for differing varieties at a local, state, national, and global level. In addition, Earth's resources (abiotic and biotic) as they relate to environmental issues (such as mining) are included.

- Energy resources
    - Renewable and nonrenewable energy sources and efficiency
    - Alternate energy sources and efficiency
    - Resource availability
    - Mining
- Air (primary and secondary air pollution, greenhouse gases)
- Water (potable water, importance of wetlands, groundwater, hypoxia, eutrophication)
- Soil (desertification, mass wasting, sediment contamination)

Chemistry – Unit Overview and Outline

Chemistry is a high school level course which satisfies Ohio Core science graduation requirements as required by section 3313.603 of the Ohio Revised Code that requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

This course introduces students to key concepts and theories that provide a foundation for further study in other sciences as well as advanced science disciplines. Chemistry comprises a systematic study of the predictive physical interactions of matter and subsequent events that occur in the natural world. The study of matter through the exploration of classification, its structure and its interactions is how this course is organized.

Students engage in investigations to understand and explain the behavior of matter in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications. An understanding of leading theories and how they have informed current knowledge prepares students with higher order cognitive capabilities of evaluation, prediction, and application.

Science Inquiry and Application

During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions and concepts that guide scientific investigations;*
- *Design and conduct scientific investigations;*
- *Use technology and mathematics to improve investigations and communications;*
- *Formulate and revise explanations and models using logic and evidence (critical thinking);*
- *Recognize and analyze explanations and models; and*
- *Communicate and defend a scientific argument.*
- *Apply Catholic values to development and application of science concepts.*

Course Content

The following information may be taught in any order. The sequence provided here does not represent a recommended sequence as there is no recommended sequence.

Classifying Matter

Elaboration for Instruction

Effective communication in science requires students to describe matter using skills which accurately quantify and qualify materials. These skills require students to master using metric prefixes, significant digits, scientific notation, standard units, derived units, error analysis, dimensional analysis, etc. In essence, students are well-versed in communicating findings using numbers to describe and distinguish specific characteristics of various materials with standardized language.

- Scientific measurement and communications
- Distinguishing characteristics of different materials

Structure of Matter
Elaboration for Instruction

The changes, and thereby reactions, that matter undergoes are directly connected to the structure of the atoms from which the matter is composed. These changes, which occur at either the atomic level and/or the subatomic level, incur variation in the energy associated with each constituent. Energy changes that occur at the subatomic level require and result in tremendous energy changes. Societal implications for such changes are vast and the study thereof potentially provides students with a broader perspective in which their knowledge is applied to not only immediate experiences, but to global conditions affecting Earth and its future well-being.

- Atomic structure
    - Evolution of atomic models/theory
    - Properties of valence electrons
    - Computations based on number of subatomic particles-atomic number, atomic mass, percent abundance
- Periodic Variation
    - Electron configuration
    - Atomic size, ionization, electronegativity
    - Properties: density, melting point, phase at room temperature, conductivity
- Nuclear changes and reactions
    - Nuclear Stability
    - Nuclear equations (alpha, beta)
    - Radioactive decay
        - Unstable nucleus, nuclear force
        - Decay of nucleus (integer level half-life and characteristics of products)
        - Fission

Interactions of Matter
Elaboration for Instruction

The interactions that matter undergoes can be studied from an intramolecular perspective, as well as an intermolecular perspective (from the intramolecular perspective, students study how atoms come together to form various materials and how those materials respond under various conditions). From the intermolecular perspective, materials behave in varied ways according to characteristic properties. For example, some atoms lose electrons thereby differentiating a material from one which is inert and does not. Some atoms have bonding structures that make materials very strong and therefore useful in situations requiring hard and strong structures. Some materials have atomic structures that only them to they be diffused, while others have high *flow* capacity.

Intramolecular

- Nomenclature
- Chemical Bonding
- Chemical Reactions
    - Balancing
    - Kinetics and Equilibrium
- Stoichiometry
    - Molar calculations
    - Limiting reagents, chemical composition, empirical and molecular formula
    - Concentration of solutions
- Acids/Bases
    - Differentiation between acids and bases
    - Calculation of Hydronium and hydroxide ions
    - Identification of common acid/bases

Intermolecular

- Properties of solids, liquids and gases
- Changes of State (energy consideration of phase changes)
    - Gas
    - Behavior
    - Laws
    - Measuring

Geology – Unit Overview and Outline

Physical Geology is a high school level course which satisfies Ohio Core science graduation requirements as required by section 3313.603 of the Ohio Revised Code that requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

Physical geology incorporates chemistry, physics and environmental science, and introduces students to key concepts, principles and theories within geology.

Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Science Inquiry and Application

During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions and concepts that guide scientific investigations;*
- *Design and conduct scientific investigations;*
- *Use technology and mathematics to improve investigations and communications;*
- *Formulate and revise explanations and models using logic and evidence (critical thinking);*
- *Recognize and analyze explanations and models; and*
- *Communicate and defend a scientific argument.*
- *Apply Catholic values to development and application of science concepts.*

Course Content

The following information may be taught in any order. The sequence provided here does not represent a recommended sequence as there is no recommended sequence.

Minerals

- Atoms and Elements
- Chemical bonding (ionic, covalent, metallic)
- Crystallinity (crystal structure)
- Criteria of a mineral (crystalline solid, occurs in nature, inorganic, defined chemical composition)
- Properties of minerals (hardness, luster, cleavage, streak, crystal shape. fluorescence, flammability, density/specific gravity, malleability)

Igneous

- Mafic and felsic rocks and minerals
- Intrusive (igneous structures: dikes, sills, batholiths, pegmatites)
- Earth's interior (inner core, outer core, lower mantle, upper mantle, Mohorovicic discontinuity, crust)
- Magnetic reversals and Earth's magnetic field
- Thermal energy within the Earth
- Extrusive (volcanic activity, volcanoes: cinder cones, composite, shield)
- Bowen's Reaction Series (continuous and discontinuous branches)

Metamorphic

- Pressure, stress, temperature, and compressional forces
- Foliated (regional), non-foliated (contact)
- Parent rock and degrees of metamorphism
- Metamorphic zones (where metamorphic rocks are found)

Sedimentary

- The Ocean
    - Tides (Daily, Neap and Spring)
    - Currents (deep and shallow, rip and longshore)
    - Thermal energy and water density
    - Waves
    - Ocean features (ridges, trenches, island systems, abyssal zone, shelves, slopes, reefs, island arcs)
    - Passive and active continental margins
- Division of sedimentary rocks and minerals (chemical, clastic/physical, organic)
- Depositional environments
- Streams (channels, streambeds, floodplains, cross-bedding, alluvial fans, deltas)
- Transgressing and regressing sea levels

Earth's History

- The Geologic Rock Record
    - Relative and Absolute Age
    - Principles to determine relative age
        - Original horizontality
        - Superposition
        - Cross-cutting relationships
    - Absolute Age
        - Radiometric dating (isotopes, radioactive decay)
        - Correct uses of radiometric dating
    - Combining Relative and Absolute Age data
    - The Geologic Time Scale
        - Comprehending geologic time
        - Climate changes evident through the rock record
        - Fossil record

Plate Tectonics

- Internal Earth
    - Seismic waves
        - S and P waves
        - Velocities, reflection, refraction of waves
    - Structure of Earth (note: specific layers were part of eighth grade)
        - Asthenosphere
        - Lithosphere
        - Mohorovicic boundary (Moho)
        - Composition of each of the layers of Earth

        - Gravity, magnetism, and isostasy
        - Thermal energy (geothermal gradient and heat flow)
- Historical review (note: this would include a review of Continental Drift and Sea-Floor Spreading found in eighth grade)
    - Paleomagnetism and magnetic anomalies
    - Paleoclimatology
- Plate motion (note: introduced in eighth grade)
    - Causes and evidence of plate motion
    - Measuring plate motion
    - Characteristics of oceanic and continental plates
    - Relationship of plate movement and geologic events and features
    - Mantle plumes

Earth's resources

- Energy resources
    - Efficiency of renewable and nonrenewable energy sources
    - Resource availability
    - Extraction of resources
- Air (primary and secondary air pollution, greenhouse gases)
- Water (potable water, importance of wetlands, groundwater, hypoxia, eutrophication)
- Soil (desertification, mass wasting, sediment contamination)

Glacial Geology

- Glaciers and glaciation
    - Evidence of past glaciers (including features formed through erosion or deposition)
    - Glacial deposition and erosion (including features formed through erosion or deposition)
    - Data from ice cores
        - Historical changes (glacial ages, amounts, locations, particulate matter, correlation to fossil evidence)
        - Evidence of climate changes
    - Glacial distribution and causes of glaciation
    - Types of glaciers - Continental (ice sheets, ice caps), alpine/valley (piedmont, valley, cirque, ice caps)
    - Glacial structure, formation and movement

Physics – Unit Overview and Outline

Physics is a high school level course which satisfies Ohio Core science graduation requirements as required by section 3313.603 of the Ohio Revised Code that requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

This course introduces students to key concepts and theories that provide a foundation for further study in science and scientific literacy. Physics is a systematic study of the predictive physical interactions of matter and subsequent events that occur in the natural world.
Students engage in investigations to understand and explain the behavior of nature in a variety of inquiry and design scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Science Inquiry and Application

During the years of grades 9 through 12 all students must use the following scientific processes to construct their knowledge and understanding in all science content areas:

- *Identify questions and concepts that guide scientific investigations;*
- *Design and conduct scientific investigations;*
- *Use technology and mathematics to improve investigations and communications;*
- *Formulate and revise explanations and models using logic and evidence (critical thinking);*
- *Recognize and analyze explanations and models; and*
- *Communicate and defend a scientific argument.*
- *Apply Catholic values to development and application of science concepts.*

Course Content

The following information may be taught in any order. The sequence provided here does not represent a-recommended sequence as there is no recommended sequence.

Motion in Two Dimensions and Periodic Motion
Elaboration for Instruction

One-dimensional to two-dimensional motion, the ideas of displacement, velocity and acceleration that were introduced in Physical Science are developed further in this topic. Simple examples of projectile, oscillating (spring systems, pendulums), and circular motion are used to demonstrate these different types of motion.

- Vectors (two-dimensional)
- Projectile motion
- Circular motion
- Linear and two-dimensional periodic motion

Forces and Two-Dimensional Motion
Elaboration for Instruction

Gravitational force acts between all masses and always creates a force of attraction (introduced in Grade 8 and Physical Science). Application of Newton's Universal Law of Gravitation is used to explain how two objects that are gravitationally bound orbit a common center of mass. Incorporating spring forces (in static and cases of oscillatory motion), air resistance and friction are included in this topic. Also included are Newton's laws of motion (for objects in free fall and calculating terminal velocity when air resistance plays a significant role) and the application of Newton's laws of motion to analyze, mathematically describe and predict the effects of forces on the two-dimensional motions of objects. The effect of the gravitational force in producing a two-dimensional orbit around an object can be calculated. Newton's second law which describes the effect of forces on the motion of an object (namely balanced forces result in a constant velocity or no velocity, unbalanced forces) should be used to determine the rate of change in the velocity which is proportional to the net force applied.

Momentum is the product of the mass and the velocity of an object. Since mass is a scalar quantity and velocity is a vector quantity, momentum is a vector quantity. When objects collide, the collision can be either elastic or inelastic. For elastic collisions, both momentum and energy are conserved. For inelastic collisions, only momentum is conserved. The momentum of two objects should be calculated before and after either an elastic or inelastic collision, given the appropriate information. In this topic, one-dimensional and two-dimensional collisions are included. All components of momentum are conserved in collisions, in the absence of external forces (within a closed system).

- Newton's Laws with balanced forces
- Newton's Laws with unbalanced forces
- Momentum, conservation of momentum
- Vectors (one- and two-dimensional)

Energy, energy transformations and energy conservation
Elaboration for Instruction

Building on Physical Science (kinetic and gravitational potential energy), two-dimensional mathematical representations will be used for kinetic and potential energy in the context of springs, collisions or circular motion. In a closed system, energy is conserved and can be accounted for; however, in the real world, energy is transformed into unusable forms, generally as thermal energy. Energy transformations and conservation of energy will be evaluated in scenarios that include damped periodic motion, friction and production of thermal energy.

Force acting over a distance is work. Work will change the energy of a system so that when a pendulum is raised, work is done on it to raise the mass and give it gravitational potential energy. Then the pendulum can convert the gravitational potential energy to kinetic energy (motion). Power is the amount of work done in a given amount of time (work over time). Work and power are calculated in systems (e.g., springs, collisions or circular motion).

Energy transformation and conservation will be evaluated and calculated in conduction, convection and radiation (building upon Grade 7 and Physical Science). In any of these processes, the total energy is conserved. (Energy is always conserved.)

- Work and power
- Energy transformation and conservation
- Collisions
- Thermal energy production, friction
- Energy conservation under conduction, convection and radiation

Interactions of energy and matter – waves
Elaboration for Instruction

In interactions of energy and matter, energy often travels through matter in the form of waves. To build upon Physical Science, the measurable properties of waves (wavelength, frequency, amplitude) are used to mathematically describe properties of materials (index of refraction, reflectivity).

The behavior of light at an interface between materials with different indices of refraction such as air and glass and air and water also are included in this topic. The laws of reflection and refraction can be used to predict the geometric path of light through thin optical elements using ray diagrams and the location and sizes of images in mirrors, thin lenses and pinholes. The interference of waves through narrow slits and prisms (simple geometries) are calculated.

Observed wavelength of a wave depends upon the relative motion of the source and the observer. The Doppler equation is used to determine the change in wavelength and/or frequency due to the motion of a (sound or light) source or observer.

Note: Basis of redshift has been introduced in Physical Science.

- Wave properties
    - Frequency-wavelength relationship (mathematically)
    - Index of refraction, material properties (calculating)
    - Speeds (velocities) of waves in different media (calculating)
- Light phenomena (quantitative)
    - Ray diagrams (propagation of light)
    - Snell's Law
    - Law of Reflection (equal angles)
    - Young's Experiment (diffraction)
    - Light colors (absorption, reflection, transmission)
- Doppler effect (quantitative)

Electricity and Magnetism
Elaboration for Instruction

The strength of the force between two charges can be calculated. How electricity is produced in a generator (electric charges in motion produce magnetic fields and a changing magnetic field creates an electric field), designing working DC circuits, using resistors, energy source, switches and light bulbs in DC circuits (both parallel and series), measuring the current and voltage in different parts of a simple series and/or parallel circuit with multiple resistors (and/or light bulbs) and Kirchoff's Law also are included in this topic.

Increasing the voltage increases current if the resistance stays the same (use simple resistors, diodes, or LEDs; here, use of nonlinear resistors is excluded). For many materials, current is proportional to the voltage. Ohm's Law states that the voltage is equal to the current times the resistance.

- Coulomb's Law (electrostatic force between two charges)
- Induction (moving magnet through a coil produces electric field)
- Ampere's Law (moving charge or current produces magnetic field)
- Electric generators (relative motion between a conducting coil and a magnet can produce an electric current)
- DC circuits – parallel and series
    - Basics of Kirchoff's Law
- Properties of materials related to the electrical conduction
    - Ohm's Law

Approved textbook and material list

Kindergarten through Fifth Grade

McMillan – McGraw Hill
Science: A Closer Look (National Edition with the 2011 Ohio companion piece)

Sales Representative:
Renee Mitchel
renee_mitchel@mcgraw-hill.com
614-738-6111 or 614-891-6858

Kindergarten through Eighth Grade

Carolina Curriculum
All modular units

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