

SCIENCE CURRICULUM STANDARDS

K-12



**Office of Catholic Education:
Schools**

DIOCESE OF RICHMOND
September, 2014

SCIENCE CURRICULUM STANDARDS

Diocese of Richmond

September, 2014

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The Office of Catholic Education: Schools of the Diocese of Richmond would like to thank the Science Curriculum Committee for its work in revising and updating the Science Curriculum Standards.

Science adds a unique dimension to the Catholic/Christian view of life and brings us face to face with the power, wisdom, and beauty of creation.

As Catholic school educators we believe that the study of science sheds light on the principles and processes that shape the natural world, nourishes our intrinsic curiosity about the world, and guides us in applying logical methods to explore its mysteries. Science stresses the importance of critical thinking and open-mindedness, and is a discipline founded on continually changing investigation, self-review, and gradual unfolding of ideas. Promoting inquiry, teachers organize the students, the environment, and the materials so that all learners actively participate in the process of exploration, discovery, and learning.

It is our hope that these standards assist our schools and teachers in inspiring students who will go out into the greater society as curious, scientifically literate, Catholic/Christian decision makers and informed citizens who possess a strong moral responsibility.

Sincerely,

Francine Conway
Superintendent of Schools

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Assistant Superintendent Diocese of Richmond

“Science can purify religion from error and superstition. Religion can purify science from idolatry and false absolutes.”

Pope John Paul II (Letter to Rev. George V. Coyne, S.J., Director of the Vatican Observatory,
1 June 1988.)

Diocese of Richmond Science Curriculum

Philosophy Statement

The universe is a place subject to fundamental scientific principles. An understanding of these principles will better prepare an individual to cope with a world in which rapid technological developments are taking place. As knowledge rapidly expands, it is most important for students to learn to make rationale and moral decisions based upon scientific principles and their Catholic Christian values. The skills and knowledge afforded students to make these types of decisions should reflect their appropriate level of intellectual and emotional growth. This curriculum is designed to stimulate curiosity and to develop morally responsible, scientifically literate citizens. This curriculum stresses the process of science as a way of learning and further emphasizes that scientific knowledge is always subject to change based upon new discoveries and additional knowledge.

Science Teachers as Moral Educators

“The introduction of ethics in science classes is not the only way to portray science as receptive to open-mindedness and critical questioning. But it is an effective way, and it places science squarely in the context in which it actually operates in society. In addition, the very methods of inquiry and standards of public reasoning that science advances can make a valuable contribution to the moral education of students, beginning whenever the study of science begins.

“Although ethical questions cannot be answered by science alone (there is this much to the fact/value distinction), it seems clear that a reasonable approach to an ethical question requires carefully attending to, and seeking out, all the relevant facts. Screening out information that may make it more difficult to support one's favored position is contrary to reasonable ethical reflection; and it is contrary to good scientific reasoning. The scientific caution against generalizing from an unrepresentative sampling can help explain the shortcomings of stereotyping (common in racist and sexist thinking, e.g.). The scientific importance of looking at things from as many relevant perspectives as possible can help students understand and resist egocentric thinking, one of the most formidable barriers to reasonableness in social relationships. And the power of analogical reasoning in science can enhance ethical reasoning as well... ”

“... Of course, school science programs need to take carefully into account the readiness students have for particular science content and any related ethical issues. At present, there is very little material explicitly designed to assist teachers who wish to integrate ethics into their science teaching. Although there is a growing literature on moral education at these levels, very little addresses the science curriculum. However, the December 1995 report of the Committee on National Standards for Science Education targets objectives that refer to aspects of scientific practice and uses of science that clearly suggest the need to integrate ethics and values issues in science classes. For example, concern the ways in which scientists are expected to conduct research—sorting out evidence, testing hypotheses, making reliable inferences, accurately reporting data, working cooperatively with others, and the like. The report also includes suggestions for units on personal and social perspectives on science and on the nature of science and science inquiry. Just how any of these objectives might best be met in various levels of the school curriculum needs to be worked out with considerable care; but recent statements of science education goals and objectives at both the state and national level suggest that this task should be undertaken.” (Pritchard, 2006)

Pritchard, M. (2006) "Reasonable Children: Science Teachers as Moral Educators" Online Ethics Center for Engineering 6/21/2006 National Academy of Engineering Accessed: Friday, September 20, 2013
<www.onlineethics.org/Education/precollege/childrenreason.aspx>

Goals

All students will:

1. Develop an understanding of the processes and skills necessary for scientific investigation, problem solving, and critical thinking.
2. Develop responsible Catholic Christian decision making skills in matters related to science, engineering and technology's impact on society with respect for the environment and living things.
3. Recognize that science is an integrated study that involves oral and written communication, mathematics, and technology, and is influenced by religious beliefs.
4. Develop an interest, a sense of wonder, and curiosity about the study of the universe while recognizing the objective nature of science with respect to God as Creator.
5. Recognize that science searches for natural explanations of observed phenomena while supernatural explanations are outside the purview of science.
6. Develop an understanding of the scientific process and understand the structure of science, which includes organizing data into facts, principles, models, laws, theories and hypotheses.

Practices

All students will:

1. Ask questions (for science) and defining problems (for engineering)
2. Develop and use models
3. Plan and carry out investigations
4. Analyze and interpret data
5. Construct and interpret graphs
6. Use mathematics and computational thinking
7. Use SI units, scientific notation, significant digits, and dimensional analysis;
8. Construct explanations (for science) and design solutions (for engineering)
9. Mathematical and procedural error analysis;
10. Engage in argument from evidence
11. Obtain, evaluate, and communicate information (NGSS, 2013)

Standards

The National Science Education Standards and the Virginia Standards of Learning are met and exceeded by the Science Curriculum Standards of the Diocese of Richmond. The January 2013 draft of the Next Generation Science Standards (NGSS) was used in preparing this document.

The format of specific content area standards for the four core high school subjects follows the outline used by the Virginia Department of Education, with appropriate amendments applicable for the schools of the Diocese.

Safety

In implementing the *Science Standards*, teachers must be certain that students know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups.

Safety must be given the highest priority in implementing the instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrollment should not exceed the designed capacity of the room and may not exceed capacity for laboratory rooms.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous prior to their use in an instructional activity. Such information is referenced through Materials Safety Data Sheets (MSDS). The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

While no comprehensive list exists to cover all situations, the following should be reviewed to avoid potential safety problems. Appropriate safety procedures should be used in the following situations:

- observing wildlife; handling living and preserved organisms; and coming in contact with natural hazards, such as poison ivy, ticks, mushrooms, insects, spiders, and snakes;
- engaging in field activities in, near, or over bodies of water;
- handling glass tubing and other glassware, sharp objects, and labware;
- handling natural gas burners, Bunsen burners, and other sources of flame/heat;
- working in or with direct sunlight (sunburn and eye damage);
- using extreme temperatures and cryogenic materials;
- handling hazardous chemicals including toxins, carcinogens, and flammable and explosive materials;
- producing acid/base neutralization reactions/dilutions;
- producing toxic gases;
- generating/working with high pressures;
- working with biological cultures including their appropriate disposal and recombinant DNA;
- handling power equipment/motors;
- working with high voltage/exposed wiring; and
- working with laser beam, UV, and other radiation.

The use of human body fluids or tissues is generally prohibited for classroom lab activities. Further guidance from the following sources may be referenced:

- OSHA (Occupational Safety and Health Administration);
- ISEF (International Science and Engineering Fair) rules; and
- public health departments' and school divisions' protocols.

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PRE-KINDERGARTEN

**Moved Pre-K Curriculum to the new program for Early Learners
and Junior Kindergarten in 2019.**

PRE-KINDERGARTEN

**Moved Pre-K Curriculum to the new program for Early Learners
and Junior Kindergarten in 2019.**

KINDERGARTEN

Earth and Space Science: Earth and Human Activity

Broad Concept: The students will investigate the effects of sunlight on the Earth's surface and design structure to reduce warming effects on Earth's surface.

The students will:

- ☐ ESS 1 _____ Make observations to determine the effect of sunlight on Earth's surface

Examples of Earth's surface include:

- Sand
- Soil
- Rocks
- Water

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

Examples of structures include:

- Umbrellas
- Canopies
- Tents

- ☐ ESS 3 _____ Use and share observations of local weather conditions to describe patterns over time

Examples of observations include:

- Sunny
- Cloudy
- Rainy
- Warm

Examples of patterns include:

- It is usually cooler in the morning than in the afternoon
- The number of sunny days versus cloudy days in different months

Suggested Resources:

www.Brainpopjr.com

www.Kids.discovery.com

www.kidsastronomy.com

National Geographic Kids: Kids' Games, Animals, Photos

STREAM Perspectives

Broad Concept: Students are able to identify and describe health and safety habits and responsibilities.

- Ask questions to determine cause and effect relationships of good nutrition and healthy habits of rest, exercise and cleanliness. Excellent opportunity to invite a doctor, dentist, nutritionist, etc to the classroom.
- Read texts and use media to determine dangers associated with natural disasters.
- Recognize that God made the earth and all living things on it.
- Ask questions, make observations and gather information about ways people show respect and care for the earth and all living things.
- Recognize that God is a part of everything in our world.

Suggested Resources:

Coloring book on natural disasters

Lesson plan with links to videos and activities on poison prevention

Life Science: Ecosystems and the Interrelationships of Plants, Animals and Their Environment

Broad Concept: Students will investigate and develop an understanding of the connection between the needs of living things and what plants and animals, including humans, need to survive.

The students will:

- ☐ LS 1 _____ Describe what plants and animals need to survive
 - Describe the life needs of plants:
 - Nutrients
 - Water
 - Air
 - Light
 - Adequate space to grow
 - Describe the life needs of animals:
 - Food
 - Water
 - Air
 - Shelter
 - Space
 - Predict what would happen to animals and plants if life needs were not met. Create and investigation with plants to test the predictions.

Hands on activity:

- Animal Diversity: To motivate and guide student observation of animal and plant similarities, diversity and appropriateness to live in different environments; to show that stories sometimes give plants and animals attributes.

Computer activity:

- Plant and Animal Diversity: This activity will help the students to recognize similarities and differences in plants and animals. Students will be able to classify living things according to the observable characteristics.

iPad App:

- Leaf Snap: An Electronic Field Guide

- ☐ LS 2 _____ Explain connections between the places an animal or plant lives and how it meets its needs

○ **Examples of various places include:**

- The desert
- The forest
- The plains
- A pond

○ **Examples of needs include:**

- Food
- Water
- Air
- Shelter
- Space

Video:

- Animals Making A Living: The video explores the wide range of food-finding strategies in the plant and animal world.
- Animals find needs in environment: This lesson provides students with opportunities to investigate the habitats of local plants and animals and explore some of the ways animals depend on plants and each other.

- ☐ LS 3 _____ Describe simple changes in life cycles of plants and animals

○ Plants life cycle changes include:

- Seedling to full grown plant

○ Animals life cycle changes include:

- Changes in size, color, shape and covering

Video:

- Animals life cycles: <https://www.youtube.com/watch?v=xmsTccmRMh4>
- Plant life cycle: https://www.youtube.com/watch?v=zXzOi7-nx_w

Physical Science: Matter

Broad Concept: Students will investigate and understand that objects can be described by their physical properties.

The students will:

- ☐ PS 1 _____ Investigate and understand that the position, motion and physical properties of an object can be described
 - **Examples include:**
 - Colors
 - Shapes
 - Textures
 - Relative size and weight (big/little, large/small, heavy/light, wide/thin, long/short)
 - Position (under/over, in/out, above/below, left/right) and speed (fast/slow)
- ☐ PS 2 _____ Investigate and understand that water flows and has properties that can be observed and tested
 - **Examples include:**
 - Water occurs in different states (solid, liquid, gas)
 - The natural flow of water is downhill
 - Some materials float in water, while others sink
 - Relative size and weight (big/little, large/small, heavy/light, wide/thin, long/short)
 - Position (under/over, in/out, above/below, left/right) and speed (fast/slow)

Physical Science: Forces and interactions, Pushes and Pulls

Broad Concept: Students will gain conceptual understanding of different strengths or directions of pushes and pulls on the motion of various objects.

The students will:

- ☐ PS 1 _____ Plan and conduct an investigation to compare the effects of different strengths or Different directions of pushes and pulls on the motion of an object
 - **Examples of pushes or pulls could include:**
 - A string attached to an object being pulled
 - A person pushing an object
 - A person stopping a rolling ball
 - Two objects colliding and pushing on each other
- ☐ PS 2 _____ Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull
 - **Examples of problems requiring a solution could include:**
 - Having a marble or other object move a certain distance
 - Follow a particular path and knock down other objects
 - **Examples of solutions could include:**
 - Tools such as a ramp to increase the speed of the object
 - A structure that would cause an object such as a marble or ball to turn

Suggested Resources:

www.firstyears.com

[BrainPOP Jr.-K-3 Educational Movies, Quizzes, Lessons...](#)

GRADE 1

Earth and Space Science: Earth's Place in the Solar System

Broad Concept: Students will recognize the repeating patterns of Earth due to its place in the solar system.

Students will:

- ☐ ESS 1_____ Use observations of the sun, moon and stars to describe patterns that can be predicted
 - **Examples of patterns could include:**
 - The sun and moon appear to rise in one part of the sky and move across the sky, and set
 - Stars other than our sun are visible at night but not during the day
- ☐ ESS 2_____ Make observations at different times of the year to relate the amount of daylight to the time of year
 - Compare and contrast the amount of daylight in the winter to the amount in the spring or fall

Suggested Resources:

Adventures of the Argonauts: Teacher resources and activities

STREAM Perspectives

Broad Concept: Students will establish an understanding of God's place and love for His creation of planet Earth.

- Construct an argument with evidence of the role of humans as caretakers of the Earth.
- Ask questions to determine cause and effect relationships of the practice of good nutrition and healthy habits of rest, exercise and cleanliness.
- Read texts and use media to present evidence of the beauty of God's creation and identify and describe ways to treat it with respect.
- Demonstrate respect for all living creatures.

Suggested Resources:

Lesson ideas:

Being Caretakers of the Earth: Introduces concepts of reducing, reusing and recycling
Games and activities: Nutrition Games

Life Science: Organization and Development of Living Things

Broad Concept: Students will develop an understanding of how parts of animals are used to help them survive, grow and meet their needs.

Students will:

- ☐ LS 1 _____ Identify and explain how animals/humans use their external parts to help them survive, grow and meet their needs
 - **Examples for animals parts could include:**
 - Body coverings (hair, fur, feathers, scales)
 - Body shapes
 - Appendages (arms, legs, wings, fins and tails)
 - Means of movement (walking, crawling, flying and swimming)
 - Their sense organs (eyes, ears, nose, mouth, touch)
- ☐ LS 2 _____ Create a model representing the types of animal homes (water or land) that match the physical characteristics of the animals
 - **Examples include:**
 - Fins and scales help fish live and move in the water
 - Fur and legs allow dogs to live and move on land
- ☐ LS 3 _____ Determine patterns in behavior of parents and offspring that help offspring survive
 - **Examples of patterns of behaviors could include:**
 - The signals that offspring make (such as crying, cheeping and other vocalizations)
 - Responses of the parents (such as feeding, comforting and protecting the offspring)
- ☐ LS 4 _____ Identify parts of plants and their functions
 - **Parts of plants include:**
 - Seeds
 - Roots
 - Stems
 - Leaves
 - Flowers
 - **Key concepts include:**
 - Needs of plants
 - Air
 - Water
 - Light
 - Nutrients
 - Places to grow
 - **Functions:**
 - Growth
 - Reproduction

- ❑ LS 5 _____ Observe the sequential life cycle of plants
 - **Examples include:**
 - Roots
 - Stems
 - Leaves
 - Flowers
 - Seeds (life cycles)
- ❑ LS 6 _____ Based on observations, create and interpret a model of a plant
 - **Parts to include:**
 - Seeds
 - Roots
 - Stems
 - Leaves
 - Flowers
 - Fruit

Suggested Resources:

Hands-on Activity:

<http://www2.mcrel.org/compendium/activityDetail.asp?activityID=208>

Video: Owl/San Diego Zoo Animals

Plant videos and songs: <http://jenna.looktothestar.org/plant-videos>

Physical Science: Matter

Broad Concept: Students will gain conceptual understanding of materials' interactions with water.

Students will:

- ❑ PS 1 _____ Investigate and understand that moving objects produce different kinds of motion
 - **Examples include:**
 - Objects may have straight, circular and back-and-forth motions
 - Objects may vibrate and produce sound
 - Pushes and pulls can change the movement of an object
 - The motion of objects may be observed in toys and in playground activities

Physical Science: Waves, Light and Sound

Broad Concept: Students are expected to develop an understanding of the relationship between sound and materials that vibrate as well as between the availability of light and ability to see objects.

Students will:

- ☐ PS 1 _____ Plan and conduct investigations to provide evidence that vibrating materials make sound and that sound can make materials vibrate
 - **Examples of vibrating materials that make sound could include:**
 - Tuning forks
 - Plucking a stretched string
 - **Examples of how sound can make matter vibrate could include:**
 - Holding a piece of paper near a speaker making sound
 - Holding an object near a vibrating tuning fork
- ☐ PS 2 _____ Make observations to construct an understanding that objects can be seen only when illuminated
 - **Examples of observations could include:**
 - Those made in a completely dark room
 - A pinhole box and a video of a cave explorer with a flashlight
 - **Examples of illumination could include:**
 - An external light source
 - An object giving off its own light
- ☐ PS 3 _____ Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light
 - **Examples of materials could include:**
 - Transparent, such as clear plastic
 - Translucent, such as wax paper
 - Opaque, such as cardboard and reflective, such as a mirror
- ☐ PS 4 _____ Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance
 - **Examples of devices could include:**
 - A light source to send signals
 - Paper cup and string ‘telephones’
 - A pattern of drum beats
 - Opaque, such as cardboard and reflective

Suggested Resources:

BrainPOP Jr. – K-3 Educational Movies, Quizzes, Lessons...
First School Years

GRADE 2

Earth Science: Earth's Systems

Broad Concept: Students are able to understand that Earth's processes and changes can occur at various rates.

The student will:

- ☐ ESS 1 _____ Use information from several sources to provide evidence that Earth events can occur quickly or slowly
 - **Examples of events and timescales could include:**
 - Volcanic explosions and earthquakes, which happen quickly
 - Erosion of rocks, which occurs slowly

Suggested Resources:

Interactive Websites:

- Volcanic Eruptions
- PBS Website: Savage Earth
- NOAA Miami Library: Hurricane and Natural Disaster Brochures
- Shake, Rattle, and Roll: Earth's changing processes
- Shape It Up! – Science NetLinks

STREAM Perspectives

Broad Concept: Students will establish an understanding of God's place and love for His creation of planet Earth.

- Plan and conduct investigations to determine ways that scientific knowledge can be used to help living things.
- Evaluate the consequences of ways to keep our bodies healthy.
- Concepts may include: Good nutrition, cleanliness, exercise and sleep.
- Use evidence to construct an explanation of the need to respect and care for all of God's creation.
- Recognize life as a gift from God.

Life Science: Interrelationships in Ecosystems: Plants, Animals and Their Environment

Broad Concept: Students are expected to develop an understanding of life cycles in plants and animals and to compare the diversity of life in different habitats.

Students will:

- ☐ LS 1 _____ Understand and observe that habitats change over time.
 - **Examples include:**
 - Recognize how habitat changes affect organisms

- ❑ LS 2 _____ Understand the food chain
 - **Examples include:**
 - Similarities in the food chain
 - Differences in the food chain
- ❑ LS 3 _____ Investigate and understand that animals go through a series of changes in their life cycles
 - **Concepts include:**
 - Living things change in an orderly way as they grow
 - The pattern of change from birth to death is called the life cycle
 - Some animals, frogs and butterflies, go through distinct stages in their life cycles while others do not
- ❑ LS 4 _____ Investigate and understand that plants go through a series of orderly changes in their life cycles
 - **Concepts include:**
 - Flowering plants undergo many changes from the formation of flower to the development of fruit
- ❑ LS 5 _____ Investigate and understand that living things are part of a system
 - **Concepts include:**
 - Living organisms are interdependent with their living and nonliving surroundings

Suggested Resources:

Different Habitats: Examples of plants and animals in different habitats

Pollinators: The bees role as a pollinator

Physical Science: Structures and Properties of Matter

Broad Concept: Students will develop an understanding of observable properties of matter through analysis and classification of different materials.

The student will:

- ❑ PS 1 _____ Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties
 - **Observations could include:**
 - Color
 - Texture
 - Hardness
 - Flexibility
 - Patterns (similar properties that different materials share)

- ❑ PS 2 _____ Analyze data to determine which materials have the properties that are best suited for an intended purpose
 - **Examples of properties could include:**
 - Strength
 - Flexibility
 - Hardness
 - Texture
 - Absorbency
- ❑ PS 3 _____ Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object
 - **Examples of pieces could include:**
 - Blocks
 - Building bricks
 - Other assorted small objects
- ❑ PS 4 _____ Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot
 - **Examples include:**
 - Reversible change could include materials such as water and butter at different temperatures
 - Irreversible changes could include cooking an egg, freezing a plant leaf and heating paper
- ❑ PS 5 _____ Investigate and understand basic properties of solids, liquids and gases
 - **Examples include:**
 - Mass and volume
 - Processes involved with changes in matter from one state to another, such as condensation
 - Evaporation, melting and freezing

Physical Science: Force Motion and Energy

Broad Concept: Students will investigate and understand that natural and artificial magnets have certain characteristics and attract specific types of metals.

The student will:

- ❑ PS 1 _____ Demonstrate the characteristics of magnetism
 - **Examples include:**
 - Magnetism, iron, magnetic/non-magnetic, poles, attract/repel
 - Important applications of magnetism including the magnetic compass

Suggested Resources:

BrainPOP Jr. – K-3 Educational Movies, Quizzes, Lessons...

First School Years

SchoolMedia Interactive – Elementary Educational...

GRADE 3

Earth and Space Science: Earth's Place in the Solar System

Broad Concept: The student will investigate and understand the characteristics of Earth and the Solar System

The student will:

- ☐ ESS 1 _____ Analyze essential principles and ideas about the universe
 - Identify the position of the sun, moon, planets and stars in the solar system
 - Know the characteristics of the sun, planets and their moons
 - Know all planets orbit the sun
 - Know that the sun provides light and heat necessary to maintain the temperature of the Earth
 - Know that the moon does not change shape, but at different times appears to change shapes (moon's phases)
 - Explain the relationship between the rotation of the Earth on its axis and the day and night cycle
 - Describe the causes of Earth's seasons
 - Know the sun – earth – moon relationships (seasons and tides)

Earth and Space Science: Earth's Systems

Broad Concept: The student will investigate and understand the various structures and processes of the Earth system.

The student will:

- ☐ ESS 1 _____ Analyze various structures of the Earth
 - Define the differences between rocks and minerals
Example: Minerals look the same throughout while you can see different minerals within the rock
 - Compare and classify rocks as igneous, metamorphic and sedimentary
 - Explain the difference between rock and minerals
- ☐ ESS 2 _____ Investigate and understand the major components of soil
 - Know that soil provides support and nutrients necessary for plant growth
 - Identify rock, clay, silt, sand and humus as components of soil
 - Understand soil is a natural resource and should be conserved
 - Identify the ways weathering and erosion occur
- ☐ ESS 3 _____ Understand the water cycle and its relationship to life on Earth
 - Water is essential for living things
 - The water cycle involves the process of evaporation, precipitation and condensation
 - There are many sources of water on Earth (oceans, rivers, lakes, wells, reservoirs)
 - Water on Earth is limited and needs to be conserved

Suggested Resources:

Adventures of the Argonauts, All About Astronomy, Astronomy: Our Place in Space, Blast Off on a Trip to Our Solar System, Earth Guide, Go to the Head of the Solar System, JPL Virtual Field Trip, NASA Kids, Our Solar System, Shoot a Cannonball into Orbit, Solar System, The Solar System, Space Fun & Games, Sun, Moon and Stars, To the Moon

STREAM Perspectives

Broad Concept: Students will establish an understanding of God's place and love for His creation of planet Earth.

- Define a simple problem related to ways to stay healthy, i.e., good nutrition, cleanliness, exercise, sleep habits that can be solved through the development of a new or improved object or tool.
- Demonstrate an awareness of God as creator of all things.
- Debate the merit of a solution to a problem caused by human lack of care for creation.
- Identify and describe ways to respect the sanctity of human life.

Life and Environmental Science: Interrelationships in Ecosystems: Plants, Animals and Their Environment

Broad Concept: Students are expected to develop an understanding of the impact of environment changes; some organisms survive and reproduce, some move to new habitats, some move into a new or transformed environment, and some die.

The student will:

- ☐ LS 1 _____ Construct an argument that some animals form groups that help members survive
 - Populations and communities
 - Predator
- ☐ LS 2 _____ Investigate adaptations that allow animals to satisfy life needs and respond to their environment
 - Behavioral adaptations
 - Physical adaptations
- ☐ LS 3 _____ Investigate/understand relationships among organisms in aquatic and terrestrial food chains
 - Producers, consumers, decomposers
 - Herbivores, carnivores, omnivores
- ☐ LS 4 _____ Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago
 - Examples of data could include type, size and distributions of fossils
 - Examples of fossils and environments could include:
 - Marine fossils found on dry land
 - Tropical plant fossils found in Arctic areas
 - Fossils of extinct organisms

- ☐ LS 5 _____ Develop an argument that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all
 - Examples of evidence could include:
 - Needs and characteristics of the organisms and habitats involved
 - The organisms and their habitats make up a system in which the parts depend on each other
- ☐ LS 6 _____ Defend a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there change
 - Examples environmental changes could include:
 - Changes in land features
 - Changes in water, food, temperature and other organisms
 - The human role in conserving limited resources

Suggested Resources:

Fossil Formation and Dinosaurs, Interdependence of life through food chains and food webs, Animal Adaptations

Physical Science: Matter

Broad Concept: The student will investigate and understand that objects are made of materials that can be described by their physical properties.

The student will:

- ☐ PS 1 _____ Identify an object's physical property
 - Know the three states of matter: solid, liquid and gases
 - Know the objects are made of more than one material (e.g., toys, shoes, furniture)
 - Know that physical properties remain the same even if the material is changed in visible size
 - Examples include:**
 - Color
 - Texture
 - Temperature
 - Phase
 - Ability to dissolve in water
 - Recognize the difference between mass and volume of an object

Physical Science: Forces and Their Interactions

Broad Concept: Students will understand what force, motion and energy are and how they are connected.

The student will:

- ☐ PS 1 _____ Investigate and demonstrate the characteristics of a moving object
 - Know that forces cause a change in motion
 - Know that friction is a force that opposes motion
 - Know how motion is described by distance and time

- ☐ PS 2 _____ Investigate the effects of motion on an object

Examples include:

- An unbalanced force on one side of an object can make it start moving
- Balanced forces pushing on a box from both sides will produce no motion

Examples of motion with a predictable pattern could include:

- A child swinging in a swing
- Two children on a see-saw

Physical Science: Sources of Energy

Broad Concept: Students will investigate and understand different sources of energy.

The student will:

- ☐ PS 1 _____ Identify the following sources of energy
- Know that the sun, water and wind are all sources of energy
 - Fossil fuels and nuclear power are sources of energy

Suggested Resources:

Forceful Furniture: Quick class demonstration of balanced and unbalanced forces

Balanced and Unbalanced Forces: A learning module that guides student understanding of balanced and unbalanced forces, and air resistance.

Physical Science: Simple Machines

Broad Concept: Students will understand that simple machines are used to make work easier.

The student will:

- ☐ PS 1 _____ Identify and differentiate the six types of simple machines
- Know the purpose and function of the six simple machines
 - Differentiate and classify specific examples of simple machines found in school and household items:
 - A screwdriver
 - Nutcracker
 - Screw
 - Flagpole pulley
 - Ramp
 - A seesaw
 - Analyze the use of and explain the function of each of the types of simple machines
 - An example would be that an inclined plane is a ramp to make it easier for a heavy object to be moved up or down
 - Identify the simple machines which compose a compound machine, such as scissors or a wheelbarrow

Physical Science: Magnification Tools

Broad Concept: Students will investigate and understand magnification tools.

The student will:

- ☐ PS 1 _____ Analyze the use of:
- A magnifying glass, Microscope, Telescope

GRADE 4

Earth and Space Science: Earth's Place in the Solar System

Broad Concept: The student will investigate and understand the characteristics of Earth and the Solar System.

The Student will:

- ☐ ESS 1 _____ Understand the organization of the Solar System

Concepts include:

- Identify the characteristics of the planets

Examples include:

- Appearance
- Size
- Distance from the sun
- Investigate and understand the Earth in relationship to the moon, sun and other planets. Comparisons may include relative size and position
- Sequence the eight planets in the Solar System based on their position from the sun (Mercury, first from the sun, etc.)
- Sequence the eight planets in the Solar System based on their size (Jupiter is the largest)
- Describe the relative size and position of the moon, stars and planets

Activity: Construct a model of the sun and planets in our Solar System

- ☐ ESS 2 _____ Describe the motions of the Earth, sun and moon

Key Concepts include:

- Describe and differentiate between revolution and rotation of the Earth
- Use terminology to describe the phases of the moon

Examples include:

- Waning or waxing moon
- Full moon
- Crescent moon
- New moon
- Describe how Earth's axial tilt causes the seasons

- ☐ ESS 3 _____ Understand the composition of the Earth, moon and sun

Describe and differentiate between revolution and rotation of the Earth

- Name the eight planets and describe them as either terrestrial planets or gas giants
- Describe the sun's characteristics using size, color and composition

Examples include:

- Solar flares
- Dark spots

Earth and Space Science: Earth's Landforms, Systems and Processes that Shape the Earth

Broad Concept: The student will understand the various processes and changes of Earth's landforms and characteristics, providing deeper understanding of human activity and Earth's natural resources.

The Student will:

- ☐ ESS 1 _____ Compare structures of the Earth's surface
 - Compare Earth's land features (including volcanoes, mountains, valleys, canyons, caverns and islands)
 - Compare Earth's salt and fresh water features (including oceans, rivers, lakes, ponds, streams and glaciers)
- ☐ ESS 2 _____ Evaluate evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time

Examples include:

 - Rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time
 - A canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock
- ☐ ESS 3 _____ Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind or vegetation

Examples of variables to test could include:

 - Angle of slope in the downhill movement of water
 - Amount of vegetation
 - Speed of wind
 - Relative rate of deposition
 - Cycles of freezing and thawing of water
 - Cycles of heating and cooling
 - Volume of water flow
- ☐ ESS 4 _____ Analyze and interpret data from maps to describe patterns of Earth's features
 - Topographic maps of Earth's land and ocean floor
 - Location of mountains, continental boundaries, volcanoes and earthquakes
- ☐ ESS 5 _____ Generate and compare multiple solutions of the impact of Natural Disasters

Examples include: earthquake resistant buildings and monitoring earthquake activity

Suggested Resources:

Interactive Websites:

BBC Kids – Comprehensive website on rocks and soils with readings, games and a quiz

Gemology online – Informative website that lists various gemstones and rocks

Dynamic Planet – Learn about rock characteristics

Exploring Earth – Rock characteristics and formation

Learner.org – Test your knowledge on rock characteristics, formations and cycles

Rocky's Rock Cycle Game – Learn, play or test concepts on the rock cycle

STREAM Perspectives

Broad Concept: Students gain an understanding of the interrelationships of science and the Catholic Faith.

- Discuss Catholic beliefs in relationship to science topics including being good stewards of the Earth
- Debate the evidence of the importance of respecting mind, body and spirit

Life Science: Structure, Function and Information Processing

Broad Concept: Students are expected to build upon an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior and reproduction.

The student will:

- ☐ LS 1 _____ Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior and reproduction
 - Emphasis with internal structures include: plant and animal cell, cell membrane versus cell wall, chloroplasts and shape contrasting the differences between them
 - Emphasis on photosynthesis to include sunlight, chlorophyll, water, CO₂, O₂ and sugar
 - Emphasis on structures include: plant structures (thorns, stems, roots, colored petals and leaves) and animal structures (stomach, lung, brain, heart and skin)
 - Emphasis on reproduction to include: pollination, stamen, pistil, sepal, embryo, spore and seed)
 - Emphasis on plant dormancy
- ☐ LS 2 _____ Investigate how plants and animals in an ecosystem interact with one another and the nonliving environment
 - Behavioral and structural adaptations
 - Organization of communities
 - Flow of energy through food webs
 - Habitats and niches
 - Life cycles
 - Influence of human activity on ecosystems

- ☐ LS 3 _____ Use a model to describe that animals receive different types of information through their senses, process the information in their brain and respond to the information in different ways
- Emphasis is on systems of information transfer

Suggested Resources:

Survival and Adaptations: Great non-fiction reading source

Interactive Brain Fun: Information website with teacher resources

Physical Science: Matter

Broad Concept: Students will describe the properties, structure and changes in matter.

The student will:

- ☐ PS 1 _____ Analyze changes in different states of matter
- Describe the three states of matter (solid, liquid, gas)
 - Demonstrate how heating and cooling can change the different states of a Material

Physical Science: Forms of Energy

Broad Concept: Students will recognize different forms of energy.

The student will:

- ☐ PS 1 _____ Analyze different forms of energy
- Concepts should include:**
- Electrical and mechanical
 - Chemical
 - Kinetic and Potential

Physical Science: Electricity and Magnetism

Broad Concept: Students will investigate and understand the characteristics of electricity and magnetism.

The student will:

- ☐ PS 1 _____ Investigate and understand the characteristics of electricity
- Key Concepts should include:**
- Conductors and insulators
 - Basic circuits and current electricity
 - Static electricity
 - The ability of electrical energy to be transformed into light and motion, and to produce heat

- ☐ PS 2 _____ Determine cause and effect relationships of electric or magnetic interactions

Examples of electric force and magnetic force include:

- The force on hair from an electrically charged balloon
- The electrical forces between a charged rod and pieces of paper
- The force between two permanent magnets
- The force between an electromagnet and steel paperclips
- The force exerted by one magnet versus the force exerted by two magnets
- How the distance between two objects affects strength of the force
- How the orientation of magnets affects the direction of magnetic force

Suggested Resources:

Magnets and Springs: Students test various objects to determine if they have magnetic interactions

Inspector Detector: Design and build a device that can pass above a surface and detect magnetic fields

Invisible Force: Design a setup so that when a steel ball rolls past a magnet, it changes direction and hits a target that's sitting off to the side

Physical Science: Moving Objects

Broad Concept: Students will investigate the characteristics and interactions of moving objects.
The student will:

- ☐ PS 1 _____ Analyze moving objects

Key Concepts include:

- Motion is described by an object's direction and speed
- Changes in motion are related to force and mass
- Friction is a force that opposes motion
- Moving objects have kinetic energy

Suggested Resources:

Gummy Bear Wave Machine: Fun and engaging inquiry-based lab with teacher notes and video

PHET Simulations: Online simulations in a variety of physical science concepts. Lesson plans may accompany many simulations.

GRADE 5

Earth and Space Science: Earth's Place in the Solar System

Broad Concept: The student will extend their understanding of the sun's impact on Earth. Additionally, students will build upon the understanding of the interrelationships of Earth's systems using mapping tools.

The Student will:

- ☐ ESS 1 _____ Support an argument that the differences in the apparent brightness of the sun compared to other stars is due to their relative distance from Earth

Concepts include:

- ☐ ESS 2 _____ Represent data in graphical displays to reveal patterns of:
 - Daily changes in length and direction of shadows
 - Day and night
 - Seasonal appearance of some stars in the night sky

Suggested Resources:

Interactive Websites:

[Astronomy, Our Place in Space](#)

[Earth Guide](#)

[Foss Web Sun, Moon and Stars Learning Module](#)

Earth and Space Science: Earth's Interrelated Systems

Broad Concept: The student demonstrates an understanding of how Earth's major systems interact in various ways.

The Student will:

- ☐ ESS 1 _____ Identify the geosphere, biosphere, hydrosphere and atmosphere
- ☐ ESS 2 _____ Develop a model using an example to describe the ways the geosphere, biosphere, hydrosphere and atmosphere interact.

Examples:

- The influence of the ocean on ecosystems, landform shape and climate
- The influence of the atmosphere on landforms and ecosystems through weather and climate
- The influence of mountain ranges on wind and clouds in the atmosphere

Earth and Space Science: Earth's Structure

Broad Concept: The student will analyze the various structures and processes of the Earth system.

The Student will:

- ☐ ESS 1 _____ Describe the basic structure of Earth's interior
 - Know the features of the crust (core, mantle, crust)
 - Explore the plate tectonic theory and its relationship to the movement of the Earth's crust
 - Describe how Earth's surface is constantly changing as a result of movement of these plates. Examples: earthquakes, volcanoes and mountain building
 - Plot the locations of volcanoes and earthquakes to illustrate a pattern of geological activity and how this pattern may help to predict them
 - Examine topographical maps
- ☐ ESS 2 _____ Investigate and understand how Earth's surface is constantly changing
Key concepts include:
 - Identification of rock types
 - The rock cycle and how transformations between rocks occur
 - Earth history and fossil evidence
 - Weathering, erosion and deposition
 - Human impact
- ☐ ESS 3 _____ Demonstrate an understanding of weather patterns and phenomena and make connections to weather in a particular place and time
 - Compare daily and seasonal changes in weather conditions (including wind speed and direction, precipitation and temperature) and patterns
 - Predict upcoming weather events from weather data collected through observations and measurements
 - Explain how global patterns such as the jet stream and water currents influence local weather in measurable terms such as temperature, wind direction and speed and precipitation
 - Identify and describe the different types of weather fronts and the weather conditions associated with each

Suggested Resources:

Virtual Lab: Ecosystems, Organisms and Trophic Levels – Interactions throughout Earth's systems

Interactive Website:

Tree House Weather Kids – Atmospheric Interactions and Weather

Kid Storm – Atmospheric Interactions and Extreme Weather Patterns

STREAM Perspectives

Obtain and combine information about ways Catholic and other religious communities use science to protect the Earth's resources and environment.

Life Science: Energy in Organisms and Ecosystems

Broad Concept: Using models, students can describe the movement of matter among plants, animals, decomposers and the environment and that energy in animals' food was once energy from the sun.

The student will:

- ☐ LS 1 _____ Construct models to describe that energy in animals' food was once energy from the sun. This food is used for metabolic processes: body repair, growth, motion and maintenance of body warmth.
 - Examples of models could include diagrams and flowcharts
 - Emphasis is on cell components and functions to include the mitochondria, ATP, nucleus and DNA
- ☐ LS 2 _____ Defend an argument that plants get the materials they need for growth from air and water
 - Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil
- ☐ LS 3 _____ Develop a model to describe the movement of matter and energy among plants, animals, decomposers and the environment
 - Emphasis is on the concept that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food and plant structures.
- ☐ LS 4 _____ Investigate and understand that organisms are made of cells and have distinguishing characteristics.
 - Basic cell structures and functions (animal and plant cells)
 - Kingdoms of living things
 - Vascular and nonvascular plants
 - Vertebrates and invertebrates

Suggested Resources:

Interactive Notes: Northwestern University provides an interactive note page on Decomposers.

- Lesson Idea: Photosynthesis and dinosaurs
- Interdependence of life through food chains and food webs
- Animal Adaptations

Physical Science: Matter and Its Interactions

Broad Concept: Students will extend conceptual understandings of matter and its interactions with various substances.

The student will:

- ☐ PS 1 _____ Develop a model to describe that matter is made of particles too small to be seen
 - Examples of evidence to include:
 - Adding air to expand a basketball
 - Compressing air in a syringe
 - *Dissolving sugar in water
 - *Evaporating salt water
 - Emphasis on atomic structure to include:

- Electrons
- Protons
- Neutrons
- Nucleus

- ❑ PS 2 _____ Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling or mixing substances, the total mass of matter is conserved.
 - Examples of changes or reactions:
 - Changes in states of matter
 - Dissolving to form new substances
 - Mixing to form new substances
- ❑ PS 3 _____ Make observations and measurements to identify materials based on their properties
 - Examples of materials to identify:
 - Baking soda and other powders
 - Metals
 - Minerals
 - Liquids
 - Examples of properties include:
 - Color
 - Hardness
 - Reflectivity
 - Electrical conductivity
 - Thermal conductivity
 - Density
 - Solubility
- ❑ PS 4 _____ Emphasis should include the Periodic Table of Elements and categorical properties; metals/nonmetals, groups/families and atomic number
- ❑ PS 5 _____ Conduct an investigation to determine whether the mixing of two or more substances results in new substances

Suggested Resources:

BBC School Science Clips: [Solids and Liquids](#)

Science Net Links: [Hot and Cold Colors](#), interactive investigation

[SciLinks](#): Website with links to various properties of matter activities, lessons and investigations

GRADE 6 LIFE SCIENCE

The student will:

- ☐ LS 1 _____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of the Earth
 - Its natural resources
 - Concern for the environment
 - Sensitivity to the consequences of the actions of man
- ☐ LS 2 _____ Incorporate the practices of science and engineering into the study of GeoScience.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results
- ☐ LS 3 _____ Demonstrate mastery of these computational skills:
 - Ability to interpret graphs, charts and tables
 - Use of ratios (fractions, percent and decimals)
 - Use of metric system
 - Use of scales (in relation to ratios)
 - Solve rate problems using both metric & English units

Strand 1: Cells are the basic unit of life

Suggested Resource: Cell Structures – A website with several options to reinforce learning of organelles; links to videos and interactive games.

The student will:

- ☐ 1. _____ Investigate and understand that all living things are made of cells:
 - Key concepts include:
 - State the cell theory
 - Explain how the discovery of microscopes affected the development of the cell theory

- Distinguish between prokaryotes and eukaryotes
- Name organelles and their functions
- ❑ 2. _____ Investigate and understand the processes within a cell:
 - Describe how cells use and make energy (ATP)
 - Describe the process of cell division of both unicellular and multicellular organisms
 - Distinguish between sexual reproduction and asexual reproduction
 - Describe the process of mitosis, identifying each stage and depicting what is happening to DNA
 - Describe the process of meiosis, explaining gametes and haploid number
 - devise a method to test the validity of predictions and

Strand 2: Organisms are classified based on characteristics

Suggested Resource: Cereal Box Canvas – Using a cereal box as the canvas for information, students describe a disease caused by a bacteria or a virus.

The student will:

- ❑ 1. _____ Differentiate among organisms based on specific characteristics:
 - Key concepts include:
 - Distinguish between producers, consumers and decomposers
 - Differentiate between prey and predators, as well as adaptations of each
 - State characteristics of unicellular organisms, including bacteria, archaea and protists
 - Use the system of binomial nomenclature, naming the eight levels of classification
 - Recognize the similarities of organisms based on domain, kingdom and phylum
 - List characteristics of different kingdoms
 - Use a dichotomous key to identify an organism
- ❑ 2. _____ Investigate and understand characteristics of plants

Suggested Activity: Photosynthesis Stations – Using a microscope, observe stomata. Diagram photosynthesis. Observe transpiration.

Suggested Activity: Interpreting A Food Web – Worksheet to practice identifying parts of a food web.

- Key concepts include:
 - State differences between plant cells and animal cells, including chloroplasts and cell walls
 - Describe plant reproduction, including seeds, pollen, fruit and flowers
 - Explain the process of photosynthesis, including the energy transformation and the chemical reaction
 - Recognize plants' role as a producer and a foundation of the food web

- ❑ 3. _____ Investigate and understand characteristics of animals

Suggested Resource: Effects of Insulation – An experiment designed to test how insulation affects temperature changes, including data tables and graphing.

Suggested Activity: Life Science – Classification

Suggested Activity: Life Science – Body Systems

- Key concepts include:
 - State differences between invertebrates and vertebrates
 - Describe adaptations animals have to live in terrestrial or aquatic environments
 - Recognize animals' role as a consumer and/or decomposer within the food web
 - Describe the levels of organization: cell, tissue, organ, organ system, organism
 - State function of, name organs within, and describe disorders/diseases related to a body system: skeletal, muscular, respiratory, digestive, excretory, circulatory, immune, integumentary, nervous, endocrine, respiratory
 - Explain homeostasis
 - Give examples of growth and development occurring in an organism

Strand 3: Organisms pass traits to offspring through heredity

Suggested Resource: Learn Genetics – This is a valuable resource from the University of Utah when introducing genetics to middle school students. It includes teacher resources and lesson plans.

The student will:

- ❑ 1. _____ Investigate patterns of heredity:
- Key concepts include:
 - State contributions of Gregor Mendel
 - Distinguish between characteristics and traits
 - Distinguish between genes and chromosomes
 - Explain the relationship of genes and chromosomes to the passing of characteristics
 - Relate meiosis and mitosis to the process of inheriting traits
 - Explain the difference between dominant and recessive traits
 - Use a Punnett square to predict the genotype and phenotype of offspring, using different ratios (fractions and percentages)
 - Describe characteristics of genetic disorders

Suggested Activity: Life Science – Disorders & Diseases

- ☐ 2._____ Investigate how patterns of heredity can change over time.

Suggested Resource: Charles Darwin Game – An interactive game reinforcing the concepts of natural selection by the Science Channel.

Suggested Resource: Evolution & DNA – *ENSI* is a site supported by Indiana University, which offers lessons and labs on evolution, DNA and the origin of life

Suggested Resource: Natural Selection – Interactive webquest based on natural selection

- Key concepts include:
 - Explain that variations in DNA and RNA code affects protein synthesis
 - Describe the use of selective breeding in agriculture
 - Relate natural selection within an environment to heredity
 - Name and describe specific genetic mutations: substitution, insertion, deletion
 - Describe evolution of characteristics demonstrated by fossil records

Strand 4: Ecosystems are dynamic and within an ecosystem, populations interact

Suggested Resource: Predator & Prey – And interactive simulation that allows students to manipulate the predator/prey relationship and observe effects on population.

Suggested Activity: Life Science - Biomes

The student will:

- ☐ 1._____ Investigate the need for food/energy:

- Key concepts include:
 - Describe the relationship among predator/prey and the impact of competition
 - Describe the interaction within a symbiotic relationship
 - Explain the relationship among producers, consumers and decomposers within a food web

- ☐ 2._____ Investigate the role of human impact within an ecosystem:

- Key concepts include:
 - Distinguish between the different biomes based on descriptive characteristics
 - Describe different types of pollution
 - State population factors that affect (threaten or enhance) species survival
 - Explain methods of environmentally aware stewardship within an ecosystem

GRADE 7 PHYSICAL SCIENCE

The student will:

- ☐ PS 1 _____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of the Earth
 - Its natural resources
 - Concern for the environment
 - Sensitivity to the consequences of the actions of man

- ☐ PS 2 _____ Incorporate the practices of science and engineering into the study of GeoScience.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results

- ☐ PS 3 _____ Demonstrate mastery of these computational skills:
 - Ability to interpret graphs, charts and tables
 - Use of ratios (fractions, percent and decimals)
 - Use of metric system
 - Use of scales (in relation to ratios)
 - Solve rate problems using both metric & English units

Strand 1: Physics

Suggested Activity: Physical Science – Team Building

Suggested Resource: STEM: Physics – Great STEM resource

Concept 1: Work, Force, and Motion

Suggested Resource: Physics in Sports – Fantastic short videos explaining the physics of everyday actions, including physics of NHL hockey, NASCAR, NFL football, etc.

Suggested Resource: Create a Graph – This is an easy to use by comprehensive student graphing site that can be used when teaching graphs and charts or can be used to graph student experimental results

Suggested Resource: Foil Boats – An engineering experiment, creating boats from foil

Suggested Resource: Science of Speed – NSF pairs with NASCAR for the “Science of Speed”

Suggested Activity: Physical Science – Forces & Motion

Suggested Activity: Physical Science – Speed

The student will:

- ❑ 1. _____ Investigate and understand the scientific principles of work, force and motion:
 - Key concepts include:
 - Define, calculate using SI units and analyze speed, velocity and acceleration
 - Define, calculate and analyze power, work and force
 - Recognize simple and complex machines and define, calculate and analyze mechanical advantage and efficiency
 - State and apply Newton’s laws of motion
 - Technological applications of work, force and motion
 - Use dimensional analysis to convert units of rate
 - Key concepts for areas of elaboration include:
 - Horsepower
 - Centripetal force

Concept 2: Sound and Light

Suggested Resource: Wave Interference – Demonstrate wave interference

The student will:

- ❑ 2. _____ Investigate and understand the characteristics of sound and light waves:
 - Key concepts include:
 - Define, calculate using SI units and analyze wavelength, frequency and speed
 - Identify the parts of a transverse wave, including wavelength, amplitude, trough, crest
 - Identify the parts of a longitudinal wave, including wavelength, rarefaction, compression
 - Understand characteristics of sound, including resonance, reverberation and interference
 - Understand characteristics of light, including diffraction, reflection and refraction (lenses and mirrors), electromagnetic spectrum
 - Technological applications of sound and light
 - Key concepts for areas of elaboration include:
 - Color and prisms

Concept 3: Energy

Suggested Resource: Skate Board Park – Students create the skate board park, with interactive graphs and measurements to demonstrate energy transformation.

The student will:

- ❑ 3. _____ Investigate and understand states and forms of energy, as well as changes in energy.
 - Key concepts include:
 - Understand potential and kinetic energy and the transformation between the two
 - Differentiate between heat, mechanical, chemical, electrical, thermal, radiant and nuclear energy
 - Understand the Law of Conservation of Matter and Energy
 - Define conduction, convection and radiation
 - Research energy production from fusion and fission
 - Technological applications of energy
 - Key concepts for areas of elaboration include:
 - Calculate potential and kinetic energy
 - Transfer of energy: heat to light and chemical to electric and light to chemical
 - Research alternative energy sources

Concept 4: Electricity and Magnetism

Suggested Resource: Electromagnet – An experiment designed to create and to test an electromagnet, including data tables and graphing.

Suggested Activity: Physical Science - Circuits

The student will:

- ❑ 4. _____ Investigate and understand basic principles of electricity and magnetism.
 - Key concepts include:
 - Investigate and explain static electricity
 - Explain current electricity, using parallel and series circuits as well as alternating and direct currents
 - Describe the relationship between a magnetic field and electric current
 - Explain uses of electromagnets, motors and generators
 - Differentiate among conductors, semiconductors and insulators
 - Technological applications of electricity and magnetism
 - Key concepts for areas of elaboration include:
 - Attraction and repulsion
 - Appliances, electronics, computers
 - Suggested activity – Physical Science - Circuits

Strand 2: Chemistry

Suggested Resource: Middle School Chemistry – Free Science Activities, Access Chemistry Multimedia

Suggested Resource: Safety in the Laboratory – This is a comprehensive six-hour online safety training program created by Flinn Scientific. The 40 separate video chapters that make up the course may be viewed either individually or as part of a certification sequence.

Suggested Resource: Physical Science Practice – This is Chem4Kids, an easy to access resource for physical science students (includes practice quizzes)

Concept 1: The Atom

The student will:

- ❑ 1. _____ Investigate the atomic nature of matter.
 - Key concepts include:
 - Construct and explain models that illustrate the structure of the atom, including Bohr and electron cloud
 - Describe location, charge and relative size of protons, neutrons and electrons
 - Describe the contributions of Dalton, Thomson, Rutherford and Bohr to the atomic model
 - Key concepts for areas of elaboration include:
 - Ions and isotopes

Concept 2: The Periodic Table

Suggested Resource: chrome-extension://chachkegffmilnmdlonllkhkfkakghieInteractivePeriodicTable/app/PeriodicTable.html – Easy to use interactive periodic with preferences tab that lets you highlight specifics and change units. Online quiz available.

Suggested Resources: <http://www.periodicvideos.com/index.htm> - 118 informative short videos on the elements sponsored by the University of Nottingham

Suggested Activity: Physical Science – Chemical reactions

Suggested Activity: Physical Science – Density

The student will:

- ❑ 2. _____ Obtain and explain information from the periodic table.
 - Key concepts include:
 - Recognize symbols of elements, atomic number and atomic mass
 - Identify characteristics of families (groups) and periods
 - Classify elements as metals, metalloids and nonmetals
 - Key concepts for areas of elaboration include:
 - Oxidation number
 - Synthetic elements

Concept 3: Classes of Matter

The student will:

- ☐ 3. _____ Investigate, identify and classify characteristic classes of matter.
 - Key concepts include:
 - Solids, liquids and gases
 - Acids, bases and salts
 - Solutions, suspensions and colloids
 - Elements, compounds and mixtures
 - Saturated and supersaturated solutions
 - Organic and inorganic substances

Concept 4: Properties and Changes of Matter

The student will:

- ☐ 4. _____ Investigate and explain properties and changes of matter.
 - Key concepts include:
 - Describe and identify physical properties (including shape, density, color, odor, solubility)
 - Explain the effect of temperature and particle size on solubility
 - Describe and identify chemical properties (pH, reactivity, combustibility)
 - Describe and identify evidence of chemical reactions (including types of reactions, reactants/products)
 - Describe and identify evidence of nuclear reactions (fission and fusion)

Concept 5: Bonding

Suggested Resource: Balancing Equations #1 – Online practice balancing equations; varying levels of difficulty

Suggested Resource: Balancing Equations #2 – Online practice balancing equations; visually demonstrating with atom representations

The student will:

- ☐ 5. _____ Describe the formation of compounds through ionic and covalent bonding.
 - Key concepts include:
 - Describe the nature of bonding: ionic and covalent
 - Write formulas and name compounds
 - State the law of theory of conservation of matter and energy
 - Use balanced chemical equations to describe chemical reactions

GRADE 8 EARTH SCIENCE

The student will:

- ☐ ES 1 _____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of the Earth
 - Its natural resources
 - Concern for the environment
 - Sensitivity to the consequences of the actions of man
- ☐ ES 2 _____ Incorporate the practices of science and engineering into the study of GeoScience.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results
- ☐ ES 3 _____ Demonstrate mastery of these computational skills:
 - Ability to interpret graphs, charts and tables
 - Use of ratios (fractions, percent and decimals)
 - Use of metric system
 - Use of scales (in relation to ratios)
 - Solve rate problems using both metric & English units

Strand 1: Earth's Place in the Universe

Concept 1: The Universe and Its Stars

The student will:

- ☐ 1. _____ Observe, describe, predict and explain patterns of the apparent motion of the sun, the moon and stars in the sky using models
- ☐ 2. _____ Describe that the universe began with a period of extreme and rapid expansion known as the Big Bang

- ☐ 3. _____ Understand Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe
- ☐ 4. _____ Describe the position and motion of our solar system in our galaxy and the overall scale, structure and age of the universe
- ☐ 5. _____ Be familiar with units used to measure the scale of our solar system, namely astronomical units and light years
- ☐ 6. _____ Understand that the light year is the unit of measurement used for distances in space

Concept 2: Earth and the Solar System

The student will:

- ☐ 1. _____ Recognize that the solar system consists of the sun and a collection of objects, including planets, their moons and asteroids, comets and meteors that are held in orbit around the sun by its gravitational pull on them
- ☐ 2. _____ Compare the relative sizes and distances of the Sun, Moon, Earth, other major planets, moons, asteroids, Kuiper Belt Object (KBO) or plutoids, and comets
- ☐ 3. _____ Categorize planets as terrestrial or Jovian planets
- ☐ 4. _____ Recognize that Pluto is not a planet; it is a dwarf planet with characteristics similar to a KBO
- ☐ 5. _____ Locate the Asteroid Belt and the Kuiper Belt
- ☐ 6. _____ Use a model of the solar system to explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars
- ☐ 7. _____ Describe how the Earth's axis is tilted
- ☐ 8. _____ Explain how seasons and Earth's tilted axis are related
- ☐ 9. _____ Describe the Moon's phases
- ☐ 10. _____ Diagram lunar and solar eclipse

Concept 3: The Sun

The student will:

- ☐ 1. _____ Identify patterns in solar activities (sunspot cycle, solar flares, solar wind)
- ☐ 2. _____ Relate events on the Sun to phenomena such as auroras, disruption of radio and satellite communications, and power grid disturbances
- ☐ 3. _____ Describe how nuclear fusion produces energy in the Sun

Suggested Activity: Earth Science – Graphing Solar Activity

Concept 4: Stellar Evolution

The student will:

- ☐ 1. _____ Explain how the Hertzsprung-Russell (H-R) diagram can be used to infer the Temperature, life span and mass of a star from its color
- ☐ 2. _____ Explain how the balance between fusion and gravity controls the evolution of a star (equilibrium)
- ☐ 3. _____ Describe how nuclear fusion and other processes in stars have led to the formation of all the other chemical elements

Concept 5: Space Exploration and Space History

The student will:

- ☐ 1. _____ Follow the history of space exploration
- ☐ 2. _____ Describe the technology and advancements required for space exploration

Concept 6: The History of Planet Earth

The student will:

- ☐ 1. _____ Describe how evidence from rocks allows understanding of the evolution of life on Earth
- ☐ 2. _____ Recognize similarities between Earth processes today to those that occurred in the past
- ☐ 3. _____ State major catastrophic events, such as volcanic eruptions or the impacts of asteroids, that have affected life on Earth
- ☐ 4. _____ State the Law of Superposition and Principle of Horizontality
- ☐ 5. _____ Use evidence from geologic layers and radioactive dating to indicate Earth's age
- ☐ 6. _____ Use evidence from fossils to determine changes in life and environmental conditions over time
- ☐ 7. _____ Determine the approximate age of a sample, when given the half-life of a radioactive substance (in graph or tabular form)
- ☐ 8. _____ Identify a sequence of geologic events using relative-age dating principles

Strand 2: Earth's Systems

Concept 1: Earth Materials and Systems

The student will:

- ☐ 1. _____ Understand that Earth's processes are dependent upon cycles (energy and matter)
- ☐ 2. _____ Recognize that the flow of energy and matter produce chemical and physical changes in Earth's materials and living organisms

Concept 2: Geologic Processes

The student will:

- ☐ 1. _____ Describe the theory of plate tectonics and continental drift
- ☐ 2. _____ Describe the movement of Earth's continental and oceanic plates through time, beginning with Pangaea
- ☐ 3. _____ Associate plate movement with climate change, distribution of organisms (past and present) and geographic similarities on different continents
- ☐ 4. _____ Describe the process of convection and how it affects seafloor spreading
- ☐ 5. _____ Explain how plate tectonics accounts for the features and processes that occur on or near the Earth's surface
- ☐ 6. _____ Diagram three types of plate boundaries (divergent, convergent and transform) and describe geographic features associated with them (e.g., continental rifts and mid-ocean ridges, volcanic and island arcs, deep-sea trenches, transform faults)

Suggested Activity: Earth Science – Pangaea Reconstruction

Suggested Activity: Earth Science – Plate Tectonics

Concept 3: Interior Earth

The student will:

- ☐ 1. _____ Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated
- ☐ 2. _____ Describe layers of Earth, including lithosphere and asthenosphere
- ☐ 3. _____ Validate the models of the interior of the Earth

Concept 4: The Solid Earth

The student will:

- ☐ 1. _____ Explain the origin of Virginia landforms and the physiographical provinces of Virginia
- ☐ 2. _____ Describe and identify surface features using maps and satellite images of Virginia
- ☐ 3. _____ Explain how physical and chemical weathering leads to erosion and the formation of soils and sediments
- ☐ 4. _____ Describe how coastal features are formed by wave erosion and deposition
- ☐ 5. _____ Use the distribution of earthquakes and volcanoes to locate and determine the types of plate boundaries
- ☐ 6. _____ Describe how the sizes of earthquakes and volcanoes are measured or characterized
- ☐ 7. _____ Describe the effects of earthquakes and volcanic eruptions on humans
- ☐ 8. _____ Explain how volcanoes change the atmosphere, hydrosphere and other Earth systems
- ☐ 9. _____ Explain primary (P) and secondary (S) seismic wave and how to determine the Epicenter of an earthquake
- ☐ 10. _____ Describe the three major types of volcanoes (shield volcano, stratovolcano and cinder cones)
- ☐ 11. _____ Describe habitat changes as a result of earthquakes and volcanoes
- ☐ 12. _____ Understand the value of mapping the history of natural hazards in a region in order to forecast the locations of future events

Suggested Activity: Earth Science – Longitude

Concept 5: Rocks and Minerals

The student will:

- ☐ 1. _____ Identify common rock-forming minerals (quartz, feldspar, biotite, calcite, hornblende)
- ☐ 2. _____ Identify common igneous, sedimentary and metamorphic rocks
- ☐ 3. _____ Describe the processes that change one kind of rock into another (rock cycle)
- ☐ 4. _____ Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition
- ☐ 5. _____ Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive
- ☐ 6. _____ Explain how the texture (foliated, nonfoliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism

Strand 3: The Fluid Earth

Concept 1: The Roles of Water in Earth's Surface Processes

The student will:

- ☐ 1. _____ Describe the water cycle
- ☐ 2. _____ Describe gyres
- ☐ 3. _____ Explain how the Coriolis effect controls oceanic circulation
- ☐ 4. _____ Explain how changes in temperature and salinity cause variations in density, which drive a global pattern of interconnected ocean currents
- ☐ 5. _____ Compare and contrast surface water systems (lakes, rivers, streams, wetlands)
- ☐ 6. _____ Explain how water quality in both groundwater and surface systems is impacted by land use decisions
- ☐ 7. _____ Explain how the Chesapeake Bay was formed
- ☐ 8. _____ Identify the major watersheds of the Chesapeake Bay, including major tributaries
- ☐ 9. _____ Analyze the human impact on the watershed as a result of runoff
- ☐ 10. _____ Explain the types, process and beneficial functions of wetlands

Suggested Activity: Earth Science – James River Tour

Suggested Activity: Earth Science – Groundwater

Concept 2: Weather and Climate

The student will:

- ☐ 1. _____ Gather basic information from weather maps including fronts, systems and basic measurements
- ☐ 2. _____ Describe the effects of latitude, altitude, geography and oceans on weather
- ☐ 3. _____ Explain the effects of greenhouse gas
- ☐ 4. _____ Describe heat transfer by ocean currents and winds, including global wind belts
- ☐ 5. _____ Explain the differences between maritime, continental, tropical and polar air masses
- ☐ 6. _____ Investigate natural and human-caused changes to the atmosphere
- ☐ 7. _____ Describe the composition and layers of the atmosphere
- ☐ 8. _____ Describe methods to reduce ozone depletion
- ☐ 9. _____ Describe relative humidity in terms of the moisture content of the air and the moisture capacity of the air and how these depend on the temperature
- ☐ 10. _____ Interpret a weather map, describing present weather conditions and predicting changes in weather
- ☐ 11. _____ Describe the various conditions of formation associated with severe weather
- ☐ 12. _____ Describe the damage resulting from and the social impact of severe weather
- ☐ 13. _____ Analyze data, including climate and geological evidence, to find relationships between global temperatures and changes in the atmosphere composition

Suggested Activity: Earth Science – Earth's Atmospheric Layers

Strand 4: Earth and Human Activity

Concept 1: Natural Resources

The student will:

- ☐ 1. _____ Know different natural energy and material resources and know how to classify them as renewable or nonrenewable
- ☐ 2. _____ Understand the interactions between Earth systems and human activities
- ☐ 3. _____ Describe renewable and nonrenewable sources of energy for human Consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits

Concept 2: Biogeology

The student will:

- ☐ 1. _____ Describe how evolution is shaped by Earth's varying geological conditions
- ☐ 2. _____ Relate evolution to the changes in land surfaces and the composition of soil, atmosphere and hydrosphere

Suggested Activity: Earth Science - Avalanche

HIGH SCHOOL GEOSCIENCE

The student will:

- ☐ GS.A_____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of the Earth
 - Its natural resources
 - Concern for the environment
 - Sensitivity to the consequences of the actions of man
- ☐ GS.B_____ Incorporate the practices of science and engineering into the study of GeoScience.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results

The student will:

- ☐ GS.1_____ Plan and conduct investigations in which:
 - a) Volume, area, mass, elapsed time, direction, temperature, pressure, distance, density and changes in elevation/depth are calculated utilizing the most appropriate tools
 - b) Technologies, including computers, probeware and geospatial technologies, are used to collect, analyze and report data and to demonstrate concepts and simulate experimental conditions
 - c) Scales, diagrams, charts, graphs, tables, imagery, models and profiles are constructed and interpreted
 - d) Maps and globes are read and interpreted, including location by latitude and longitude
 - e) Variables are manipulated with repeated trials
 - f) Current applications are used to reinforce Earth science concepts

- ☐ GS.2_____ Demonstrate an understanding of the nature of science and scientific reasoning and logic.
 - Key Concepts Include:
 - a) Science explains and predicts the interactions and dynamics of complex Earth systems
 - b) Evidence is required to evaluate hypotheses and explanations
 - c) Observation and logic are essential for reaching a conclusion
 - d) Evidence is evaluated for scientific theories

- ☐ GS.3_____ Investigate and understand the characteristics of Earth and the solar system.
 - Key Concepts Include:
 - a) Position of Earth in the solar system
 - b) Sun-Earth-Moon relationships (seasons, tides and eclipses)
 - c) Characteristics of the sun, planets and their moons, comets, meteors and asteroids
 - d) The history and contributions of space exploration

- ☐ GS.4_____ Investigate and understand how to identify major rock-forming and ore minerals based on physical and chemical properties.
 - Key Concepts Include:
 - a) Hardness, color and streak, luster, cleavage, fracture and unique properties
 - b) Uses of minerals

- ☐ GS.5_____ Investigate and understand the rock cycle as it relates to the origin and transformation of rock types and how to identify common rock types based on mineral composition and textures.
 - Key Concepts Include:
 - a) Igneous rocks
 - b) Sedimentary rocks
 - c) Metamorphic rocks

- ☐ GS.6_____ Investigate and understand the differences between renewable and nonrenewable resources.
 - Key Concepts Include:
 - a) Fossil fuels, minerals, rocks, water and vegetation
 - b) Advantages and disadvantages of various energy sources
 - c) Resources found in Virginia
 - d) Environmental costs and benefits

- ☐ GS.7_____ Investigate and understand geologic processes including plate tectonics.
 - Key Concepts Include:
 - a) Geologic processes and their resulting features
 - b) Tectonic processes

- ☐ GS.8_____ Investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans.
- Key Concepts Include:
 - a) Processes of soil development
 - b) Development of karst topography
 - c) Relationships between groundwater zones, including saturated and unsaturated zones, and the water table
 - d) Identification of sources of fresh water including rivers, springs, and aquifers, with reference to the hydrologic cycle
 - e) Dependence on freshwater resources and the effects of human usage on water quality
 - f) Identification of the major watershed systems in Virginia, including the Chesapeake Bay and its tributaries
- ☐ GS.9_____ Investigate and understand that many aspects of history and evolution of Earth and life can be inferred by studying rocks and fossils.
- Key Concepts Include:
 - a) Traces and remains of ancient, often extinct, life are preserved by various means in many sedimentary rocks
 - b) Superposition, cross-cutting relationships, index fossils, and radioactive decay are methods of dating bodies of rock
 - c) Absolute and relative dating have different applications but can be used together to determine the age of rocks and structures
 - d) Rocks and fossils from many different geologic periods and epochs are found in Virginia
- ☐ GS.10_____ Investigate and understand that oceans are complex, interactive physical, chemical, geological and biological systems that are subject to long-and short-term variations.
- Key Concepts Include:
 - a) Physical and chemical changes related to tides, waves, currents, sea level and ice cap variations, upwelling and salinity variations
 - b) Importance of environmental and geologic implications
 - c) Systems interactions
 - d) Features of the sea floor as reflections of tectonic processes
 - e) Economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay

- ❑ GS.11_____ Investigate and understand the origin of evolution of the atmosphere and the interrelationship of geologic processes, biologic processes and human activities on its composition and dynamics.
- Key Concepts Include:
 - a) Scientific evidence for atmospheric composition changes over geologic time
 - b) Current theories related to the effects of early life on the chemical makeup of the atmosphere
 - c) Atmospheric regulation mechanisms including the effects of density differences and energy transfer
 - d) Potential changes to the atmosphere and climate due to human, biologic and geologic activity
- ❑ GS.12_____ Investigate and understand that energy transfer between the sun and Earth and its atmosphere drives weather and climate on Earth:
- Key Concepts Include.
 - a) Observation and collection of weather data
 - b) Prediction of weather patterns
 - c) Severe weather occurrences, such as tornadoes, hurricanes and major storms
 - d) Weather phenomena and the factors that affect climate including radiation, conduction and convection
- ❑ GS.13_____ Investigate and understand scientific concepts related to the origin and evolution of the universe.
- Key Concepts Include:
 - a) The history of astronomy through the ages including key scientists and their contributions to understanding
 - b) Cosmology including the Big Bang theory
 - c) The origin and evolution of stars, star systems and galaxies

BIOLOGY

The student will:

- ☐ BIO.A_____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of natural resources
 - Stem cell research
 - Genetic engineering and cloning
 - *In vitro* fertilization
- ☐ BIO.B_____ Incorporate the practices of science and engineering into the study of Biology.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results

The student will:

- ☐ BIO.1_____ Demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:
 - a) Observations of living organisms are recorded in the lab and in the field
 - b) Chemicals and equipment are used in a safe manner
 - c) Appropriate technology is used for gathering and analyzing data, communicating results, modeling concepts and simulating experimental conditions
 - d) Proper preparation and examination of specimens using a compound light microscope
 - e) Research utilizes scientific literature
 - f) Differentiation is made between a scientific hypothesis, theory and law
 - g) Alternative scientific explanations and models are recognized and analyzed

- ☐ BIO.2_____ Investigate and understand the chemical and biochemical principles essential for life.
- Key Concepts Include:
 - a) Water chemistry and its impact on life processes
 - b) The structure and function of macromolecules
 - c) The nature of enzymes
 - d) The capture, storage, transformation and flow of energy through the processes of photosynthesis, cellular respiration and chemosynthesis
- ☐ BIO.3_____ Investigate and understand relationships between cell structure and function.
- Key Concepts Include:
 - a) Evidence supporting the cell theory
 - b) Characteristics of prokaryotic and eukaryotic cells
 - c) Similarities between the activities of the organelles in a single cell and a whole organism
 - d) The cell membrane model
 - e) The impact of surface area to volume ratio on cell division, material transport, and other life processes
- ☐ BIO.4_____ Investigate and understand common mechanisms of inheritance and protein Synthesis.
- Key Concepts Include:
 - a) Events of the cell cycle
 - b) Gamete formation by meiosis
 - c) Sources of genetic variation
 - d) Historical development of the structural model of DNA
 - e) The structure, function and replication of nucleic acids
 - f) Events involved in protein synthesis
 - g) Cell differentiation
 - h) Prediction of inheritance of traits based on the Mendelian laws of heredity
 - i) Use, limitations and misuse of genetic information
 - j) Exploration of the impact of DNA technologies
- ☐ BIO.5_____ Investigate and understand bases for modern classification systems.
- Key Concepts Include:
 - a) Structural similarities among organisms
 - b) Examination of distinguishing features of organisms in the three Domains and characteristics of viruses and prions
 - c) Fossil record interpretation
 - d) Comparison of developmental stages of different organisms
 - e) Examination of molecular biological and biochemical similarities and differences among organisms
 - f) Interpretation of phylogenetic trees and cladograms

- ❑ BIO.6_____ Investigate and understand how populations change through time.
- Key Concepts Include:
 - a) Evidence found in fossil records
 - b) How genetic variation , reproductive strategies and environmental pressures impact the survival of populations
 - c) Natural selection
 - d) Emergence of new species
 - e) Scientific evidence and explanations for biological evolution
- ❑ BIO.7_____ Investigate and understand dynamic equilibria within populations, communities and ecosystems.
- Key Concepts Include:
 - a) Features of ecosystems
 - b) Interactions within and among populations including trophic levels, carrying capacities, limiting factors and growth curves
 - c) Nutrient cycling with energy flow through ecosystems
 - d) Succession patterns in ecosystems
 - e) The effects of natural events and human activities on ecosystem

CHEMISTRY

The student will:

- ☐ CH.A_____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of natural resources
 - Nuclear energy issues
- ☐ CH.B_____ Incorporate the practices of science and engineering into the study of Chemistry.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results

The student will:

- ☐ CH.1_____ Investigate and understand that experiments in which variables are measured, analyzed and evaluated produce observations and verifiable data.
 - Key Concepts Include:
 - a) Designated laboratory techniques
 - b) Safe use of chemicals and equipment
 - c) Proper response to emergency situations
 - d) Use of appropriate technology is used for gathering data, communicating results and using simulations to model concepts
 - e) Construction and defense of a scientific viewpoint
- ☐ CH.2_____ Investigate and understand that the placement of elements on the periodic table is a function of their atomic structure. The periodic table is a tool used for the investigations of:
 - a) Average atomic mass, mass number and atomic number
 - b) Isotopes, half lives and radioactive decay
 - c) Mass and charge characteristics of subatomic particles
 - d) Families or groups
 - e) Periods

- f) Trends including atomic radii, electro negativity, shielding effect, and ionization energy
- g) Electron configurations, valence electrons, ions and oxidation numbers
- h) Chemical and physical properties
- i) Historical and quantum models

❑ CH.3 _____ Investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations.

- Key Concepts Include:
 - a) Nomenclature
 - b) Writing chemical formulas
 - c) Balancing chemical equations
 - d) Bonding types
 - e) Reaction types
 - f) Understand enthalpy, entropy and free energy and use them to determine the spontaneity of a reaction
 - g) Describe the properties of acids and bases
 - h) Redox reactions
 - i) Factors affecting reaction rates

❑ CH.4 _____ Investigate and understand that chemical quantities are based on molar relationships.

- Key Concepts Include:
 - a) Avogadro's principle
 - b) Molar volume
 - c) Stoichiometric relationships
 - d) Solution concentrations
 - e) pH and pOH

❑ CH.5 _____ Investigate and understand that the phases of matter are explained by kinetic theory and forces of attraction between particles.

- Key Concepts Include:
 - a) Properties of solids, liquids, gases and plasma
 - b) Intermolecular forces
 - c) Understand and use gas laws
 - d) Vapor pressure
 - e) Phase changes
 - f) Molar heats of fusion and vaporization
 - g) Specific heat capacity
 - h) Colligative properties

❑ CH.6 _____ Investigate and understand how basic chemical properties relate to organic chemistry and biochemistry.

- Key Concepts Include:
 - a) Unique properties of carbon that allow multi-carbon compounds
 - b) Macromolecules in living things

PHYSICS

The student will:

- ☐ PH.A _____ Understand the impact of science on human activity and the environment in relation to Catholic morality and beliefs.
 - Key concepts may include:
 - Stewardship of natural resources
 - Nuclear energy issues
- ☐ PH.B _____ Incorporate the practices of science and engineering into the study of Physics.
 - Key concepts include:
 - Asking questions (for science) and defining problems (for engineering)
 - Developing and using models
 - Planning and carrying out investigations
 - Using mathematics and computational thinking
 - Constructing explanations (for science) and designing solutions (for engineering)
 - Engaging in argument from evidence
 - Obtaining, evaluating and communicating information
 - Understanding the limitations of the experimental apparatus and design
 - Understanding the limitations of measured quantities through the appropriate use of significant figures or error ranges
 - Understanding the use of appropriate technology for gathering and analyzing data and communicating results

The student will:

- ☐ PH.1 _____ Investigate and understand how to analyze and interpret data.
 - Key Concepts Include:
 - a) A description of a physical problem is translated into a mathematical statement in order to find a solution
 - b) Relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data
 - c) The slope of a linear relationship is calculated and includes appropriate units
 - d) Interpolated, extrapolated and analyzed trends are used to make predictions
 - e) Situations with vector quantities are analyzed utilizing trigonometric or graphical methods

- ☐ PH.2_____ Investigate and demonstrate an understanding of the nature of science, scientific reasoning and logic.
- Key Concepts Include:
 - a) Analysis of scientific sources to develop and refine research hypotheses
 - b) Analysis of how science explains and predicts relationships
 - c) Evaluation of evidence for scientific theories
 - d) Examination of how new discoveries result in modification of existing theories or establishment of new paradigms
 - e) Construction and defense of a scientific viewpoint
- ☐ PH.3_____ Investigate and understand the interrelationships among mass, distance, force and time through mathematical and experimental processes.
- Key Concepts Include:
 - a) Linear motion
 - b) Uniform circular motion
 - c) Torque
 - d) Rotational motion
 - e) Projectile motion
 - f) Newton's laws of motion
 - g) Gravitation
 - h) Planetary motion
 - i) The impact of frictional forces (static and kinetic)
 - j) Work, power and energy
- ☐ PH.4_____ Investigate and understand that quantities including mass, energy, momentum (including angular) and charge are conserved.
- Key Concepts Include:
 - a) Kinetic and potential energy
 - b) Elastic and inelastic collisions
 - c) Mass/energy equivalence
- ☐ PH.5_____ Investigate and understand that energy can be transferred and transformed to provide usable work.
- Key Concepts Include:
 - a) Transfer and storage of energy among systems including mechanical, thermal, gravitational, electromagnetic, chemical and nuclear systems
 - b) Efficiency of systems
- ☐ PH.6_____ Investigate and understand vibrations and wave phenomena.
- Key Concepts Include:
 - a) Hooke's Law
 - b) Wave characteristics
 - c) Light and sound in terms of wave models
 - d) Interference of waves
 - e) Reflection and refraction
 - f) Mirrors and lenses
 - g) Snell's Law

- ☐ PH.7 _____ Investigate and understand that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves through visible light to gamma radiation.
- Key Concepts Include:
 - a) The properties, behaviors and relative size of radio waves, microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays
 - b) Wave/particle dual nature of light
 - c) Current applications based on the respective wavelengths
- ☐ PH.8 _____ Investigate and understand how to use the field concept to describe the effects of gravitational, electric and magnetic forces.
- Key Concepts Include:
 - a) Inverse square laws (Newton's law of universal gravitation and Coulomb's law)
 - b) Technological applications
- ☐ PH.9 _____ Investigate and understand how to diagram, construct and analyze basic electrical circuits and explain the function of various circuit components.
- Key Concepts Include:
 - a) Ohm's law
 - b) Series, parallel and combined circuits
 - c) Electrical power
 - d) Alternating and direct currents
- ☐ PH.10 _____ Investigate and understand the properties of fluids.
- Key Concepts Include:
 - a) Density and specific gravity
 - b) The pressure exerted by a fluid
 - c) Flow rate
 - d) Archimedes', Bernoulli's and Pascal's Principles
- ☐ PH.11 _____ Investigate and understand that extremely large and extremely small quantities are not necessarily described by the same laws as those studied in Newtonian physics.
- Key Concepts Include:
 - a) Wave/particle duality
 - b) Wave properties of matter
 - c) Matter/energy equivalence
 - d) Quantum mechanics and uncertainty
 - e) Relativity
 - f) Nuclear physics
 - g) Solid state physics
 - h) Nanotechnology
 - i) Superconductivity
 - j) Radioactivity

Suggested Resources – Middle School

Science Video Resources

You can also find them on ...

YouTube – <http://www.youtube.com/user/JeffersonLab>

Facebook – <http://www.facebook.com/JeffersonLab>

Twitter – <http://twitter.com/Jblab>

Below are the http addresses for the resources included within the middle school curriculum.

- Balancing Equations #1 - <http://education.jlab.org/elementbalancing/>
- Balancing Equations #2 - <http://phet.colorado.edu/en/simulation/balancing-chemical-equations>
- Cell Structure - <http://www.neok12.com/Cell-Structures.htm>
- Cereal Box Canvas - <http://www.shellyssciencepot.com/Worksheets/Bacteria-Viruses/CerealBoxDescription-ResearchOrganizer.pdf>
- Charles Darwin Game - <http://science.discovery.com/games-and-interactives/charles-darwin-game.htm>
- Create a Graph - <http://nces.ed.gov/nceskids/createagraph/>
- Effects of Insulation - <http://education.jlab.org/beamsactivity/6thgrade/coldstuff/index.html>
- Electromagnet - <http://education.jlab.org/beamsactivity/6thgrade/magnetsandelectromagnets/index.html>
- Elements videos - <http://www.periodicvideos.com/index.htm>
- Evolution & DNA - <http://www.indiana.edu/~ensiweb/home.html>
- Foil Boats - <http://education.jlab.org/beamsactivity/6thgrade/designandengineering/index.html>
- Science of Speed - http://www.nsf.gov/news/news_summ.jsp?cntn_id=114504
- <http://www.shellyssciencepot.com/DarwinTrip/Task.htm>
- Interactive Periodic Table - <chrome-extension://chachkegffmilnmdlollkhkfkakghie/app/PeriodicTable.html>

- Interpreting A Food Web - <http://www.shellyssciencepot.com/Worksheets/Ecology/InterpretingAFoodWeb.pdf>
- Learn Genetics - <http://learn.genetics.utah.edu/>
- Middle School Chemistry - <http://www.middleschoolchemistry.com/>
- Natural Selection - <http://www.shellyssciencepot.com/DarwinTrip/Task.htm>
- Photosynthesis Station - <http://www.shellyssciencepot.com/Worksheets/Plantae/PhotosynthesisStations.pdf>
- Physical Science - <http://www.chem4kids.com/>
- Physics in Sports - <http://science360.gov/topic/Physics/>
- Predator & Prey - <http://www.sims.scienceinstruction.org/predprey/>
- Safety in the Laboratory - <http://labsafety.flinnsci.com/CourseDetails.aspx?CourseCode=MS>
- Skate Board Park - <https://phet.colorado.edu/en/simulation/energy-skate-park>
- STEM: Physics - <http://www.engr.ncsu.edu/theengineeringplace/educators/k8plans.php>
- Wave Interference - <https://phet.colorado.edu/en/simulation/wave-interference>

Suggested Activities – Middle School

Life Science: Biomes, Climate & Statistics

Objective: To use quantitative data to infer a relationship between rainfall, biome classification, and global location

Materials needed: Access to rainfall data for stated cities; calculator; map or globe
Time needed: One class period (45 minutes)

LAB: Statistics about climate

Find a source that provides numeric data about rainfall for the cities of Helsinki, Cairo, & Johannesburg. You must find data concerning (1) monthly rainfall for at least six different months within a 12 month period & (2) average annual rainfall.

1. Create a data table to organize your collected data (months of year, amount of rainfall, location).
2. Calculate the mean monthly precipitation based on the data found.
3. Compare the mean monthly precipitation you calculated for Helsinki to the average annual precipitation on the chart for Helsinki.
4. Would you expect the months not shown for Helsinki to have more or less precipitation than the months shown? Why?
5. What is the mode for monthly precipitation in Cairo? What does this suggest about the climate in Cairo?
6. Based on what you have learned in this chapter, in which biome do you think each of the three cities lies? Justify your choice
 - a) Helsinki
 - b) Cairo
 - c) Johannesburg
7. Compare the amounts of precipitation in the three locations on the chart. Look at a world map and locate the listed locations. What is the relationship between latitude and precipitation?

Life Science: Body Systems

Subject: Human Biology-Body Parts

Materials needed: Large roll of paper (bulletin board paper works best), markers/crayons/colored pencils, reference materials & computer access

Time required: Several days (depending on the length of class period)

Prior Knowledge: Students will have already been introduced to the human body; discussion will already have been held on various body systems and how they work in the human body

Objective:

To demonstrate understanding of location, size, and shape of major organs within the body & to draw those organs to scale

Procedure:

1. Group students into pairs
2. Measure paper. Have students measure out rolled paper by having partner lie down on paper. Allow about six inches above head and below feet. Cut paper off roll. Switch places and repeat.
3. Trace outline. Roll paper out flat on floor space. Have one partner lie down on paper. Arms and legs should be slightly spread apart. Have partner trace outline of body with pencil. Switch places.
4. Trace outline of body with black marker.
5. Using reference books or computer, have students draw the following body parts, using the appropriate color of marker. Students should have body parts approximately the correct size and in the correct position.
5. Label body parts: heart, lungs, kidneys, small intestine, large intestine, esophagus, stomach, pancreas, liver, bladder, brain, gall bladder
6. Display in hallway

Extension—Other body parts can be added as they are being discussed, such as bones, muscles, etc. They can be added to the drawings or as an overlay on the original drawing

Life Science: Classification

Subject: Living Organisms—Vertebrates

Materials needed: project sheet; students provide own materials related to chosen projects

Time required: Two weeks

Prior knowledge: Students will have completed study of other living organisms. Discuss with students what is a vertebrate and what makes vertebrates different from invertebrates and other living organisms.

Procedure: Discuss project with students to be sure they understand all the requirements. Students divide into groups. Provide reference materials and/or computer access for research.

VERTEBRATES PROJECT

We are beginning the final chapter on living organisms, which are the vertebrates. I will be giving you some notes on vertebrates, but you will be working in groups to learn about the different types of vertebrates—fish, amphibians, reptiles, birds, and mammals. Then your group will present what you learned to the rest of the class.

You will be able to choose the group with which you will work. ALL members of the group must participate. If there is a problem with any member of the group not participating, please see me as soon as possible.

While you will be given time during class to work on this project, you will also have to do some work at home. Decide, as a group, what projects you want to do and then decide who will do what for each group and what you will work on at school and at home. You will be allowed access to the library and the computers, as well as any science equipment you might need. Then just do a great job and work together to complete your assignment!

You will need to complete the two starred projects and your group will complete four additional projects. All work is due on _____, and we will begin presentations that day. Your group will present information on your chosen class of vertebrates.

The two required projects are (1) a written report, typed and submitted in a folder, about your class of vertebrate and (2) a model of a representative animal from your class. You may make the animal out of any material—clay, paper mache, Styrofoam, etc., but it must be large enough for students to see it from all parts of the room. You will also choose 4 projects from the following list. If your group comes up with another idea for a project, please check with me before you begin.

I want you to learn something from all of this, but I also want you to have fun. Enjoy what you are doing, but if you run into problems, please see me. Good luck!

MENU OF PROJECTS

****Written report**—This should list the characteristics of this class of vertebrates, anything special about the class, and representative members of this class.

****Model**—Construct a model of one of the representative members of your class. It can be life sized, but it must be big enough for the whole class to see it. It may be made of any material-styrofoam, paper mache, clay, play doh, etc. Make it look real!

Advertisement—Create an ad advertising your class or vertebrate. This should be poster sized.

Banner—A large flag-like banner showing the different characteristics/animals of your assigned class

Book Jacket—If you were writing a book about your class, what information would you put on the book jacket? Make sure you illustrate the cover

Brochure—A tri-fold brochure about your class and the organisms in it

Card game/board game—Create a game that your classmates could play to demonstrate factual knowledge about your assigned class

Commemorative stamp—The post office creates new stamps all the time. Create a stamp about a member of your class. Make the stamp poster size so it can be seen.

Commercial—Create a commercial about your class. You will perform this for your classmates, or it can be previously taped and simply played for the class.

Diorama—Use a large box to create a diorama of your class of vertebrate(s) in its (their) natural habitat.

Mobile—Create a hanging mobile with either the characteristics or representative members of your class.

One act play—Create a play about your class with the animals of your class describing their characteristics.

Rap/song—Create a rap or song about your class. You will sing it to your classmates.

Poem—Create a poem about your class. It should be at least 12 lines long. It must have a rhyming pattern.

Power Point—Create a power point presentation about your class. You will show it to the class.

Puppet show—Create puppets of the representative animals in your class and perform it for your classmates.

Design an experiment—Create and perform an experiment to test something dealing with your assigned class.

You have a different idea? Let me know!

Life Science – Disorders & Diseases

Objective:

- To research facts concerning an assigned disease or disorder
- To present those facts in a format such as a computer generated pamphlet

Procedure:

Once assigned a disorder/disease, research to complete the following information sheet. Then, use that information to create a pamphlet about your disease/disorder. Your target audience is a patient, age 13. [Consider vocabulary and layout that would appeal to a 13 year old.]

Grading:

Overall grade will be based on accuracy of information, details presented, layout of pamphlet, effectiveness for target audience, and overall appearance.

Name of disease: _____

Physiology (Give a detailed description of what's going on in the body when someone has this disease.)	
Targeted population (Are there groups of people more likely to have this? This can be race, gender, age, etc.)	
Patient complaints (How do they know they are sick?)	
Patient symptoms (What are doctors looking for? Is there a specific test that can be done?)	
Treatment (This can be medicine or it can be a procedure. Describe what positive effect the treatment is supposed to have.)	
Complications from treatment (Sometimes treatments have negative results.)	
Result if untreated (If the person with this disease declines medical help, what are the possible outcomes? Why?)	

Physical Science: Circuit

BATTERY MAKING

Lesson plan developed by Keith DeWeese

Overview:

Students will make batteries out of lemons, potatoes and themselves and hook them up in a variety of ways.

Purpose (Objective):

Students will discover how a battery works, as well as learn how current and voltage relate and interact.

Materials:

Potatoes
Lemons
Galvanized (molten, not electrogalvanized) nails
3" copper wire sections
2 wires with alligator clips on the ends
Sandpaper
Multimeter

Getting Ready (Background Information):

Explain how voltage and current relate using the equation $V=IR$. You can go into great detail about the units used as well (ohms, amperes, volts). Explain how series voltages add together while parallel ones don't. Now explain how parallel currents can add together.

Motivate! (Engage):

Tell the students they are going to make batteries out of lemons or potatoes. This should be enough.

Activity (Explore):

First, sandpaper the copper wires. This isn't always necessary, but junk can build up on them. Next stick the nail and the wire into the potato or lemon. Don't allow them to touch on the inside. Next take the wires with alligator clips and connect one to the nail and one to the copper wire. Measure the voltage with the voltmeter. Measure the current. Now take the whole class's batteries and hook them up in series and parallel and prove that series voltages add together while parallel currents increase one another. Repeat the entire activity letting each student hold the wire in one hand and the nail in the other.

Safety Tips:

The wires and nails can be sharp. Also, lemon juice in the eye hurts! Don't worry — nobody can get shocked in this experiment.

Concept Discovery (Explanation):

Show the kids that if a whole class links together they can generate 15-20 volts. Give examples of what kinds of voltages are used (12 for a car, 120 for house, 1.5 for a battery). Use their fear of getting shocked to explain current and why you have to have current to get shocked.

Going Further (Elaboration):

Talk about large quantities of electricity — transformers and other things. Put the electricity they are making into perspective.

Closure:

Review the concepts again next week. See if they remember current and voltage and the differences between parallel and series circuits.

Assessment (Evaluation):

There is no real way to evaluate anyone on this.

Connections (Integration with Other Content Areas):

This was a good activity to explain prefixes, such as milli. Relating the electronics to meters and grams made this useful.

Physical Science – Density, a physical property

Objective:

- To collect quantitative data using measuring tools & to use that data to calculate derived units
- To determine the relationship between a millimeter & a cubic centimeter
- To use water displacement to determine volume of a solid

Materials needed: 1 cm cubes (4 per group); graduated cylinder (cubes must fit into cylinder); water; calculator

Time: 45 minutes

Procedure:

1. The cubes are identical. Choose one and measure its dimensions. Record.
2. Using those measured values, calculate volume. (Assuming all cubes are equal, compute total volume of the four cubes.)
3. Put approximately 10 mL water in graduated cylinder. Record actual amount.
4. Place 4cubes into the graduated cylinder. Record volume of water with cubes in cylinder.
5. Using those measured values, calculate volume.

LAB ZONE: Directed Inquiry

Measure the cube's height. _____ cm

Measure the cube's length. _____ cm

Measure the cube's width. _____ cm

Calculate the cube's volume. Show work below. _____ cm^3

What is the water's volume before the cubes are added? _____ mL

What is the water's volume after the cubes are added? _____ mL

What is the volume of the cubes? Show work below. _____ mL

POST LAB QUESTIONS

Answer these on separate paper. Use complete sentences. Skip a line between answers.

1. What equipment did you use to find the length of the cube?
2. What is true about the length, the width, and the height of the cube? (HINT: Look at your measurements.)
3. What is the formula to find volume of a cube? Do not abbreviate.
4. What equipment did you use to find the volume of the cube by the volume displacement method?
5. What two measurements did you need to make using the graduated cylinder?
6. How did you calculate volume using the water displacement method?
7. Why would someone prefer to use the water displacement method instead of the ruler method to find the volume of a solid? (HINT: Think about shape.)
8. What is the volume of the cubes in milliliters? What is the volume of the cubes in cubic centimeters?
9. What is true about a milliliter and a cubic centimeter?

Physical Science: Forces & Motion

Marshmallow Catapult (<http://betterlesson.com/lesson/3412/marshmallow-catapults>)

Marshmallow Catapult Design Challenge Description

THIS WILL TAKE ABOUT A WEEK FROM START TO FINISH

Each group will design and build a marshmallow catapult using the following materials to achieve the goal:

- 1 meter of masking tape
- 2 Plastic cups
- 4 Rubber bands
- 2 Plastic spoons
- 2 Paperclips
- 15 cm x 15 cm Piece of cardboard
- Large (standard size) marshmallows to launch

Goal: Launch a marshmallow at least 5 meters (in the air) and not outside of a ½ meter width.

Day 1: Assign activity and partners, discuss rubric, answer questions and allow students time to brainstorm a solution with their partner. Students should individually design a solution and then share their design.

Day 2: Students should design a final solution and create orthographic projections of their design HW: Draw their catapult as a technological system.

Day 3: Students will be given the materials above and will construct their catapults, leave about 5-10 minutes for clean-up and wrap-up. Students should be recording their updates and redesigns in their journal (a few pieces of paper where they will identify constraints, trade-offs, modifications, etc.).

Day 4: Final construction and test!

Tips for test day:

Have students move the desks to the side of the room facing inward. Designate a launch area and measure out a 5-meter line and a half a meter wide span. This designates the acceptable landing area.

Safety: Everyone should wear safety goggles! There will be flying marshmallows and rubberbands might come loose or snap--state these dangers to your students.

Have the rubrics laid out with a pen ready to record the grades. Remember: you'll be judging the quality of the construction before launching. This will allow you to discard the catapults after the launch occurs.

Don't forget to purchase marshmallows. If you do forget, a piece of paper rolled into a ball will work.

Physical Science – Scientific Method



LAB: PAPERING THE SKIES WITH THE SCIENTIFIC METHOD

Adapted by Maricar Harris, based on a creation of Trina L. of Florida for middleschoolscience.com 2002

Purpose: Using a paper airplane, create (complete with procedure and graphed data) and perform a lab to demonstrate the scientific method

Limitations:

- The only materials you are allowed to use during the experiment are: data tables (to record data), ruler or meter stick (because measurements are important), paper (for paper airplane construction), pen (to write data collected), colored pencils/tape/paperclips/staples (to decorate/add to your plane, if you choose to).
- Part of your grade will be based on division of labor and successful input to the group project. Be sure each person has a job to do.

Before you begin constructing your plane,

1. Do an online search to determine how your group wants to fold the paper airplane. Print out those instructions in order to have them in class. The airplane is to be created in class, not at home.
2. You must write out **your step-by-step procedure** for the experiment. If written correctly, the procedure could be given to another group and the same experiment would be performed. Be certain your procedure includes: (not necessarily in this order – just use this as a checklist when you think you’ve written a complete procedure)
 - a. Only one independent variable (What are you changing?)
 - b. Quantity to be measured
 - c. Safety precautions
 - d. Multiple trials per variable
 - e. Data tables (number of columns should match number of trials)
 - f. Observation tables (number of columns should match number of trials)
 - g. Control group (What is the control group?)
3. **Write a hypothesis**. Make a prediction based on the procedure you have developed to use the paper airplane. It must be written in the format “If -----, then ---.” Be sure that what you predict is what you are measuring.
4. **Type the procedure, labeled data & observation tables, and hypothesis**. Assignment description is “Lab: Scientific Method Using Paper Airplanes”. Print two copies, one to submit to Mrs. Harris & one to use while you experiment. Your group will not proceed unless this is submitted. Late work will be penalized. Submit one copy per group. Data & observation tables will be a separate page, with spaces large enough to write data during experiment.

While you experiment:

1. Collect data, writing measurements (with units) in your pre-constructed data tables.
2. Write observations, especially any errors or problems encountered.

After you experiment: [Each of the following will be submitted on a separate piece of paper. Items 2,3,4,5 are to be answered using at least 3-5 complete sentences, typed following middle school guidelines.]

1. **Graph data**, using a line graph. Be sure to follow all graphing instructions. This cannot be computer generated. Mrs. Harris will supply the graph paper.
2. **Write conclusion**. State your hypothesis (which you wrote before beginning the experiment). Was it proven correct or incorrect? What data (outcomes of the experiment) supports this statement?
3. **Write analysis**. Describe anything unexpected that happened during the experiment. What would you do differently to make this experiment run more smoothly next time.
4. **Write summary**. How did your procedure demonstrate the scientific method? Be sure to use specific terminology stated in the textbook and relate those terms to this experiment. Details matter.
5. **Write personal statement**. The purpose of this activity was to demonstrate the scientific method. Was that accomplished? Why or why not? What other things did you learn by doing this experiment?

Write group evaluation. List the members of your group. Specifically state what each person's responsibility was in the before, during, and after phases of this activity. This can be done in sentence format, chart format, or bulleted format.

TEACHER NOTES Objectives or Learner Outcomes.

1. Create an understanding of the scientific method by having students develop their own process to demonstrate steps in the scientific method.
2. Allow the students to use their creative talents to develop a plan that will fulfill the requirements of the assignment and at the same time give them a chance to express themselves in a manner that will help them expand their thinking to reach self-actualization. Tell them to make this an experience that has a uniqueness and personal ownership. Make it show part of themselves.

Suggestions

By not limiting the ways the students can demonstrate the scientific method, it is my hope that they will create a plan that is unique to themselves and gain ownership in a lesson in creativity as well as using the scientific process of solving a problem. This is establishing a non-threatening process which I hope will result in self-expression and creativity.

They are limited to using only the model paper airplane provided but they are not limited as to what they can do with it. An option here would be to have them find their own plane but limit the number of folds to 6.

Possible ideas that could be the outcome of this assignment • decorating the plane to give it personal identity and give it a name • developing a method of flying the plane that is different; different ways of throwing the plane, such as with your eyes open or closed, right or left hand, angle of throwing or at different distances above the ground.

Testing the wind direction and throwing against or with the wind.

- Adding weight to the plane to determine the effect on the plane's ability to fly. Paper clips would be a good addition. Staples
- Taping the plane together so that it has more rigid structure without much additional weight

This process can be expanded to allow students to research and find different models of paper planes. If you decide to allow students to pick their own models, I recommend that you try out some of the models. I put a lot of paper in the trash trying to fold some of the models. Some students will be frustrated by the process of folding and unfolding, others will accept the challenge and go with the flow. This lab or investigation allows for differences in students and gives them a tool to use as they develop their own creativity solutions to complete the assignment.

Here are some websites for different models other than the one used in the original lab.

<http://www.paperairplanes.co.uk>

<http://www.geocities.com/CapeCanaveral/Runway/6095/mainplan.html>

<http://www.zurqui.co.cr/crinfocus/paper/airplane.html>

<http://www.josephpalmer.com/planes/Airplane.shtml>

<http://www.onenorthpole.com/ToyShop/Paperairplanes.html> <http://www.pchelp.net/planes.htm>

http://teams.lacoe.edu/documentation/projects/math/airplane_sites.html

<http://www.khs.com/aboutgpa.htm>

http://www.wannalearn.com/Just_for_Fun/Making_Paper_Airplanes/

<http://www.cbc4kids.cbc.ca/general/the-lab/flights-of-fancy/archive.html>

<http://home.inreach.com/jdcard/engl3007/airplane.htm#OperatingInstructions>

RUBRIC FOR GRADING LAB

Complete in your quadrille. You will get it back ungraded if it is done on a piece of paper and not in your notebook.

- All parts of the lab labeled and the part name underlined 5 points. (Example Hypothesis)
- Hypothesis 5 points
- Tables and Graphs 5 points each if properly labeled
- Procedure 15 points
- All materials 5 points
- Your directions for the lab 10 points (Be creative in your method of doing the lab.)
- Discussion and Conclusion (5 points each) 10 points Discuss and analyze the data collected and your conclusion must either support or disprove your hypothesis
- Total of 45 points

Physical Science: SI measurements

LAB: Tools & Measurements

1. What tool are you using?
2. What measurement are you taking?
3. In what increments is your tool calibrated?
4. Read the index card. Complete the task. Answer the question on the card. (There may be multiple parts to this. Read carefully.) You may refer to your text book and/or class notes to answer these questions.

For each station you visit, the questions above must be answered. Use complete sentences. Answer the questions in the appropriate box on your answer sheet.

STATION A

STATION B

STATION C

STATION D

STATION E

STATION F

REMEMBER: All answers must be written in complete sentences, even measurements.

STATION A:

- a) Use a ruler to measure the length of the leaf. Write down the length. Remember to include units.
- b) What is the difference between length and width?

STATION B:

- a) Use the balance to determine the mass of the beaker. Write down the mass. Remember to include units.
- b) Why should you not touch the balance when measuring mass? (If you touched the balance when measuring, then redo step a and correct your measurement.)

STATION C:

- a) Use the meter stick to measure the width of the table. Write down the length. Remember to include units.
- b) Why must you make sure you measure straight across the table? (If you did not measure straight across when measuring, then redo step a and correct your measurement.)

STATION D:

- a) Use the thermometer to measure the temperature of the water. Do not leave the thermometer in the water unattended. Do not stir with the thermometer. Write down the temperature in degrees Celsius. Remember to include units.
- b) Why is it a safety precaution to NOT leave the thermometer in the water unattended? Be specific.

STATION E:

- a) Pour all of the water in the beaker into the graduated cylinder. Use the graduated cylinder to measure the volume of the water. Write down the volume. Remember to include units. When you're done, pour all of the water back into the beaker for the next group.
- b) What do you call the curved surface at the top of the water? Do you read from the top of the curve or from the bottom of the curve?

STATION F:

- a) Use the spring scale to measure the weight of the metal. Write down the weight. Remember to include units.
- b) How is weight different from mass? State at least three differences.

Physical Science: Speed

Battery Operated Model Car Experiments by Arthur N. DiVito, Ph.D. (copyright © 2000 by A. N. DiVito)

MATERIALS NEEDED:

- stopwatches
- different battery operated model cars (any toy store will have them)
- tape rulers (the longer the better)
-

REMARKS:

The more stopwatches and cars the better. Many students could be involved by having them act as official timers. Actually, this is preferred since mistakes are very common when it comes to working stopwatches. The stopwatches might have a few features which cause re-setting confusion; so, if five timers are employed, a couple could drop out and you'd still have three good readings.

No two cars will operate at the same speed. For fun, it's best to have a good variety of cars, ranging from big-wheel tracksters to little roadsters. It's also a good idea to have extra batteries around. These kinds of cars will run at surprisingly constant rates provided, of course, the surface is level.

THE ACTIVITY:

These experiments must always begin with teams of students determining the velocity (speed, actually, since direction will always be forward) of each car. To do this, they should mark off a pretty good length (30 feet or more), then time the car over the stretch of distance. It would be very unusual for these kind of cars to travel a straight line over such a distance, so it a good idea to use a long stick (yard or meter sticks or longer) to poke the car along its side to keep it in line (with practice, this will work just fine). This determination of each car's velocity must always be done because no car will have the same speed over different battery ages and different surfaces. There are a myriad of experiments that can be performed once these speeds are known. At the very least, the students could be asked to determine how far a particular car would travel in a prescribed number of seconds; or, how long it would take a car to travel a prescribed distance.

Excellent activities include such things as:

- Start two cars (facing each other) at opposite ends of a certain stretch, and determine the time and/or position of their collision.
- Give a slower car a head start, and determine the time and/or position when the faster will catch up to it.

Here's an experiment that can be used to model a compound inequality:

Tie a light string to the back of a slower car so that the total length from the front of the car to the end of the string is, say 20 inches or centimeters. Give this a car a 100 in or cm head start. The question is, over what interval of time will the front of the faster car be between the end of the string and the front of the slower car?

With a little creativity, the sky's the limit for the kinds of activities that clever instructors can devise with these materials.

Physical Science: Team Building

PIPE CLEANER TOWERS ACTIVITY

Contributors: Dr. Laura Bottomley & Heather Smolensky
www.engr.ncsu.edu/theengineeringplace/

Group Size: 3-4

Time Required: 15-20 minutes

Summary: Students will use simple materials to build the tallest, free standing tower within the time constraints and using the efforts of all team members.

Engineering Connection: Engineers work with many different types of materials and must design within the restrictions of a particular problem or project. Cost, type of materials available, time, and other constraints often dictate many aspects of a design. This activity helps students to appreciate the planning, resources, and constraints that often govern an engineer's work, as well as the benefits of team work and diversity.

Learning Objectives:

- ☐ Concept of limited resources and constraints
- ☐ Teamwork
- ☐ Project Planning

Materials: Each group will need:

- ☐ 15 Pipe Cleaners (bundles of 14 with one wrapped around to secure and separate them)

Safety: Caution students that the ends of the pipe cleaner wires may be sharp.

Introduction: Use the information from the section titled 'Engineering Connection' to introduce the activity to students. Tell them that they will be using 'high-tech' materials to build the tallest, free standing tower that they can within certain time constraints. Check for understanding on the term 'free-standing' by asking one of the students to define it for the rest of the group. Then show the students your high-tech materials: pipe cleaners!

Procedure:

1. Either break the students up into groups of 3 or 4, or give them 10 seconds to quietly and quickly choose their team members. The age of students will dictate the procedure that you use.
2. Pass out bundles of 15 pipe cleaners to each group.
3. Tell the students that they will have five to ten minutes to build. Ask for any questions and then tell them to begin.

4. After two to four minutes have passed, tell them to freeze. Tell the students that engineers often work within the restrictions of project plans and budgets and that sometimes resources become available or are eliminated after a project has begun. To symbolize this, for the next five minutes, each team member must place one arm behind her/his back. This restriction generally elicits chatter and enthusiasm amongst the group. Tell the students to continue, and that they have three minutes left to build (Modification: you may alternatively take a pipe cleaner from each group to symbolize a budget cut; however, restricting building to one hand per team member forces the students to work together to accomplish their task).

5. After another two minutes, stop them again. Tell them that, as engineers, we work in a global marketplace. This means being able to communicate with people from many different cultures and countries. Their business has just been purchased by a company based in (insert your favorite esoteric country here— we use Eritrea). Since they do not speak any of the native languages of this country communication is difficult. To symbolize this constraint, the students may no longer talk. Tell them they have one minute to finish.

6. Count down from ten and ask all the students to stop working on their structures. Walk around the room and make note of all the different shapes and designs that the students have created. Compare the towers, commenting on the good points of their design (sometimes the only good thing is to say that they have a future in abstract art) and find the tallest, free-standing structure amongst them. Depending on the age of the students, you may make this a big production. Note: the most successful designs will generally incorporate a small base made from just one pipe cleaner.

7. Ask the students if everyone came up with the same design, and why not? They should answer that they all have different ideas, and this speaks to the importance and role of diversity in engineering and problem-solving. Discuss the different shapes that the teams used for the foundation of their structure, and how they may have used beams and columns to support their structures. Indicate that architectural/civil/mechanical engineers use these same principles, although with different materials, to construct homes, commercial buildings, bridges, and even toys. Finally, wrap up by asking the students if they could do a better job if they performed this activity again or with more time? Tell them that engineers look to improve existing designs and may try things many, many times before they find the optimal solution.

8. Cleanup – Tell students that their prize for putting together such inventive designs is that they must return the pipe cleaners to you exactly the way that they received them.

Extensions: If the groups are succeeding too fast, shorten the time between challenges. If few groups are experiencing success, give more time between challenges.

Earth Science: Solar Activity

Graphing Solar Activity

1. Set up a graph on your graph paper with:
 - **Years** on the **x-axis** and
 - **Number of sunspots** (0 – 210 using an interval of 10) on the **y-axis**.
 - Number the graph so that it takes up as much room on the paper as possible. The intervals for the graphs is stated for you so the graphs can be connected to form a uniform timeline.
2. . Your data begins with 1700 and goes to 2013, and you must go to http://solarscience.msfc.nasa.gov/greenwch/spot_num.txt to get the monthly totals for 2014 forward.
3. Data for 1749 to present is based on monthly activity. You will need to calculate the yearly average (add up the activity for each month and divide by 12 or the number of months if not a complete year)
4. Plot the sunspot number against time using the yearly averages for 1700-2013.
5. Connect graphs together matching connector years for the years 1700-2014.
6. Open an Excel spreadsheet and enter the monthly data for the years 2010 – 2014. Create a line graph for the monthly averages for 2010-2014.
7. Answer questions on theme paper, **individually**.

Question for the Students

1. Connect the points you've plotted with a smooth curve. You'll notice that there are very clear peaks (maximums) and valleys (minimums). Which years are the **maximums** and which years are **minimums**? Label these years on your graph with a **capital M** and **lower case m**, respectively.

2. Is there is a regular pattern?

To answer this question, take note of what scientists call the solar cycle, i.e., how many years are there between a solar maximum, a solar minimum and the next solar maximum? For example, in 1705 there is a maximum, in 1711-1712 there is a minimum, in 1717 a maximum. So the first solar cycle you plotted lasted 12 years (subtract 1705 from 1717). Take note of the other solar cycles by making a table of maximums, minimums and the years between.

Maximum	Minimum	Years Between			
1705	1711-1712	12			
			Maximum	Minimum	Years Between
Maximum	Minimum	Years Between			

- a) If you had to guess at the average solar cycle length, what would it be from 1700-present?
- b) Now find the average solar cycle length with a calculator. Show your work:

3. If you had to make a prediction for the years 2011 and 2017, would the years be maximums or minimums?

4. How many sunspots were there during the year you were born? Predict whether it will be closer to a maximum or a minimum when you graduate from high school and for when you turn 21 years old.

5 Using the monthly averages for the years 2010-2014, which months have the most sunspots and the least number of sunspots? Is there a pattern?

6. Does the data indicate a possible relationship between the Sun's and Earth's magnetic field? How?

Year	# of Sun Spots				
		1735	34	1772	66.5
1700	5	1736	70	1773	34.8
1701	11	1737	81	1774	30.6
1702	16	1738	111	1775	7.0
1703	23	1739	101	1776	19.8
1704	36	1740	73	1777	92.5
1705	58	1741	40	1778	154.4
1706	29	1742	20	1779	125.9
1707	20	1743	16	1780	84.8
1708	10	1744	5	1781	68.1
1709	8	1745	11	1782	38.5
1710	3	1746	22	1783	22.8
1711	0	1747	40	1784	10.2
1712	0	1748	60	1785	24.1
1713	2	1749	80.9	1786	82.9
1714	11	1750	83.4	1787	132.0
1715	27	1751	47.7	1788	130.9
1716	47	1752	47.8	1789	118.1
1717	63	1753	30.7	1790	89.9
1718	60	1754	12.2	1791	66.6
1719	39	1755	9.6	1792	60.0
1720	28	1756	10.2	1793	469
1721	26	1757	32.4	1794	41.0
1722	22	1758	47.6	1795	21.2
1723	11	1759	54.0	1796	16.0
1724	21	1760	62.9	1797	6.4
1725	40	1761	85.9	1798	4.1
1726	78	1762	61.2	1799	6.8
1727	122	1763	45.1		
1728	103	1764	36.4		
1729	73	1765	20.9	1800	14.5
1730	47	1766	11.4	1801	34.0
1731	35	1767	37.8	1802	45.0
1732	11	1768	69.8	1803	43.1
1733	5	1769	106.1	1804	47.5
1734	16	1770	100.8	1805	42.2
		1771	816.		

1806	28.1	1843	10.7	1879	6.0
1807	10.1	1844	15.0	1880	32.3
1808	8.1	1845	40.1	1881	54.3
1809	2.5	1846	61.5	1882	59.7
1810	0.0	1847	98.5	1883	63.7
1811	1.4	1848	124.7	1884	63.5
1812	5.0	1849	96.3	1885	52.2
1813	12.2	1850	66.6	1886	25.4
1814	13.9	1851	64.5	1887	13.1
1815	35.4	1852	54.1	1888	6.8
1816	45.8	1853	39.0	1889	6.3
1817	41.1	1854	20.6	1890	7.1
1818	30.1	1855	6.7	1891	35.6
1819	23.9	1856	4.3	1892	7300
1820	15.6	1857	22.7	1893	85.1
1821	6.6	1858	54.8	1894	78.0
1822	4.0	1859	93.8	1895	64.0
1823	1.8	1860	95.8	1896	41.8
1824	8.5	1861	77.2	1897	262
1825	16.6	1862	59.1	1898	267
1826	36.3	1863	44.0	1899	12.1
1827	49.6	1864	47.0	1900	95
1828	64.2	1865	30.5	1901	2.7
1829	67.0	1866	16.3	1902	5.0
1830	70.9	1867	7.3	1903	244
1831	47.8	1868	37.6	1904	42.0
1832	27.5	1869	74.0	1905	63.5
1833	8.5	1870	139.0	1906	53.8
1834	13.2	1871	111.2	1907	62.0
1835	56.9	1872	101.6	1908	48.5
1836	121.5	1873	66.2		
1837	1383	1874	44.7		
1838	103.2	1875	17.0		
1839	85.7	1876	11.3		
1840	64.6	1877	12.4		
1841	36.7	1878	3.4		
1842	24.2				

1909	43.9	1944	9.6	1979	155.4
1910	18.6	1945	33.2	1980	154.6
1911	5.7	1946	92.6	1981	140.4
1912	3.6	1947	151.6	1982	115.9
1913	1.4	1948	136.3	1983	66.6
1914	9.6	1949	134.7	1984	45.9
1915	47.4	1950	83.9	1985	17.9
1916	57.1	1951	69.4	1986	13.4
1917	103.9	1952	31.5	1987	29.4
1918	80.6	1953	13.9	1988	100.2
1919	63.6	1954	4.4	1989	157.6
1920	37.6	1955	38.0	1990	142.2
1921	26.1	1956	141.7	1991	145.8
1922	14.2	1957	190.2	1992	94.5
1923	5.8	1958	184.8	1993	54.7
1924	16.7	1959	159.0	1994	29.9
1925	44.7	1960	112.3	1995	17.9
1926	63.9	1961	53.9	1996	8.6
1927	69.0	1962	37.6	1997	21.5
1928	77.8	1963	27.9	1998	64.3
1929	64.9	1964	10.2	1999	93.3
1930	35.7	1965	15.1		
1931	212	1966	47.0		
1932	11.1	1967	93.8	2000	119.0
1933	5.7	1968	105.9	2001	110.9
1934	8.7	1969	105.5	2002	104.0
1935	36.1	1970	104.5	2003	63.7
1936	79.7	1971	66.6	2004	40.4
1937	114.4	1972	68.9	2005	29.8
1938	109.6	1973	380	2006	15.2
1939	88.8	1974	34.5	2007	7.5
1940	67.8	1975	15.5	2008	2.8
1941	47.5	1976	12.6	2009	3.1
1942	30.6	1977	27.5		
1943	16.3	1978	92.5		

Monthly sunspot activity for 2010 to 2014:

2010	1	13.2		7	43.8			
	2	18.8		8	50.6	2013	1	62.9
	3	15.3		9	78.0		2	38.1
	4	8.0		10	88.0		3	67.9
	5	8.7		11	96.7		4	72.4
	6	13.6		12	73.0		5	78.7
	7	16.1					6	52.5
	8	19.6	2012	1	58.3		7	57.0
	9	25.2		2	32.9		8	66.0
	10	23.5		3	64.3		9	37.0
	11	21.5		4	55.2		10	85.6
	12	14.4		5	69.0		11	77.6
				6	64.5		12	90.3
2011	1	18.8		7	66.5			
	2	29.6		8	63.0	2014	1	82.0
	3	55.8		9	61.4		2	102.8
	4	54.4		10	53.3		3	
	5	41.5		11	61.8			
	6	37.0		12	40.8			

Last modified March 9, 2014 by Melinda Mericle; previously on January 19, 2009 by [Jennifer Bergman](#).

The source of this material is *Windows to the Universe*, at <http://windows2universe.org/> from the [National Earth Science Teachers Association \(NESTA\)](#). The Website was developed in part with the support of [UCAR](#) and [NCAR](#), where it resided from 2000 – 2010.

Earth Science – Pangaea Reconstruction

Before scientists understood plate tectonics, they were puzzled by the many similarities they saw in the rocks and fossils on continents on opposite sides of the Atlantic Ocean. One geologist, Alfred Wegener, had the courage to argue the unlikelihood of these similarities all being coincidence. Wegener proposed that at one time the continents must have been a single landmass, which he named Pangaea. In this activity you will look at a few examples of the geologic similarities Wegener saw, and determine how you would use this information to reconstruct a portion of Pangaea—such evidence has also been found in Australia, Antarctica, and Asia, but for this activity we will only be focusing on the coasts of the Atlantic Ocean.

1. Go to <http://pubs.usgs.gov/gip/dynamic/historical.html#anchor9588978> and read the historical perspective behind Wegener's theory.
2. *On your World Continents map, mark the following three areas in different colors. Go to: http://education.nationalgeographic.com/education/mapping/interactive-map/?ar_a=1 (you can use the stamps feature to enter the features on the map as a guide) or http://mrnuessbaum.com/interactive_world_map/ to help identify areas to be marked.*

A) Mesosaurus Fossils

Fossils of a reptile similar to an alligator are found along the **east coast of South America** from **15°S to 40°S** and inland as far as **Paraguay**. Though this reptile was unable to swim across the ocean, Mesosaurus fossils are also found in **Africa** throughout a region that includes **Angola, Namibia, Botswana, and South Africa**.

B) Rocks of the Pan-African Province

550 million-year-old rocks that are distinctive to **West Africa** in a region around the equator (**Nigeria, Cameroon, Central African Republic, Gabon, and Republic of the Congo**) can also be found in eastern **Brazil** between the **equator and 20°S**.

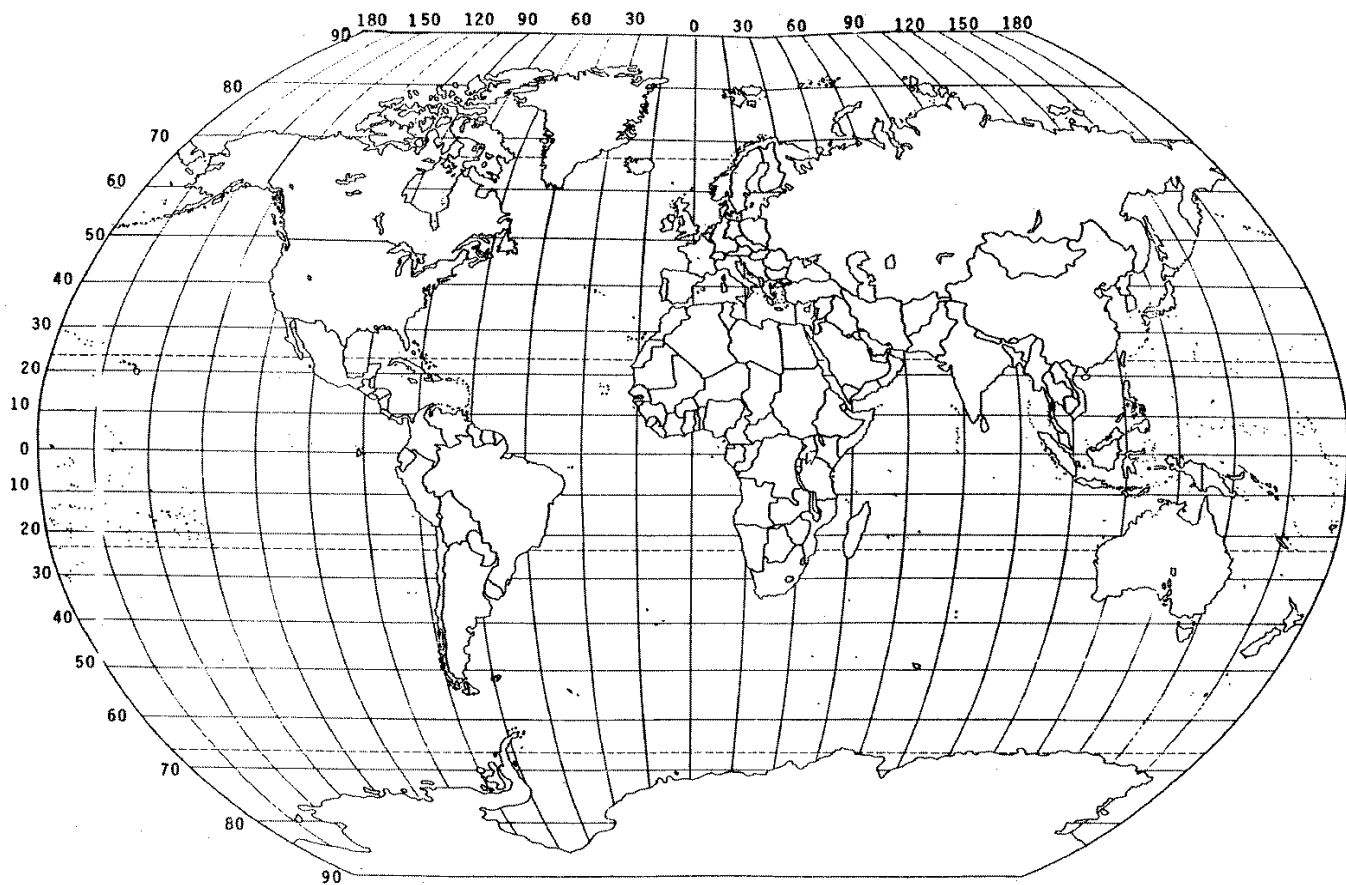
C) Mountain Ranges

Formed between 250 million years ago and 700 million years ago, a complex system of mountain ranges that lines either side of the northern Atlantic suggests that Pangaea lasted for hundreds of millions of years, spanning multiple mountain building events. In particular, the **Appalachian Mountains** on the **east coast of North America (40° N and 78° W)** are of a similar age, trend (the direction of rock folding), and rock types as the **Caledonia Mountains (53° N and 118° W) found in the United Kingdom and Norway**—as though the Caledonian Mountains were a continuation of the Appalachians. The **Mauritanide mountain belt along the northwest coast of Africa (which begins just north of the equator and extends along the coast past the Prime Meridian)** also have strong geologic similarities to the **Appalachian Mountains**. Related mountains also stretch into the **west coast of Spain and the east coast of Greenland**.

3. Go to <http://pubs.usgs.gov/gip/dynamic/continents.html> and verify that you have marked the correct regions on your map.
4. Cut out the **continents bordering the Atlantic Ocean**, and rearrange them so that the areas you have marked line up. Do not worry about the islands, they formed after the break-up of Pangaea.

Discussion Questions:

1. In your own words explain what the Continental Drift Theory states.
The Earth's plates are moved very slowly, 1-4 inches per year, by convection currents emanating from the mantle. These plates have been moving for millions of years and continue to move today.
2. How did Alfred Wegener try to prove that the continents of Africa and South America were once connected?
Alfred Wegener discovered that the magnetic bands in rocks from South America did not point to the North Pole as they should. If these rocks were moved to the position that Wegener thought they were created then they did point to the North Pole. He also matched rocks from Africa and South America for mineral content and age.
3. What caused Pangaea to break up?
Pangaea split apart for the same reason that the plates are moving today. Convection currents in the mantle move the plates of the Earth at 1-4 inches per year.
4. What is the Continental Drift Theory?
The continental drift theory states that the plates of the Earth are moving at 1-4 inches per year. This movement is caused by convection currents in the mantle. The continents have been moving into their present position for about 250 million years. They were once joined into one huge continent called Pangaea.
5. What happened at the Triple Junction? Where is it located today?
The triple junction was a tear in the Earth's crust that allowed massive amounts of lava to pour out. This zone was located in west central Africa and eastern South America. Geologists use this junction to prove that the two continents of South America and Africa were joined at one time. The rocks located in these regions are identical for mineral content and age.
6. Based on the geologic past, we can assume that Earth is always changing. What modern-day evidence supports this idea? Where do they often occur?
Earthquake and they occur along fault lines.
5. Go to <http://www.khanacademy.org/science/cosmology-and-astronomy/earth-history-topic/plate-tectonics/v/pangaea#>! And watch the video explanation on Pangaea.



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Earth Science – Plate Tectonics

Directions: Answer the following questions in complete sentences. You will not be penalized for wrong answers.

1. What is a lithospheric plate?
2. Do lithospheric plates ever move? If you answer “yes”, how do they move? If you answer “no”, why don’t they move?
3. What is density?

Instruction Sheet

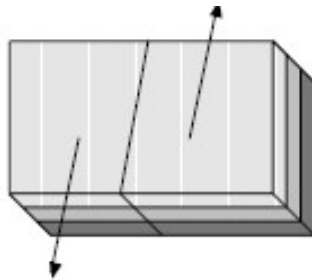
Directions: In groups of 3-4 people, rotate between the different stations to investigate the differences between plate boundaries.

Answer the questions presented at each station and rotate when instructed.

Station 1: Transform Boundary

You will notice that there are three different colors of Play-Doh available for your use. At this station, Play-Doh will represent rock units.

1. Using the three different colors, create and layer three “rock units”.
2. Draw an illustration of your rock units. Include color names and label the oldest and youngest layers.
3. Using the plastic knife, cut your rock units in half so that you have two sections of “rock” each with three units.
4. With the two halves together, slide them past each other in opposite directions as shown below.



5. Describe in your own words what happens to the blocks.
6. How could this simple experiment be related to everyday life? In what specific areas would this type of plate movement be a concern?

7. Separate the different colors of Play-Doh and place them back in the correct containers.

Station 2: Convergent Boundary

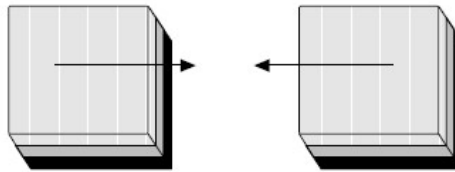
You will notice that there are three different colors of Play-Doh available for your use. At this station, Play-Doh will again represent rock units. However, you will examine a different kind of plate boundary.

8. Using the three different colors, create and layer three “rock units”.

9. Draw an illustration of your rock units. Include color names and label the oldest and youngest layers.

10. Using the plastic knife, cut your rock units in half so that you have two sections of “rock” each with three units.

11. Align the two sections of “rock” and push them together as indicated below.



12. Draw a picture showing what has happened to the rock layers.

13. How could this simple experiment be related to everyday life? In what specific areas would this type of plate movement be a concern?

14. Separate the different colors of Play-Doh and place them back in the correct containers.

Station 3: Convergent Boundary

As you can see, this station involves the use of water, Styrofoam, string, and gram masses. At this station, you will begin to investigate subduction at a convergent plate boundary.

15. Place the two pieces of Styrofoam in the middle of the container.

16. You will notice that the Styrofoam pieces are floating. Why is the Styrofoam floating?

17. What do you think would happen if two pieces of Styrofoam with different densities collided?

(You will not be penalized for incorrect answers).

18. Tie a small gram mass to each of the Styrofoam pieces, using string. Be sure to tie a different mass to each of the Styrofoam pieces and leave several inches of string that can be used for pulling the mass.

19. Place the two pieces back in the water. If the Styrofoam is unable to float, tie smaller masses to the Styrofoam pieces.
20. Using the strings, pull the two pieces of Styrofoam together so they collide.
21. Describe what happens upon impact.
22. What causes this to occur?
23. What features could occur with this type of collision? What effect would these features have for human life and the environment?

Station 4: Convergent Boundary

Using the computer, answer the following questions in complete sentences.

24. Using the computer, go to <http://pubs.usgs.gov/gip/dynamic/understanding.html>
25. Scroll down to the section that is titled “Convergent Boundaries”.
26. What are the three types of convergent boundaries?
27. Compare and contrast the convergent boundaries.
28. How does each of the convergent boundaries affect geology and the environment?
29. If you had to live along a type of convergent boundary, which would you choose and why?

Station 5: Divergent Boundary

Using the computer, answer the following questions in complete sentences.

30. Using the computer, go to <http://www.planetseed.com/sciencearticle/earth-living-planet>
31. Scroll down to “Divergent Plate Movement” and click on the picture to the right.
32. When the new window appears, select the animation in the top left corner; this illustrates divergent plate movement.
33. Record your observations regarding the position of continents, the ocean depth, and position of magma relative to time.
34. Why causes divergent plate movement?
35. Now go to http://www.wwnorton.com/college/geo/egeo2/content/animations/2_3.htm
36. Scroll down to section 2.5 – Sea Floor Spreading and click on the “View Animation” icon on the right side of the screen.
37. In what areas are the youngest rock units located? The oldest?

38. What do you notice about the shape of the mid-ocean ridge in relation to the shape of continents?

39. How might a scientist test this hypothesis of sea-floor spreading?

Station 6: Divergent Boundary

Answer the following questions regarding the demonstration performed at the beginning of class.

40. Summarize what the demonstration was showing and describe why the Styrofoam plates moved.

41. What are other explanations for the motion of divergent boundaries?

42. How might movement along a divergent boundary affect other plate boundaries?

43. Imagine that there was a divergent boundary running underneath the Mississippi River. Discuss what the United States would look like in 1,000,000 years. What would happen to the geology, weather patterns, and the environment of that area?

Review:

Go to: <http://www.learner.org/interactives/dynamicearth/index.html>

Observe the different types of plate movements:

http://www.planetseed.com/files/flash/science/features/earth/livingplanet/plate_boundaries/en/index.html?width=570&height=475&popup=true

Earth Science – James River Tour

Stream Development: A Google™ Earth Tour

Overview:

Students will use Google™ Earth to visualize the development of a stream from its mouth entering into the Chesapeake Bay up to its headwaters. The tour follows the James River as it passes through major cities and farmland. By the end, students have seen how the river changes along its course from the oldest sections of the river near the mouth to the youngest sections of the river system at the headwaters. From changes in the width of the stream, the size and number of tributaries, the presence or absence of a floodplain, meanders, and slope of the land, this tour helps students analyze a major river in their home state.

The tour includes questions about major features of the river, such as meanders and point bars, and includes thought questions on the impact of increased land use. The questions are meant to act as a guide for student thinking, focusing student attention on particular aspects of the stream and/or surrounding area. Students have to make observations and inferences, as well as predictions about how and why the river is formed the way that it is.

Advantages of Technology:

Google™ Earth allows students to “travel” along a creek as it develops in the mountains, grows, and eventually reaches the ocean. Students are able to easily manipulate the viewing angle, as well as see the path of the stream on a local and broader scale.

Virginia Standards of Learning:

ES.1 The student will plan and conduct investigations in which
b) technologies including computers, probeware, and global positioning systems (GPS), are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions;

ES.3 The student will investigate and understand how to read and interpret maps, globes, models, charts, and imagery. Key concepts include

- b) imagery (aerial photography and satellite images);
- d) location by latitude and longitude and topographic profiles.

- ES.9** The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include
- e) dependence on freshwater resources and the effects of human usage on water quality; and
 - f) identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.

Materials

- Google™ Earth program (<http://earth.google.com/>)
- Laptops or computer lab access (1 computer for every 2 students)
- James River Tour and Student Worksheet (found on CD)
- Internet Access
- Projector connected to teacher computer in order to demonstrate the basic procedures for using Google Earth (optional)

Procedure:

Download and install Google™ Earth from the following Web site: <http://earth.google.com> and open the “James River” tour found on the CD while in Google™ Earth. This will put the tour in the “Temporary Places” folder. If you want to save it to “My Places,” you need to right-click on the file and select the “save to my places” option.

This activity is designed to work as a review of stream development and ecology. In the activity students will follow the path of a stream and answer questions about the river formations at various stops along the way.

NOTE: Students must click on the name of each place-mark during the tour in order for the questions and description of each place to become visible.

Place students into pairs and allow them to share a computer. Have them open up the “Potomac River” Tour on Google™ Earth. Students should play the tour and be prepared to write answers to the questions at each place mark. The place marks have multiple questions and may require students to reference notes or at least examine the place in more detail than the tour allows.

Students should watch the tour more than once in order to grasp everything that they are seeing in detail. At each place mark, students can zoom in or manipulate the scene to enhance their understanding.

Assessment Strategies:

Formative assessment occurs during the activity as the teacher monitors student progress. Turning in responses to the tour's built in questions will allow for the teacher to further evaluate student understanding. The stream development worksheet provides the same questions as the tour, scaffolding the tour for students. This format should help them be sure to answer each tour question.

Resources:

Stream Development Student Worksheet

This worksheet is to accompany the James River Google Earth Tour. The questions found in the tour are also found on this worksheet with space provided to record your observations, thoughts and sketches.

1. **Overview.** Virginia and Chesapeake Bay. The Chesapeake Bay is the largest estuary in the United States.

2. Mouth of James River

This is where the James River flows out into the Chesapeake Bay.

How wide is this portion of the river? Hint: Use the ruler tool along the top toolbar to measure the river width.

How old is this section of the river compared to the headwaters? Why?

3. Mouth of James River- Close-up

How does the color of the water change from the river out into the Chesapeake Bay?

What could this color change indicate?

4. James River south of Williamsburg

Look at the width of the James River. How does the width compare to that at the river's mouth? Again, use the ruler tool to determine the width.

5. Large tributary

Another river flows into the James River here. What impact does this have on the James?

Take note of the number and size of tributaries in the lower section of the James.

What does this say about the relative age of the lower section of the river compared to the rest of the river?

6. Tributary- Close-up

This is the same tributary as the last stop, just farther away from where it enters the James River.

By looking at this portion of the tributary, can you determine how it gets its water supply?

7. Special Feature

Look at the overall river shape around this placemark. Sketch the river, identifying where river water should be moving fastest.

Explain why water moves fastest where you indicated.

What is the name of this river shape?

8. Point bar

On the inside of a curve in the river, there is a collection of sediment called a point bar.

Why might sediment collect here?

Also look at the river's width. Compare the width of the river here to the width of the river you noted at the mouth of the James. Describe the difference.

9. James River Richmond

There is much development in this area. Note the color of the river water here. What could that represent?

What impact could that have on organisms in the river? Use a specific example to illustrate your point.

10. Vegetation

Note the green vegetation lining the river. What role could the vegetation play in protecting the river?

11. River Curve SE of Grassy Island

Here's another dramatic curve in the river (called a _____).

If this curve gets bigger and bigger, what is likely to happen?

What new feature might be formed here in the future?

12. Joining of 2 rivers

See the rivers to the west and to the east of the placemark? These rivers join together to form one bigger river that locally flows southwest here.

13. River following strike of folds

Note how the river is contained in a valley. The creases in the ridges on either side of the river valley represent areas where water collects and runs down into the river.

How wide is the river here (compared to the portions downstream)?

14. High Elevation

Describe the terrain here.

Is there a floodplain? What is evidence of this?

What is the overall shape of this valley?

Earth Science – Longitude

Program Overview

NOVA chronicles the seventeenth-century journey to determine longitude.

- In 1714, following a maritime disaster, British Parliament offers £20,000 for the first reliable method of determining longitude on a ship at sea.
- It is known that longitude can be found by comparing a ship's local time to the time at the port of origin. The challenge is finding a clock—a chronometer—that can keep time at sea, where temperature changes, humidity, gravity and a ship's movement affect accuracy.
- Early attempts are based on the assumption that astronomy can solve the problem.
- Self-taught clockmaker John Harrison believes the answer lies in large mechanical clocks. Through careful observation and experimentation, he invents many adaptations to improve clock accuracy. After decades of work, he realizes pocket watches are a better choice and redirects his efforts to pursue this smaller technology.

In 1764, Harrison's watch proves accurate in helping determine the longitude on a six-week voyage to Barbados.

Objective

To research and chart the shortest course to circumnavigate the globe.

MATERIALS for each team-----

- copy of "Voyage Around the World" student handout ([HTML](#))
- world map, globe or atlas, with a scale
- small tacks, pins or self-stick notes (for marking locations)
- a 12-inch piece of string (for measuring distances)

PROCEDURE-----

1. Organize students into groups and distribute student handouts and materials to each group. Explain that the challenge is to research and chart a course that takes them to each Checkpoint Destination on their way around the world once. Have students review the Nautical Rules and Checkpoint Destinations before beginning. (You may delete or change Checkpoint Destinations to best suit your students' abilities.)

2. Have students research locations that match the Checkpoint descriptions, plot these locations on a map, record the latitude and longitude for each, and plan their course from one location to the next. Then have them estimate the distance between locations, using the string and a map scale.
3. When teams have completed their routes, have them create a Google Earth file of their journey and verify their distances between checkpoints.
4. Have students exchange maps and recording charts to compare Checkpoint locations and estimated distances. Then, as a class, come up with the shortest route possible.
5. As an extension, you can have students convert the estimated distances from statute miles to nautical miles.

ACTIVITY ANSWER-----

Because the Checkpoint Destinations are open-ended, the locations and courses students choose will vary (see sample course below). When students present their locations, courses and estimated distances, they should be able to explain why each location matches the Checkpoint description, how they chose the course, and the method they used for estimating distances. Most maps students will be using show statute miles, the unit of measurement for distances on land. Distances at sea are measured in nautical miles. A nautical mile is found by dividing the Earth into 360 degrees, and then dividing each degree into 60 minutes. One nautical mile equals one minute, or 1/21,600 of the Earth's circumference. Students can convert statute miles to nautical miles by dividing the number of statute miles by 1.1508.

Sample Course

Checkpoint Destination	Location	Latitude and Longitude	Estimated Distance from Previous Checkpoint
1. Start in Greenwich, England	Greenwich, England	51° 29'N, 0°00'W	0 miles
2. Dodge an iceberg.	Reykjavik, Iceland	64° 09'N, 21°58'W	1,230 miles
3. Dock next to a cruise ship.	St. Thomas, U.S. Virgin Islands	18° 20'N, 64°55'W	4,010 miles
4. Stop at a Spanish-speaking port.	Panama Canal	9° 10'N, 79°37'W	1,540 miles

5. Stop at an English-speaking port.	Los Angeles, California	34° 00'N, 118° 15'W	3,700 miles
6. View a high mountain from a port.	(Mt. Ranier) Seattle, Washington	47° 35'N, 122° 20'W	1,540 miles
7. Visit a major oil-supplying port.	Valdez, Alaska	61° 07'N, 146° 17'W	1,230 miles
8. Photograph a kangaroo.	Sydney, Australia	33° 55'S, 151° 10'E	9,560 miles
9. Sight a penguin.	Balleny Islands, Antarctica	66° 30'S, 163° 00'E	2,470 miles
10. Collect exotic spices.	Jakarta, Indonesia	6° 09'S, 106° 49'E	4,320 miles
11. Have lunch in a country where rice is a dietary mainstay.	Singapore	1° 17'S, 103° 51'E	620 miles
12. Visit a country that has changed its name within the past 50 years.	Sri Lanka (Ceylon)	7° 30'S, 81° 50'E	1,540 miles
13. End in Greenwich, England.	Greenwich, England	51° 29'N, 0° 00'W	8,020 miles
Total Distance			39,780 (statute miles) 34,567 (nautical miles)

Books

Hobden, Heather, and Mervyn Hobden. *John Harrison and the Problem of Longitude*. Lincoln, England: Cosmic Elk, 1989.

Includes a history of John Harrison and his invention of the maritime chronometer, which solved the problem of finding longitude at sea.

Sobel, Dava. *Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time*. New York: Walker, 1995.

Takes the reader back to the maritime world of 1714, when finding the solution to the problem of determining longitude at sea was of the highest scientific, political and economic priority.

Web Sites

NOVA Online—Lost at Sea: The Search for Longitude

<http://www.pbs.org/nova/longitude/>

Will include an interactive game that provides a way to understand why knowing the time at your home port allows you to fix your longitude at sea. The site will also feature how the Global Positioning System works, a time line of ancient navigation, and contributions from leading experts on what they believe are some of the greatest scientific challenges of our day. Launch date: Currently available.

Lost at Sea: The Search for Longitude || Student Handout Voyage Around the World

You are about to embark on a voyage around the world. Your mission is to chart a course that will take you to each Checkpoint Destination on your way around the globe once. Bon voyage!

Procedure

1. Read the [Nautical Rules](#).
2. Review the Checkpoint Destination descriptions. Research and find locations that match each Checkpoint, which you must visit in order. Your goal is to visit every Checkpoint **and** circumnavigate the globe.
3. On a world map, globe or atlas mark the locations you've chosen for each Checkpoint. Record the location and its latitude and longitude for each Checkpoint.
4. Plan a course from one Checkpoint to the next and estimate the distance between each location, using the string and map scale. Then calculate the total distance for the entire voyage.
5. Open a Google Earth World Map and enter each Checkpoint location and verify distances.
6. Trade recording charts with another team and check that team's course and distance measurements.
7. Once you have checked another team's course, work as a class to chart the shortest course around the world.

Nautical Rules

- Begin and end your trip in Greenwich, England.
- Circumnavigate the globe once.
- Visit every Checkpoint Destination. (Each Checkpoint must be a different location.)

- Visit the Checkpoints in order.

Checkpoint Destination	Location	Latitude and Longitude	Estimated Distance from Previous Checkpoint
1. Start in Greenwich, England	Greenwich, England	51° 29' N, 0°00'W	0 miles
2. Dodge an iceberg.			
3. Dock next to a cruise ship.			
4. Stop at a Spanish-speaking port.			
5. Stop at an English-speaking port.			
6. View a high mountain from a port.			
7. Visit a major oil-supplying port.			
8. Photograph a kangaroo.			
9. Sight a penguin.			
10. Collect exotic spices.			
11. Have lunch in a country where rice is a dietary mainstay.			
12. Visit a country that has changed its name within the past 50 years.			
13. End in Greenwich, England.			
Total Distance			

Earth Science – Groundwater

Earth's Dynamic Surface Groundwater Computer Lab Exercise

<http://ga.water.usgs.gov/edu/mearthgw.html> and
<http://www.virginiaplaces.org/watersheds/groundwater.html>

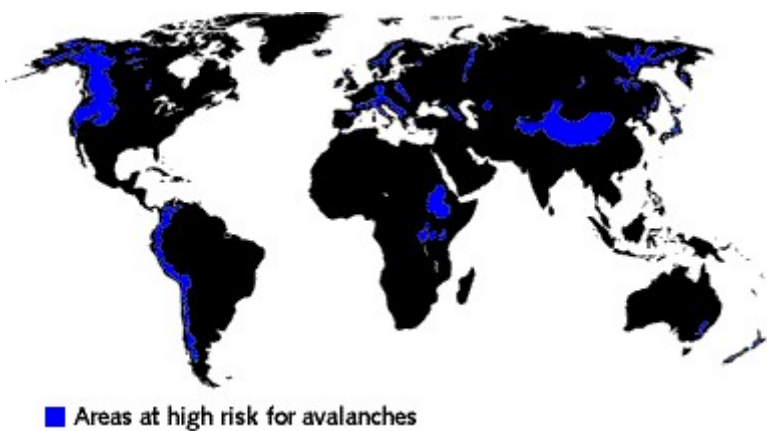
1. Much of the rainwater returns to the atmosphere after a storm in 2 ways. Name them.
2. Water soaking into the ground is termed?
3. What does infiltrated water do for the groundwater?
4. What is the term for the contact between the unsaturated and saturated zone?
5. Define an aquifer.
6. Why do some streams almost never run dry?
7. Streams discussed in question #6 are termed?
8. Water that does not infiltrate is termed?
9. What 2 factors cause flooding?
10. What type of sediments make up the North Atlantic Coastal Plain aquifer?
11. What forms during pumping?
12. What is a spring?
13. Define a cave.
14. What is the common rock making caves?
15. Which chemical reaction forms caves?
16. What is a sinkhole?
17. Looking at location map of sinkholes and caves, what type of rocks are most common in red areas?
18. What environment were the rocks that make up sinkholes and caves deposited?
19. Define karst.
20. What's a speleothem?
21. What's a stalactite?
22. What's a stalagmite?
23. What's a soda straw?

True or False	
	(1) The water table is the altitude (below ground) where the water level in a well will rise to when the well taps a confined aquifer.
	(2) If you ate canned corn last night, there is a good chance that it was irrigated with groundwater.
	(3) Land subsidence occurs in areas underlain by highly-fractured granite, which is readily dissolved by moving groundwater, especially when the water is slightly acidic.

True or False	
	(1) The water table is the altitude (below ground) where the water level in a well will rise to when the well taps a confined aquifer.
	(4) Water can flow in streams even during periods of drought due to groundwater seeping into the streambanks.
	(5) Artificial recharge to an aquifer can occur when people inject water down into a well to force it back into an aquifer so they can withdraw it later.
	(6) Big cities drill deep wells to tap naturally heated water because the heat kills bacteria and the water needs less treatment.
	(7) Bottled water often is advertised as "artesian well water." Artesian water is groundwater that is naturally filtered by an aquifer composed of fine, porous material—this artesian water can be put directly into bottles.
	(8) The heaviest users of groundwater for drinking water and other public uses are the Southwest desert States, where surface water is scarce.
	(9) The porosity and permeability of an aquifer define its ability to yield water to wells in productive amounts.
	(10) For some wells along the coastline that are drilled into porous aquifers, pumps are turned off twice a day (during periods of high tides), since tides temporarily raise saline ground-water levels, causing saltwater intrusion into freshwater aquifers.
	(11) Cities prefer to use groundwater for drinking-water supplies because surface water is in constant contact with streambeds and, thus, contains a higher concentration of dissolved minerals and other substances that must be removed.
	(12) Excessive pumping of a well can reverse the natural flow of groundwater into a river, causing the water level in the river to fall.
	(13) Most wells are shallow because a significant amount of water cannot be obtained from wells deeper than about 500 feet. This is because it is difficult for pumps to overcome the force of gravity and push water up to the land surface.
	(14) The most productive wells tap large open areas in subsurface rocks, including horizontal fissures, caverns, and lava tubes, which have connections to the land surface, thus allowing the aquifer to be quickly recharged by precipitation.
	(15) A cone of depression occurs when you drop your scoop of ice cream (made with groundwater) on the ground on a hot summer day.

Earth Science – Avalanche

Scientists estimate that there are more than 1 million avalanches each year. Complex in nature, an avalanche can range from snow falling off a roof to entire mountainsides of snow traveling for miles. The evolving field of avalanche research draws scientists from many disciplines who combine interests in geophysics, atmospheric sciences, and snow science to understand the properties of snow, snow crystal formation, snow mechanics, and the interaction between the environment and the snowpack. NOVA travels around the world to examine the state of the art of avalanche science.



Elements of a Slide...

Avalanches are a significant mountain hazard—responsible for more deaths each year in the United States than earthquakes. Once in motion, snow slides are a powerful force of nature, capable of snapping off mature trees like match sticks, and easily destroying buildings. And when an avalanche finally stops, the snow sets up like concrete, making rescue efforts extremely difficult, and chances for survival slim.

An avalanche, or slide, is simply a mass of snow moving down a slope. There are two basic elements to a slide; a steep, snow-covered slope and a trigger. But despite this apparent simplicity, avalanches can be surprisingly hard to predict. Changing weather conditions continually affect the strength of the layers within the snowpack, and the snowpack on every slope is different depending on what exposure that slope has to the wind and sun.



In fact, layers within the snowpack are the first thing that avalanche forecasters look at to try to predict the stability of a slope and its potential to slide. Different storms create distinct types and amounts of snow. Once the snow settles onto the existing snowpack, it can quickly metamorphose into distinct crystal types, which are determined both by changes in temperature and whether or not the snow is exposed to the sun.

As the season progresses, the snowpack becomes a multi-layered history of storms and weather. But even a deeply buried layer can continue to change, as changes in temperature slowly move through the snowpack, and heavier snow weighs down on lower layers. A weak layer is created whenever snow crystals are shaped in a way that prevents them from bonding tightly together.



How much of a threat an avalanche may pose depends largely on how deeply buried a weak layer is. When the snow near or on the surface doesn't have much cohesion—in other words, it's a weak layer—loose snow slides are common. The snow on the surface begins to slide from a single point, collecting more snow as it moves, and widening out into a triangular shape, creating what is commonly called a sluff. Sluffs are similar to sand rolling down a sand dune. Typically, these loose snow avalanches do not involve much snow and are not a major threat to people or property.

But the threat of larger avalanches increases as a weak layer becomes more and more deeply buried, causing the entire snowpack above to become more unstable. When a weak layer is buried underneath a strong layer, slab avalanches are possible—if enough stress is added to the slope. Stresses which might trigger a slab avalanche include new or wind-blown snow, a skier or snowmobiler, or an explosive used intentionally for avalanche control.



In a slab avalanche the snow breaks off in a single large plate, which then fractures and moves down the slope. These avalanches tend to be much larger, involve more snow, and are more dangerous to both people and property than sluffs. When people trigger them they are often in the middle of the slab, which is what makes them so deadly; when the avalanche releases the victim is quickly engulfed in the snow, and the chances for escape are slim.

Viewing Ideas

Before Watching

1. Avalanche researchers need to be concerned with a wide range of variables including the kind of snow that falls (such as light, dry, or wet), and the cumulative layering of snow on any hillside. As they watch the program, have students develop a list of properties of snow, the kind of environmental factors that might shape how layers of snow pack together, and the kinds of snow that fall.

After Watching

Have students continue discussing the characteristics and properties of snow and how scientists use this information in avalanche research. What kinds of environmental factors might influence how layers of snow fall? What kinds of snowpack layers indicate an area is at high risk for avalanches? How do people who have seen or been caught in avalanches describe how the snow changes before, during, and after an avalanche?
Avalanche!

Classroom Activity

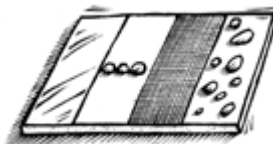
[Materials](#) | [Procedure](#) | [Activity Answer](#)

Objective

To investigate the complexities of snowpack formation and mass movements.

MATERIALS for each team -----

- copy of the "Slip Sliding Away" student handouts
- Slip Sliding Away ([PDF](#) or [HTML](#))
- Foam Board Model ([PDF](#) or [HTML](#))
- prepared Foam Board Model
- 16 oz. granulated sugar
- 5 lb. flour
- 8 oz. mashed potato flakes
- protractor
- newspaper



How Do Avalanches Form?

See in this Teachers' Domain [video segment](#) (4m 3s) how the shape of the ice crystals of snowflakes within a snow pack is a critical factor in avalanches.

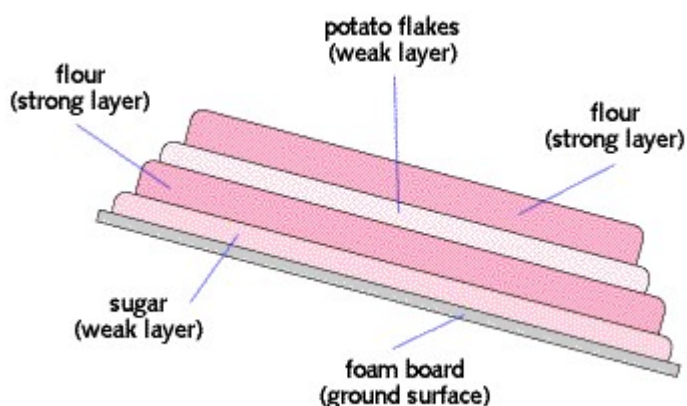
PROCEDURE -----

1. An integral part of avalanche research is understanding the complexities of snowpack formation and using this data to make predictions about how particular slopes might behave. In this activity, students layer foodstuffs to mimic the strong and weak layers within a snowpack and then cause an avalanche to occur.
2. Prior to the activity, you will need to construct boards for each team using the "Foam Board Model" directions.
3. Once the models are made, divide students into teams, gather materials, and distribute the "Slip Sliding Away" student handouts.
4. In Part I, have students predict how the snowpack will behave at different inclines on each surface. Then have students layer sugar, flour, and potato flakes to simulate different layers in a snowpack over winter.
5. In Part II, students begin to incline the board and record data as their snowpack begins to slide.
6. Conclude with a class discussion about how slope, terrain, and different layers within the snowpack affect its stability, and how objects on slopes both help prevent avalanches from forming as well as become areas of stress for triggering them.

ACTIVITY ANSWER

The word *avalanche* is derived from the Latin word meaning to "slip, glide down, and flow." Although almost anything that slides down a mountain or hillside (mud, ice, or rocks) can be called an avalanche, the term most commonly refers to snow slides.

A snowpack accumulates by layers with each new snowfall or drifting of snow. Layers within a snowpack vary and constantly change mainly due to temperature changes in the air and within the snowpack. Some layers are weak with limited bonding between snow crystals, while other layers are strong with well-bonded snow crystals. In this model, the sugar represents a weak layer at the base of the snowpack. The flour represents a strong layer, and the potato flakes simulate a second weak layer between the flour layers. The surfaces on the foam board represent various ground surfaces under the snowpack.



As the incline of the board is increased, the stress on the snowpack increases. In nature, avalanches can occur on slopes with angles above 25 degrees but are most common on slopes of 35 to 40 degrees. Students should expect to see slides on the smooth acetate surface at a lower incline angle. This is because there is very little to anchor the snowpack to the hill or mountainside. The top flour layer will likely slide first along the weak layer of potato flakes, and as stress builds, the entire snowpack will slide.

A strong layer does not necessarily mean it's a stable layer. Slab avalanches occur when a relatively strong layer lies on top of a weak layer. In a slab avalanche, the snow breaks off in a single plate, which

then fractures and slides down the slope. Students are likely to notice a slab avalanche on the burlap surface, which anchors the weak sugar layer. As a result, only the top flour layer breaks off and slides when the underlying weak potato flake layer fails.

The rocks on the plain foam and the burlap surfaces represent trees or rocks on a mountainside. Rocks and trees will help anchor a snowpack, but they are also areas of stress concentration which can trigger avalanches. If anchors are completely buried under snow, their ability to hold the snow decreases.

This model simulates only a few of the variables that scientists consider when predicting avalanches. Avalanche forecasting can be compared to the more familiar task of weather forecasting. Predicting avalanches, however, is more complex than predicting weather because it includes all of the variables associated with weather along with other variables such as snow type, terrain, slope, and chance events.

Suggested Resources – High School

Appendix 1.

THE SCIENCE PROCESS TERMINOLOGY

The processes of science are skills that are developing knowledge, concepts, and application across the curriculum. The processes are often referred to as the "hands-on " laboratory approach to science and must be used throughout the program. Each of the terms has been adapted from Elementary Science Studies, American Association for the Advancement of Science and Science Curriculum Improvement Studies, and implies active student participation.

OBSERVING: Using the senses to gather information about objects and events in the environment. This skill includes using scientific instruments to extend the range of the human senses and the ability to differentiate relevant from non-relevant.

CLASSIFYING: A method for establishing order on collections of objects or events. Students use classification systems to identify objects or events, to show similarities, differences, and interrelationships. It is important to realize that all classification systems are subjective and may change as criteria change. The test for a good classification system is whether others can use it.

MEASURING: A procedure for using instruments to determine the length, area, volume, mass, or other physical properties of an unknown quantity. It requires the proper use of instruments and the ability to calculate the measured results.

USING NUMBERS The skill includes: number sense, computation, estimation, spatial sense, and whole number operation.

COMMUNICATING: Transmitting the results of observations and experimental procedures to others through the use of such devices as: graphs, charts, tables, written descriptions, technology, oral presentations, expository writing, etc. Communication is fundamental to science, because it is in exchanging ideas and results of experiments that knowledge is validated by others.

QUESTIONING: The formulating of original questions based on observations and experiences with an event in such a way that one can experiment to seek the answers.

RELATING: In the sciences, information about relationships can be descriptive or experimental. Relationships are based on logical arguments that encompass all data. Hypothetical reasoning, deductive reasoning, coordinate graphing, the managing of variables, and the comparison of effects of one variable upon another contribute to understanding the major concepts of science.

INFERRING: An inference is a tentative explanation that is based on partial observations. Available data is gathered and an evaluation made based on the observed data. These judgments are never absolute and reflect what appears to be the most probable explanation at the time and are subject to change as new data is accumulated.

PREDICTING: Using previously-observed information to determine probable outcomes about future events.

FORMULATING HYPOTHESIS: Stating a probable outcome for some occurrence based on many observations and inferences. The validity of the hypothesis is determined from testing of two or more trials of a given experiment.

IDENTIFYING AND CONTROLLING VARIABLES: Determining what elements in a given investigation will vary or change and what will remain constant. Ideally scientists will attempt to identify all the variables before an investigation is conducted. By manipulating one variable at a time they can determine how that variable will affect the outcome.

EXPERIMENTING: The process is the culmination of all the science process skills. Experimentation often begins with observations, which lead to questions that need answers. The steps for proceeding may include forming a hypothesis, identifying and controlling variables, designing the procedure for conducting tests, implementing tests, collecting and interpreting the data and reaching a conclusion.

APPLYING: The process of inventing, creating, problem solving, and determining probabilities are applications of using knowledge to discover further information.

CONSTRUCTING MODELS: Developing physical or mental representations to explain an idea, object or event. Models are usually developed on the basis of an acceptable hypothesis.

Appendix 2

RESOURCES

Professional Organizations

The following organizations maintain many up to date resources available for all:

National Catholic Educational Association
National Association of Science Teachers
National Earth Science Teachers Association
National Association of Geoscience Teachers
National Association of Biology Teachers
National Association of Chemistry Teachers
American Association of Physics Teachers
National Marine Educators Association
American Chemical Society
American Physical Society
MidAtlantic Marine Educators Association
Virginia Association of Science Teachers
Virginia Instructors of Physics
Virginia Association of Biology Teachers

On the Web

The Bridge

Data-based activities related to the marine sciences.

TED Talks

Features a variety of speakers on numerous topics, each video about 20 minutes long.

Amazing Cells (University of Utah – learn.genetics.org)

Excellent activities related to cell structure and function with associated topics such as University of Utah

Pearson LabBench Activities (Virtual lab experiments related to the old AP Biology curriculum; useful as pre-lab exercises)

Secrets of the Sequence, VCU

Activities and videos related to molecular biology on a variety of topics including anatomy, plants, and

HHMI DVDs

Free resources many related to natural selection and evolution

<http://jersey.uoregon.edu/vlab/Piston/index.html>

Useful simulation on gas laws.

<http://phet.colorado.edu/en/simulations/category/chemistry/general>

Lots of simulations. Many allow students to manipulate variables and collect data.

www.webelements.com

Lots of useful information on each element. Can be used for student element papers, bulletin boards, posters, etc.

<http://www.chm.davidson.edu/vce/>

Many virtual labs. A great resource if you don't have the materials or time needed to do an actual experiment. Labs are sorted by topic.

<http://www.virtlab.com/main.aspx>

This site has lots of virtual labs but it is NOT free. You can sign up for a free introduction to see if the site fits your needs.

<http://web.mst.edu/~gbert/qual/qual.html>

Virtual lab on qualitative analysis.

http://web.mst.edu/~gbert/Color_Lg/color.html?536

Don't have a spectrophotometer? This virtual lab provides a nice simulation of one.

<http://web.mst.edu/~gbert/cupCal/Acups.html>

A coffee cup calorimeter virtual lab. Provides a nice introduction and some sample data before performing a calorimetry lab.

<http://web.mst.edu/~gbert/Kinetics/Kinetics.html>

Not really a virtual lab but this site does provide lots of sample kinetics data.

<http://web.mst.edu/~gbert/Electro/Electrochem.html>

Allows students to prepare cells with different electrodes and concentrations and measure their voltages.

<http://www.chemcollective.org/mr/index.php>

This ChemCollective activity might be described as a murder mystery for chemistry students. Students can "interview" suspects by viewing videos, investigate the crime scene using images, and analyze evidence from the crime lab.

http://chemcollective.org/activities/type_page/1

The ChemCollective site contains many virtual labs, separated into seven categories: stoichiometry, thermochemistry, equilibrium, acid-base chemistry, solubility, redox/electrochemistry, and analytical chemistry/lab techniques. Each lab has an associated problem for students to solve in the virtual laboratory, described on a downloadable assignment sheet.

Physics Classroom - <http://www.physicsclassroom.com/Class/>

This exceptionally useful website contains tutorials that cover many fundamental topics in physics. Animations, practice questions, diagrams, etc. are included.

Physics Numbers You Can Use - http://www.image-ination.com/test_maker/phycon.html

Gives various physical constants and properties.

Significant Digits - <http://lectureonline.cl.msu.edu/~mmp/applist/sigfig/sig.htm>

A game that allows students to practice with sigfigs.

A Great Place to Learn about the History of Physics - <http://www.aip.org/history/>

American Institute of Physics website – lots of resources.

The Yahoo Physics Site - <http://dir.yahoo.com/science/physics/>

Lots of useful links to various physics sites.

Car Braking Demo - <http://www.phy.ntnu.edu.tw/java/Reaction/reactionTime.html>

This applet allows the user to change the initial speed and coefficient of friction and then calculates the user's reaction time. Useful for studying friction and its effect on acceleration.

Projectile Motion -

http://galileo.phys.virginia.edu/classes/109N/more_stuff/Applets/ProjectileMotion/jarapplet.html

Graphs projectile motion, allows manipulation of several variables.

Linear Momentum - <http://zebu.uoregon.edu/nsf/mo.html>

Explores the conservation of linear momentum.

Virtual Billiards - <http://lectureonline.cl.msu.edu/~mmp/kap6/cd155a.htm>

Conservation of momentum with pool balls.

Buoyant Forces - <http://theory.uwinnipeg.ca/physics/fluids/node10.html>

A tutorial on buoyant force and Archimedes' Principle.

Pendulums - <http://lectureonline.cl.msu.edu/~mmp/kap13/cd363a.htm>

Useful for studying the harmonic motion of pendulums.

Doppler Effect - <http://newton.umsi.edu/exhibit/doppler.html>

Explore the Doppler Effect.

Resistors - <http://lectureonline.cl.msu.edu/~mmp/kap20/RR506a.htm>

Practice with resistors in series and parallel.

Ohm's Law - <http://micro.magnet.fsu.edu/electromag/java/ohmslaw/>

Allows user to change the resistance and voltage and measure current.

Snell's Law - <http://lectureonline.cl.msu.edu/~mmp/kap25/Snell/app.htm>

Visualize and practice calculations with Snell's Law.

Optics Bench - <http://webphysics.davidson.edu/applets/optics4/default.html>

Allows users to place mirrors, lenses, and objects. Also includes sample problems.