SCIENCE
COURSE OF STUDY

Grades Pre-K-12

Lancaster City Schools
345 E. Mulberry Street
Lancaster, Ohio  43130

June 2011
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ACKNOWLEDGMENT

The schools are the official community agencies for the education of children. Application of real-life scientific concepts is of crucial importance to Lancaster City Schools students. The school district's goals are to teach these concepts using inquiry, technology, and gathering and analyzing data. The Science Course of Study will be the framework of instruction to ensure the success of our students in their Science courses.

The work of the Science teachers is gratefully acknowledged. Their dedication and expertise has resulted in a curriculum that will “prepare students of all ages to meet academic, social, civic, cultural, and employment needs of the 21st Century.” These teachers are:

**Elementary:**
- Janilyn Bartlett
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The Vision
A community focused on student achievement

The Mission
To prepare students of all ages to meet academic, social, civic, cultural, and employment needs of the 21st Century.
Educational Philosophy

The School Board believes in the dignity and uniqueness of each student and recognizing their inherent differences, endeavors to provide a broad curriculum enabling students to reach their maximum potentials.

Success in education necessitates a curriculum that considers multiple learning styles and which encompasses a variety of teaching methods.

Mental and emotional development begins at birth and continues throughout life. Each of our schools must strive to create an atmosphere which fosters healthy and productive attitudes toward education and which encourages a life-long interest in learning.

The Lancaster City Schools are committed to:

1. teaching 21st century skills pertaining to reading, writing, mathematics, historical perspective, scientific inquiry, technology, arts, culture, health and wellness, social and vocational areas to meet or exceed a mastery level so that students continue intellectual growth and development;
2. providing experiences which enable students to develop critical thinking, reasoning, problem solving and decision making skills;
3. stimulating creativity, encouraging personal enrichment,
4. and providing approaches to wellness that enable students to define their individuality;
5. fostering attitudes of acceptance and respect for the ideas, beliefs and goals of others;
6. fostering attitudes of social responsibility so that every student contributes to their community in a positive way.

Our ultimate goal is to generate graduates of the Lancaster City Schools who, as adults, will stand confidently, participate fully, learn continually and contribute meaningfully to our world.
The goal of this school system is to accept responsibility for the development of each child into an adult who can stand confidently, participate fully, learn continually and contribute meaningfully to our world.

To achieve the desired goal, five equally important objectives with desired outcomes will be incorporated into our curriculum planning:

1. To ensure that each student develops mastery in academic skills.

2. To ensure that each student develops the capacity to recognize and analyze current and future challenges and opportunities.

3. To ensure the development of meaningful interpersonal relationships among students, staff and the community.

4. To ensure that staff, students and parents are afforded maximum feasible participation in the development and evaluation of programs and policies that meet the educational needs of all stakeholders.

5. To ensure maximum efficiency in the allocation of human and material resources.
Science Philosophy

Science is the discovery of knowledge through a standard, logical process using observation and investigation. Science education must stress this structured scientific method of inquiry. Integration of technology is necessary to explore and deepen student understanding of scientific concepts.

A hands-on approach that incorporates the use of inquiry, technology, and gathering data is felt to be the most effective instructional method. It is also believed that it is critical students ask questions, problem solve, use critical thinking, and communicate their findings to others. The Lancaster City Schools Science Course of Study details the necessary knowledge, concepts, skills, and scientific principles necessary to understand scientific issues of our time.

The planned teaching experiences should occur in an intellectual environment developed at a pace and level that corresponds with individual student needs. Opportunities should be provided for remediation, enrichment and acceleration.
**Strand: Earth and Space Science**

**Topic: Daily and Seasonal Change.** This topic focuses on observing, exploring, describing and comparing weather changes, patterns in the sky, and changing seasons.

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1)</td>
<td><strong>Weather changes every day.</strong></td>
</tr>
<tr>
<td></td>
<td>A. Wind, water and temperature are all part of daily weather changes. Weather changes throughout the day and from day to day. Weather changes can be discussed and recorded.</td>
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<tr>
<td></td>
<td>B. Measurements can be collected and documented, but the measurements should be age-appropriate (can be nonstandard).</td>
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<tr>
<td></td>
<td>C. Seasonal changes are included in the discussions, and must be based on actual observations of the weather changes.</td>
</tr>
<tr>
<td>2)</td>
<td><strong>The sun and moon are visible at different times of the day or night.</strong></td>
</tr>
<tr>
<td></td>
<td>A. The sun is visible only in the daytime, but the moon is visible sometimes at night and sometimes during the day. Observations made about the day and night are included in this content statement.</td>
</tr>
<tr>
<td></td>
<td>B. The moon can look different on different nights. Photographs of the moon can be viewed in books or virtually. Comparisons of the lit portion of the moon can be made once a week (when there are noticeable differences).</td>
</tr>
<tr>
<td>3)</td>
<td><strong>Water can be observed as lakes, ponds, rivers, streams, the ocean, rainfall, hail, sleet or snow.</strong></td>
</tr>
<tr>
<td></td>
<td>A. Different forms of water, such as rain, snow, or sleet are observed through weather events, classroom investigations, or in natural settings. These forms of water can be measured and documented in age-appropriate methods.</td>
</tr>
<tr>
<td></td>
<td>B. When it rains, water can create puddles or cause flooding. The puddles and flooding eventually go away. Some areas flood more than others.</td>
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<tr>
<td></td>
<td>C. There are numerous forms of water that can be studied at this age; it should be limited to what can actually be seen. For example: while it is true that water is in the air, this is difficult to explain, but allowing students to observe and experience fog or steam can be a way to demonstrate water is present in the air.</td>
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<tr>
<td></td>
<td>D. Study available natural streams, lakes, or ponds related to life science (what lives in the bodies of water?) or physical science (comparing the properties of water to a rock).</td>
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<tr>
<td></td>
<td>E. The ocean is the largest body of water on Earth.</td>
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<tr>
<td>4)</td>
<td><strong>Rocks and soil have properties that can help identify them.</strong></td>
</tr>
<tr>
<td></td>
<td>A. Rocks and soil have different colors and textures. Rocks and soil can be sorted by different colors and textures.</td>
</tr>
<tr>
<td></td>
<td>B. Sorting and comparing the different characteristics of rocks,</td>
</tr>
</tbody>
</table>

**Science Inquiry and Applications**

- Observe and ask questions about the natural environment.
- Plan and conduct simple investigations.
- Employ simple equipment and tools to gather data and extend the senses.
- Use appropriate mathematics with data to construct reasonable explanations.
- Communicate about observations, investigations and explanations.
- Review and ask questions about the observations and explanations of others.

**Technological and Engineering Design**

- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
such as: heavy/light, smooth/rough, or multiple color can help identify the unique characteristics. Classroom collections of rocks can help illustrate the multitude of colors and textures that are possible in nature.

C. Actual soil sample should be used to investigate the properties of soil. Investigate the soil color (what happens to the color when the soil is wet or dry?), composition (what can be seen in the soil?) and texture (how does the soil feel?).
**Strand: Physical Science**

**Pre-K**

<table>
<thead>
<tr>
<th>Topic: Observation of Objects and Materials</th>
<th>Pre-K</th>
</tr>
</thead>
<tbody>
<tr>
<td>This topic focuses on making sound and observing, exploring and describing properties of objects and materials that can be found in nature, classrooms, and homes.</td>
<td></td>
</tr>
</tbody>
</table>

1) Objects and materials are described by their properties.
   A. Color, shape, size, weight, and texture are some examples that can be used to describe and/or sort objects and materials.
   B. Objects are things that can be seen or felt, e.g., a grain of sand, a leaf, a spoon, shoes.
   C. Objects can be described in terms of the materials from which they are made (clay, cloth, paper, glass, etc.). The same kind of object can be made of different materials. For example, a spoon can be made of wood, plastic, metal, etc.
   D. Temperature observations should be limited to descriptors such as hot, warm, cold, and cool.
   E. Observations of weight can be limited to describing objects as heavy or light.
   F. People use their senses and tools to find out about their surroundings and themselves. Different senses and tools give different information.
   G. Shapes such as circles, squares, and triangles can be used to describe many things that can be seen. One way we can describe objects is to compare them to others (larger, smaller, heavier, darker, etc.).

2) Many objects can be made to produce sound.
   A. Sound can be produced by touching, blowing, or tapping objects. Sound can be made in many ways, such as: tapping to produce a sound, like cymbals, the tabletop, or drums; plucked to produce a sound, like a rubber band or a guitar string; and blown to produce a sound, like a bottle or a trumpet.
   B. A wide variety of sounds can be made with the same object. For example, a plastic bottle could be tapped or blown into.
   C. Sound is explored only through situations that can be observed and described.

**Science Inquiry and Applications**

- Observe and ask questions about the natural environment.
- Plan and conduct simple investigations.
- Employ simple equipment and tools to gather data and extend the senses.
- Use appropriate mathematics with data to construct reasonable explanations.
- Communicate about observations, investigations and explanations.
- Review and ask questions about the observations and explanations of others.

**Technological and Engineering Design**

- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
**Strand: Life Science**

**Pre-K**

<table>
<thead>
<tr>
<th><strong>Topic: Observation of Living Things.</strong> This topic focuses on observing, exploring, and describing external, physically observable characteristics and behaviors of plants and animals found in their local natural environment, in classrooms, and homes.</th>
</tr>
</thead>
</table>

1) There are many distinct environments in Ohio that support different kinds of organisms.
   A. Plants and animals have traits that improve their chances of living in different environments. Plants and animals in Ohio interact with one another for food, shelter, and nesting.
   B. Explore the easily recognizable features of the local environment. Local environments include school grounds, neighborhoods, homes, parks, streams, ponds, lakes, gardens and zoos.
   C. Focus scientific inquiry on raising and answering questions about the local environment. The questions raised can be answered through manipulating things or planned observations.
   D. Observe the features and behaviors of local organisms that are commonly found in the local environment.

2) Similarities and differences exist among individuals of the same kinds of plants and animals.
   A. Individuals among plants of the same kind and individuals of animals of the same kind show greater likeness than differences, even though they vary in some traits and behaviors.
   B. Living things have physical traits and behaviors, which influence their survival.
   C. Physical traits and behaviors of plants and animals are sometimes the same and sometimes different from the characteristics ascribed to them in stories.
   D. It is appropriate to focus on plants and animals found in the local environment. Observations of the same kind of plants and animals should include familiar grouping (pride or lions), or multiple exposures to different individuals of the same kind of plant and animal (for example maple, oak, hickory, beech, or ash) in the local government. At this grade level, it is not appropriate to require that scientific or common names be learned.

**Science Inquiry and Applications**
- Observe and ask questions about the natural environment.
- Plan and conduct simple investigations.
- Employ simple equipment and tools to gather data and extend the senses.
- Use appropriate mathematics with data to construct reasonable explanations.
- Communicate about observations, investigations and explanations.
- Review and ask questions about the observations and explanations of others.

**Technological and Engineering Design**
- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
### Strand: Earth and Space Science

**Topic: Daily and Seasonal Changes.** This topic focuses on observing, exploring, describing and comparing weather changes, patterns in the sky and changing seasons.

**Content Statements:** Weather changes occur throughout the day and from day to day. Air is a nonliving substance that surrounds Earth and wind is air that is moving. Wind, temperature and precipitation can be used to document short-term weather changes that are observable. Yearly weather changes (seasons) are observable patterns in the daily weather changes.

1) Weather changes are long term and short term.
   - A. Weather changes occur throughout the day and from day to day.
   - B. Air is non-living substance that surrounds Earth, wind is moving air.
   - C. Wind, temperature and precipitation document short-term weather changes.
   - D. Yearly weather changes (seasons) are observable patterns in the daily weather changes.

2) The moon, sun and stars are visible at different times of the day or night.
   - A. The moon, sun and stars are in different positions at different times of the day or night.
   - B. Sometimes the moon is visible during the night, sometimes the moon is during the day and at other times the moon is not visible at all.
   - C. The sun is visible only during the day.
   - D. The sun’s position in the sky changes in a single day and from season to season.
   - E. Stars are visible in the evening or morning and some are brighter than others.

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### Strand: Physical Science

**Topic: Properties of Everyday Objects and Materials.** This topic focuses on the production of sound and on observing, exploring, describing and comparing the properties of objects and materials with which the student is familiar.
Content Statements: Objects and materials can be sorted and described by their properties of the materials from which they are made. Some of the properties can include color, size or texture. Some objects and materials produce sound. Sound is produced by touching, blowing or tapping objects. The sounds that are produced vary depending on the properties of objects. Sound is produced when objects vibrate.

1) Objects and materials can be sorted and described by their properties.
   A. In Kindergarten, the concept that objects are made of specific materials (clay, cloth, paper, metal, glass, etc.) is reinforced.
      1. Objects have certain properties (weight, length, width, color, shape, size, temperature, odor, texture, flexibility, etc.) that can be described, compared, and classified.
      2. A set of objects may be sorted and classified many times in many different ways.
      3. One way objects can be described is to compare them with others (larger, smaller, heavier, darker, etc.).
   B. Temperature observations should be limited to descriptors such as hot, warm, and cold.
   C. Observations of weight can be limited to describing objects as heavy or light.
   D. Measuring instruments can be used to make accurate comparisons of objects and events.
   E. The connection between sound energy and the vibration of an object is made for objects that are touched, blown or tapped.

Scientific Inquiry and Applications
- Observe and ask questions about the natural environment.
- Plan and conduct simple investigations.
- Employ simple equipment and tools to gather data and extend the senses.
- Use appropriate mathematics with data to construct reasonable explanations.
- Communicate about observations, investigations and explanations.
- Review and ask questions about the observations and explanations of others.

Technology and Engineering Design
- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.

Strand: Life Science

Topic: Physical and Behavioral Traits of Living Things. This topic focuses on observing, exploring, describing and comparing living things in Ohio.

Content Statements: Living things include anything that is alive or has ever been alive. Living things have specific characteristics traits. Living things grow and reproduce. Living things are found almost everywhere in the world. There are somewhat different kinds in different places.

(1) Living things are different from non-living things.
   A. There are different kinds of living things. List the characteristics of...
**Living things.**

1. Living things include anything that is alive or has ever been alive. Living things have specific characteristic traits.
2. Living things grow and reproduce.
3. Living things are found almost everywhere in the world.
4. Living things grow,
5. The focus is on the traits and behaviors of living things not on attributes of nonliving things.
6. List the characteristics of living things.

**B. Animals need food; plants make their own food.**

1. Ethical treatment of animals should be employed.
2. Respect for and proper treatment of living things should be modeled and taught.

**C. Living things have physical traits and behaviors, which influence their survival.**

1. Involve children in concrete experiences in the natural environment.
   - Plan and conduct simple investigations.
   - Employ simple equipment and tools together data and extend the senses.
   - Use appropriate mathematics with data to construct reasonable explanations.
   - Communicate about observations, investigations and explanations.
   - Review and ask questions about the observations and explanations of others.

**Technology and Engineering Design**

- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.

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**Strand: Earth and Space Science: Sun, Energy and Weather**

**Topic: Sun, Energy and Weather.** This topic focuses on the sun as a source of energy and energy changes that occur to land, air, and water.

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) **The sun is the principal source of energy.**
   
   A. Sunlight warms Earth’s land, air and water. The amount of exposure to sunlight affects the amount of warming or cooling of air, water, and land.
   
   1. Observations and quantitative measurements should be
used to evaluate the warming and cooling of air, water, or soil.
2. The length of time an object or material (including water) is exposed to sunlight and resulting temperature should be observed and also the amount of time for the object or material to cool down after it is taken out of the sunlight.

2) The physical properties of water can change.
   A. These changes occur due to changing energy. Water can change from a liquid to a solid and from a solid to a liquid. Weather observations can be used to examine the property changes of water.
      1. Water can be observed in lakes, ponds, streams, wetlands, the ocean, and through weather events.
      2. Freezing and melting of water are investigated through measurements and observations using technology in the classroom or in a natural setting.
      3. Looking at maps or globes can illustrate the amount of Earth’s surface that is covered in water and why it is important to learn about water.
      4. Water can also be observed in the air as steam or fog.

### Strand: Physical Science

#### Topic: Motion and Materials

This topic focuses on the changes in properties that occur in objects and materials. Changes of position of an object are a result of pushing or pulling.

<table>
<thead>
<tr>
<th>1) Properties of objects and materials change.</th>
<th>Science Inquiry and Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Objects and materials change when exposed to various conditions, such as heating or freezing. Not all materials change in the same way.</td>
<td>• Observe and ask questions about the natural environment.</td>
</tr>
<tr>
<td>1. Things can be done to materials to change some of their properties (heating and cooling), but not all materials respond the same way to what is done to them.</td>
<td>• Plan and conduct simple investigations.</td>
</tr>
<tr>
<td>2. The properties of materials can change when it interacts</td>
<td>• Employ simple equipment and tools to gather data and extend the senses.</td>
</tr>
</tbody>
</table>

### Technological and Engineering Design

- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
3. When a warmer object is placed next to a cooler object, the warmer object gets cooler and the cooler object gets warmer until both come to the same temperature.

4. Water can be a liquid or solid and can go back and forth from one form to another.
   a. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.
   b. The amount of water left in an open container often decreases, but the amount of water in a closed container does not change.

5. It is possible to keep track of some things, seeing where they have come from and where they go.
   a. When objects are reshaped or broken into pieces, the kind, amount, and weight of the material remain the same, even though the object may look different.
   b. Many materials may be recycled and used again, sometimes in different forms.

2) Objects can be moved in a variety of ways, such as: straight, zigzag, circular, and back and forth.
   A. The position of an object can be described by locating it relative to another object or to the object’s surroundings.
      1. Object positions are described by comparing its location relative to another object (e.g., in front, behind, above, and below).
   B. An object is in motion when its position is changing.
      1. Motion occurs when there is a change in position such as:
          a. Straight line: dropped coin falling to the ground.
          b. Zigzag pattern: a football player zigzagging across the field to avoid being tackled.
          c. Back and forth: child on a swing or the vibrating strings on a guitar.
      2. Things near Earth fall to the ground unless something holds them up.
   C. The motion of an object can be affected by pushing or pulling. A push or pull is a force that can make an object move faster, slower, or go in a different direction.
      1. Changes in motion are a result of changes in energy.

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**Strand: Life Science**

**Topic: Basic Needs of Living Things.** This topic focuses on the physical needs of living things in Ohio. Energy from the sun or food, nutrients, water, shelter, and air are some of the physical needs of living things.

1) Living things have basic needs, which are met by obtaining materials from the physical environment.
   A. Living things require energy, water, and a particular range of temperatures in their environments.
      1. The world has many different environment conditions that support the life of different types or organisms.

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**Science Inquiry and Applications**

- Use appropriate mathematics with data to construct reasonable explanations.
- Communicate about observations, investigations and explanations.
- Review and ask questions about the observations and explanations of others.

**Technological and Engineering Design**

- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
2. Living things meet their basic needs for survival by obtaining necessary things and conditions from the environment.
3. This includes, but is not limited to, temperature range, amount of water, amount of sunlight, available food sources.
4. Living things require energy to respond to their environment, grow, and reproduce.

B. Plants get energy from sunlight. Animals get energy from plans and other animals.
C. Living things acquire resources from the living and non-living components of the environment.
   1. The environment includes both living (plants and animals) and non-living things such as water, air, sunlight, and nutrients.
   2. Energy is something needed to make things go, run, or happen. Examples: Plants need water to live and grow; cars need water, oil and tires; people need sleep, etc.
   3. Ideas about energy that students encounter outside of school – for example, getting “quick energy” from a candy bar or turning off a light so as not to “waste energy” – may be imprecise but are reasonably consistent with ideas about energy that we want students to learn.

Technological and Engineering Design
- Identify problems and potential technological/engineering solutions.
- Understand the design process, role of troubleshooting.
- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
Strand: Earth and Space Science

Topic: The Atmosphere. This topic focuses on air and water as they relate to weather and weather changes that can be observed and measured.

Content Statements: The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) The atmosphere is made up of air.
   A. Air has properties that can be observed and measured. The transfer or energy in the atmosphere causes air movement, which is felt as wind. Wind speed and direction can be measured.
   B. Wind can be measured with numeric value and direction (for example, wind speed is 6 mph, wind direction is moving W to E).
   C. Air takes up space (has volume) and has weight (mass). Heating and cooling of air (transfer of energy) results in movement of the air (wind). The direction and speed of the wind can be measured using a variety of instruments.
   D. Weather events that are related to wind (such as tornadoes and hurricanes) are included in this content.

2) Water is present in the air.
   A. Water is present in the air as clouds, steam, fog, rain, ice, snow, sleet or hail. When water in the air cools (change of energy), it forms small droplets of water that can be seen as clouds.
   B. Water can change from liquid to vapor in the air and from vapor to liquid. The water droplets can form into raindrops. Water droplets can change to solid by freezing into snow, sleet, or hail.
   C. Clouds are moved by flowing air.
   D. The different parts of the water cycle are explored and discussed, but the emphasis at this grade level is investigating condensation and evaporation at depth, not memorizing the water cycle itself.
   E. Cloud formation and types of clouds are introduced as they relate to weather, storm fronts, and changing weather. Again, the emphasis is not in naming cloud types, but in relating the characteristics of the clouds with weather.
   F. Factors such as water contamination/pollution can be introduced within this content statement as it relates to pollutants that can enter waterways through precipitation, evaporation and condensation.

3) Long- and short-term weather changes occur due to changes in energy.
   A. Changes in energy affect all aspects of weather, including temperature, precipitation amount, and wind.
   B. Weather is a result of energy change. Heating and cooling of water, air, and land (from sunlight) are directly related to wind, evaporation, condensation, freezing, thawing, and precipitation.
   C. Weather patterns (long-term) and fronts (short-term) can be documented through consistent measuring of temperature.
**Strand:  Physical Science**

**Topic:  Changes in Motion.** This topic focuses on observing the relationship between forces and motion.

<table>
<thead>
<tr>
<th>1) Forces change the motion of an object.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Motion can increase, change direction, or stop – depending on the force applied.</td>
</tr>
<tr>
<td>B. The change in motion of an object is related to the size of the force.</td>
</tr>
<tr>
<td>C. Some forces act without touching, such as using a magnet to move an object or objects falling to the ground.</td>
</tr>
</tbody>
</table>

Note: At this grade level, gravitational and magnetic forces should be introduced through observation and experimentation only. The definitions of these forces should not be the focus on the content statements.

**Science Inquiry and Applications**
- Observe and ask questions about the natural environment.
- Plan and conduct simple investigations.
- Employ simple equipment and tools to gather data and extend the senses.
- Use appropriate mathematics with data to construct reasonable explanations.
- Communicate about observations, investigations and explanations.
- Review and ask questions about the observations and explanations of others.

**Technological and Engineering Design**
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- Understand how physical technologies impact humans.
**Strand: Life Science**

**Topic: Interactions Within Habitats.** This topic focuses on how ecosystems work by observations of simple interactions between the biotic/living and abiotic/non-living parts of an ecosystem. Just as living things impact the environment in which they live, the environment also impacts living things.

1) Living things cause changes on Earth.
   A. Living things function and interact with their physical environments. Living things cause changes in the environments where they live; the changes can be very noticeable or slightly noticeable, fast or slow.
      1. The environment is a combination of the interactions between living and non-living components. These interactions can cause changes in groups of organisms and the physical environment. Some of the changes that can be observed are: beavers building a dam; plants growing in cracks of sidewalks; and soil formation. The focus should not be limited to human interaction with the environment. Students can observe earthworm compost bins, ant farms, and weeds growing on a vacant lot.

2) Some kinds of individuals that once lived on Earth have completely disappeared, although they were something like others that are alive today.
   A. Living things that once lived on Earth no longer exist; their basic needs were no longer met.
      1. From looking at fossils, it can be determined that many extinct plants and animals looked something like plants and animals that are alive today, while others were very different from anything alive today. The word “fossil” refers to the physical evidence of former life from a period of time prior to recorded human history.
      2. Students can explore a vast array of organisms, both extinct (Rugosa coral and ferns) and extant (brain coral and fiddleheads). Pictures, video, websites, books, local parks and museums can be used to help students visualize past environments and the organisms that lived in them.

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**Science Inquiry and Applications**

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**Strand: Earth and Space Science: Sun, Energy and Weather**

**Topic: Earth’s Resources.** This topic focuses on the Earth’s resources. While resources can be living and non-living, the emphasis is on the Earth’s non-living resources, such as water, rock, soil, and the energy resources they represent.

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

<table>
<thead>
<tr>
<th>1) Earth’s non-living resources have specific properties.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Soil is composed of pieces of rock, organic material, water, and air.</td>
</tr>
<tr>
<td>B. Soil has characteristics that can be measured and observed.</td>
</tr>
<tr>
<td>C. Rocks have unique characteristics that allow them to be sorted and compared.</td>
</tr>
<tr>
<td>D. Rocks form in different ways.</td>
</tr>
<tr>
<td>E. Air and water are non-living resources.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2) Earth’s resources can be used for energy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Many of Earth’s resources can be used for the energy they contain.</td>
</tr>
<tr>
<td>B. Renewable energy is an energy resource such as wind, water, or solar energy, which is replenished within a short amount of time by natural processes.</td>
</tr>
<tr>
<td>C. Non-renewable energy is an energy resource, such as coal, or oil that is a finite energy source that cannot be replenished in a short amount of time.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3) Some of Earth’s resources are limited.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Some of Earth’s resources become limited due to overuse and/or contamination.</td>
</tr>
<tr>
<td>B. Reducing resource use, decreasing waste and/or pollution, recycling and reusing can help conserve these resources.</td>
</tr>
</tbody>
</table>

**Science Inquiry and Applications**
- Observe and ask questions about the natural environment.
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**Technological and Engineering Design**
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- Understand goals of physical, informational and bio-related technologies.
- Understand how physical technologies impact humans.
Strand: Physical Science

**Topic: Matter and Forms of Energy.** This topic focuses on the relationship between matter and energy. Matter has specific properties and is found in all substances on Earth. Heat is a familiar form of energy that can change the state of matter.

1) All objects and substances in the natural world are composed of matter.
   A. Matter takes up space and has weight.

2) Matter exists in different states, each of which as different properties.
   A. The most common states of matter are solids, liquids, and gases.
   B. Shape and compressibility are properties that can distinguish between the states of matter.
   C. The shape of a solid is independent of its container. Liquids and gases flow and take the shape of their container.
   D. One way to change matter from one state to another is by heating or cooling.

3) Heat, electricity, light, and sound are forms of energy.
   A. There are many different forms of energy.
   B. Energy is the ability to cause motion or create change.

**Science Inquiry and Applications**
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**Strand: Life Science**

<table>
<thead>
<tr>
<th>Topic: Behavior, Growth, and Changes. This topic explores life cycles of organisms and the relationship between the natural environment and an organism’s (physical and behavioral) traits, which affect its ability to survive and reproduce.</th>
</tr>
</thead>
</table>
| 1) Offspring resemble their parents and each other.  
A. Individual organisms inherit many traits from their parents indicating a reliable way to transfer information from one generation to the next.  
B. Some behavioral traits are learned through interactions with the environment and are not inherited.  
2) Individuals of the same kind differ in their traits and sometimes the differences give individuals an advantage in surviving and reproducing.  
A. Plants and animals have physical features that are associated with the environments where they live.  
B. Plants and animals have certain physical or behavioral characteristics that improve their chances of surviving in particular environments.  
C. Individuals of the same kind have different characteristics that they have inherited. Sometimes these different characteristics give individuals an advantage in surviving and reproducing.  
3) Plants and animals have life cycles that are part of their adaptations for survival in their natural environments.  
A. Over the whole earth, organisms are growing, reproducing, dying, and decaying. The details of the life cycle are different for different organisms affecting their ability to survive and reproduce in their natural environments. |

**Science Inquiry and Applications**
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### Strand: Earth and Space Science

#### Topic: Earth’s Surface. This topic focuses on the variety of processes that shape and reshape Earth’s surface.

#### Content Statements:
The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

<table>
<thead>
<tr>
<th>1) Earth’s surface has specific characteristics and landforms that can be identified.</th>
<th>Science Inquiry and Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Earth is known as the “Blue Planet” because about 70% of Earth’s surface is covered in water.</td>
<td>• Observe and ask questions about the natural environment.</td>
</tr>
<tr>
<td>B. Freshwater is a small percentage of the overall water found on Earth; the majority is oceanic.</td>
<td>• Plan and conduct simple investigations.</td>
</tr>
<tr>
<td>C. Freshwater is found in rivers, lakes, and ground water.</td>
<td>• Employ simple equipment and tools to gather data and extend the senses.</td>
</tr>
<tr>
<td>D. The processes that continually build up or tear down the surface of the Earth are: erosion; deposition; volcanic activity; earthquakes; glacial movement; and weathering.</td>
<td>• Use appropriate mathematics with data to construct reasonable explanations.</td>
</tr>
<tr>
<td>E. Flooding, volcanoes, and earthquakes can create landforms.</td>
<td>• Communicate about observations, investigations and explanations.</td>
</tr>
<tr>
<td>F. Recognize common landforms or features through field investigations, field trips, or on topographic maps, remote sensing data, aerial photographs, physical geography maps, and/or from photographs. They are an important way to understand the formation of landforms and features.</td>
<td>• Review and ask questions about the observations and explanations of others.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2) The surface of Earth changes due to weathering.</th>
<th>Technological and Engineering Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Rocks change shape, size, and/or form at different rates due to water or ice movement, freezing and thawing, wind, plant growth, gases in the air, pollution, and catastrophic events.</td>
<td>• Identify problems and potential technological/engineering solutions.</td>
</tr>
<tr>
<td>B. Weathering is defined as a group of processes that changes rock over a long time or quickly.</td>
<td>• Understand the design process, role of troubleshooting.</td>
</tr>
<tr>
<td>C. The weathering process should be observed in nature or virtually.</td>
<td>• Understand goals of physical, informational and bio-related technologies.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3) The surface of Earth changes due to erosion and deposition.</th>
<th>• Understand how physical technologies impact humans.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Weathering is the breakdown of large rock into smaller pieces of rock and erosion is what carries the weathered material to a new location.</td>
<td></td>
</tr>
<tr>
<td>B. Water, wind, and ice physically remove and carry (erosion) rock, soil, and sediment and deposit the material in a new location.</td>
<td></td>
</tr>
<tr>
<td>C. Gravitational force affects movements of water, rock, and soil.</td>
<td></td>
</tr>
<tr>
<td>D. Erosion is a destructive process and deposition is a “constructive” process.</td>
<td></td>
</tr>
<tr>
<td>E. Topographic maps and aerial photographs can be used to locate erosion and depositional areas in Ohio.</td>
<td></td>
</tr>
</tbody>
</table>
Strand: Physical Science

Topic: Electricity, Heat and Matter. This topic focuses on the conservation of matter and physical properties of matter that allow the transfer of heat or electricity.

1) The total amount of matter is conserved when it undergoes a change.
   A. Whether an object is broken into smaller pieces, a solid is dissolved in a liquid, or a change of state occurs, the amount remains constant.
   B. The features of objects may stay the same even when other features change.
   C. Substances move from place to place, but never appear out of nowhere or just disappear.
   D. Discussion of conservation of matter should be limited to a macroscopic observable level.

2) Heat results when substances burn, when certain kinds of materials rub against each other, and when electricity flows through wires.
   A. Rubbing certain kinds of materials together, or when electricity flows through wires, the temperature increases, indicating heat has been added.
   B. Thermal conductors are materials through which heat can easily flow.
   C. Thermal insulators are objects through which heat does not easily flow.
   D. Electrical conductors are materials through which electricity can easily flow.
   E. Electrical insulators are materials through which electricity cannot easily flow.
   F. A complete loop is needed for electricity to flow through a circuit.
   G. Electrical devices will work within a complete circuit.
   H. Electrical devices will often warm when part of a working circuit.
   I. Electricity and magnetism are related; an electricity wire produces magnetic effects and moving magnets can cause electricity to flow in a coil of wire.

Science Inquiry and Applications
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<th>Strand: Life Science</th>
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<tbody>
<tr>
<td><strong>Topic:</strong> This topic focuses on using fossil evidence and living organisms to observe that suitable habitats depend upon a combination of biotic and abiotic factors.</td>
<td><strong>Science Inquiry and Applications</strong></td>
</tr>
<tr>
<td>1) Changes in an organism’s environment are sometimes beneficial to its survival and sometimes harmful.</td>
<td>• Observe and ask questions about the natural environment.</td>
</tr>
<tr>
<td>A. Ecosystems are based on interrelationships among and between biotic and abiotic factors and can change gradually or dramatically.</td>
<td>• Plan and conduct simple investigations.</td>
</tr>
<tr>
<td>B. When the environment changes, some plants and animals survive and reproduce and others die or move to new locations.</td>
<td>• Employ simple equipment and tools to gather data and extend the senses.</td>
</tr>
<tr>
<td>C. Animals’ patterns of behavior are related to the kinds and numbers of other organisms present, the availability of food and resources, and the physical attributes of the environment.</td>
<td>• Use appropriate mathematics with data to construct reasonable explanations.</td>
</tr>
<tr>
<td>D. The changes that occur in the plant and animal population can impact access to resources for the remaining organisms, which may result in migration or death.</td>
<td>• Communicate about observations, investigations and explanations.</td>
</tr>
<tr>
<td>E. Many changes have occurred in Ohio that impacted plant and animal populations.</td>
<td>• Review and ask questions about the observations and explanations of others.</td>
</tr>
<tr>
<td>F. During some geologic periods, parts of Ohio experienced glaciers and during other geologic periods, parts of Ohio were submerged with water. The climate and precipitation of Ohio has changed as documented by the fossil record.</td>
<td><strong>Technological and Engineering Design</strong></td>
</tr>
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<td></td>
<td>• Identify problems and potential technological/engineering solutions.</td>
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</table>
Strand: Earth and Space Science

Topic: Cycles and Patterns in the Solar System. This topic focuses on the characteristics, cycles, and patterns in the solar system and within the universe.

Content Statements: The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) The solar system includes the sun and all celestial bodies that orbit the sun. Each planet in the solar system has unique characteristics.
   A. The distance from the sun, size, composition, and movement of each planet are unique. Planets revolve around the sun in elliptical orbits.
      1. Eight major planets in the solar system orbit the sun.
      2. Note: The shape of Earth’s orbit is nearly circular (also true for other planets). Many graphics that illustrate the orbit overemphasize the elliptical shape, leading to the misconception regarding seasonal change being related to how “close” Earth is to the sun. The discussion of planet characteristics should be at an introductory level for this grade.
      3. General information regarding planetary positions, orbital pattern, planetary composition, and recent discoveries and projects (for example, Missions to Mars) are included in this content. Tools and technology are an essential part of understanding the workings within the solar system.
   B. Some of the planets have moons and/or debris that orbit them.
      1. Some of the planets have a moon or moons that orbit them. Earth is a planet that has a moon that orbits it.
   C. Comets, asteroids, and meteoroids orbit the sun.
      1. Asteroids are metallic, rocky bodies that orbit the sun but are too small to be classified as a planet. A meteor appears when a particle or chunk of metallic or stony matter, called a meteoroid, enters Earth’s atmosphere from outer space. Comets are a mixture of ices (both water and frozen gases) that are not part of a planet. Pluto is classified as a dwarf planet. (Definition from: http://www.nasa.gov).

2) The sun is one of many stars that exist in the universe.
   A. The sun appears to be the largest star in the sky because it is the closest to Earth. Some stars are larger than the sun and some stars are smaller than the sun.
      1. The sun is the closest star to the Earth. Models and graphics can be used to show the vast difference in size between the sun and the Earth. The sun is a medium-sized star, and is the only star in our solar system. There are many other stars of different sizes in the universe, but because they are so far away, they do not appear as large as the sun.
      2. Note: General facts about the size and composition of the sun are introduced, but details such as the age of the sun are not included in this grade.
sun, specific composition, and actual temperature values are above grade level. The emphasis should be on general characteristics of stars and beginning to understand the size and distance of the sun in relation to the Earth and the other planets.

3) Most of the cycles and patterns of motion between the Earth and sun are predictable.
   A. Earth’s revolution around the sun takes approximately 365 days. Earth completes one rotation on its axis in a 24-hour period, producing day and night. This rotation makes the sun, stars, and moon appear to change positions in the sky.
   1. Models, interactive websites, and investigations are required to illustrate the predictable patterns and cycles that lead to the understanding of day and night, seasons, years, and the amount of direct sunlight received. Three-dimensional models should be used to demonstrate that the tilt of Earth’s axis is related to the amount of direct sunlight received and resulting seasonal temperature changes.
   2. The amount of direct sunlight that Earth receives is related to the altitude of the sun, which affects the angle of the sun’s rays, and the amount of time the sun is above the horizon each day.
   B. Earth’s axis is tilted at an angle of 23.5°. This tilt, along with Earth’s revolution around the sun, affects the amount of direct sunlight that the Earth receives in a single day and throughout the year. The average daily temperature is related to the amount of direct sunlight received. Changes in average temperature throughout the year are identified as seasons.
   1. Seasonal change should be expanded in 5th grade, to include regions of the world that experience specific seasonal weather patterns (hurricane, monsoon, rainy and/or dry seasons are a few examples). This builds upon making observations of the seasons throughout the school year in the earlier grades.
   2. Different regions around the world have seasonal changes that are not based solely on average temperature. Examples include rainy season, dry season, monsoon season, etc.
**Strand: Physical Science**

**Topic: Light, Sound, and Motion.** This topic focuses on the forces that affect motion. This includes the relationship between the speed of an object, the amount of force applied and the weight of the object. Light and sound are explored as forms of energy that move in predictable ways, depending on the matter through which they move.

1) The amount of change in movement of an object is based on the weight of the object and the amount of force exerted.
   A. Movement can be measured by speed. The speed of an object is calculated by determining the distance (d) traveled in a period of time (t). Speed is calculated by dividing the distance traveled by the period of time.  
   1. An object can change its motion by speeding up, slowing down, or changing direction.  
   2. Changes in motion are caused by forces. Forces applied in the same direction increase speed. Forces applied in the opposite direction decrease speed. If no force acts on an object, the object will not change its motion or speed.  
   B. Earth pulls down on all objects with a gravitational force. Weight is a measure of the gravitational force between an object and the Earth.  
   C. Any change in speed or direction of an object requires a force and is affected by the weight of the object and the amount of force applied.

2) Light and sound are forms of energy that behave in predictable ways.
   A. Light travels and maintains its direction until it interacts with an object or when it moves from one medium to another, and then it can be reflected, refracted, or absorbed.  
   1. Light and other electromagnetic waves can be absorbed by objects, causing them to warm. How much an object’s temperature increases depends on the material of the object, the intensity of the light striking its surface, how long the light shines on the object and how much of the light is absorbed.  
   B. Sound is produced by vibrating objects and requires a medium through which to travel. The rate of vibration is related to the pitch of the sound.  
   1. Slowly vibrating objects produce sounds with a low pitch; objects that vibrate quickly produce sounds with a high pitch.

**Scientific Inquiry and Applications**

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

**Technology and Engineering Design**

- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time.
- Recognize role of design and testing in the design process.
- Apply research, innovation and invention to problem-solving.
### Strand: Life Science

**Topic: Interconnections Within Ecosystems.** This topic focuses on foundational knowledge of the structures and functions of ecosystems.

<table>
<thead>
<tr>
<th>1)</th>
<th>Organisms perform a variety of roles in an ecosystem.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Populations of organisms can be categorized by how they acquire energy.</td>
</tr>
<tr>
<td>B.</td>
<td>Food webs can be used to identify the relationships among producers, consumers, and decomposers in an ecosystem.</td>
</tr>
<tr>
<td></td>
<td>1. Producers transform energy from the sun and make food through a process called photosynthesis.</td>
</tr>
<tr>
<td></td>
<td>2. Consumers get their energy by eating plants and other animals that eat plants.</td>
</tr>
<tr>
<td></td>
<td>3. Decomposers are consumers that use waste materials and dead organisms for food then return nutrients to the ecosystem.</td>
</tr>
<tr>
<td>C.</td>
<td>Organisms have symbiotic relationships in which individuals of one species are dependent upon individuals of another species for survival.</td>
</tr>
<tr>
<td></td>
<td>1. Symbiotic relationships can be categorized as:</td>
</tr>
<tr>
<td></td>
<td>a. Mutualism: both species benefit.</td>
</tr>
<tr>
<td></td>
<td>b. Commensalism: one species benefits and the other is unaffected.</td>
</tr>
<tr>
<td></td>
<td>c. Parasitism: one species benefits and the other species is harmed.</td>
</tr>
<tr>
<td></td>
<td>d. Predator/Prey: one species consumes the other species.</td>
</tr>
<tr>
<td>2)</td>
<td>All the processes that take place within organisms require energy.</td>
</tr>
<tr>
<td>A.</td>
<td>For ecosystems, the major source of energy is sunlight.</td>
</tr>
<tr>
<td>B.</td>
<td>Energy entering ecosystems as sunlight is transferred and transformed by producers (plants or photosynthetic organisms) into energy that organisms use through the process of photosynthesis.</td>
</tr>
</tbody>
</table>

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### Strand: Earth and Space Science  

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<p>| | |</p>
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<th></th>
</tr>
</thead>
</table>
| 1) | Minerals have specific, quantifiable properties.  
A. Minerals are naturally occurring, inorganic solids.  
B. Minerals have a defined chemical composition.  
C. Minerals have observable and measurable properties.  
D. Minerals form in specific environments.  
2) | Igneous, metamorphic, and sedimentary rocks can be classified and identified based on their unique characteristics.  
A. Most rocks are made of one or more minerals, but some sedimentary rocks can be classified and identified based on their unique characteristics.  
B. Composition, types of minerals present, mineral arrangements, mineral shape/size can be used for identification.  
C. Properties can also be used to interpret the rock’s history.  
3) | Igneous, metamorphic, and sedimentary rocks form in different ways.  
A. Magma/lava cools and crystallizes to form igneous rocks.  
B. Heat and pressure applied to existing rocks forms metamorphic rocks.  
C. Sedimentary rock forms as existing rock weathers chemically and/or physically and the weathered material is compressed and lithified.  
D. Each rock type can provide information about the environment in which it was formed.  
4) | Soil is unconsolidated material that contains nutrient matter and weathered rock.  
A. Soil formation occurs at different rates.  
B. Soil formation is based on environmental conditions, type of existing bedrock, and rates of weathering.  
C. Soil forms in layers known as horizons.  
D. Soil horizons have distinguishable, measurable properties.  
5) | Rocks, minerals, and soils have common and practical uses.  
A. Nearly all manufactured material requires some kind of geologic resource.  
B. Most geologic resource are considered non-renewable, such as rocks, minerals, and soil.  

**Scientific Inquiry and Applications**  
- Identify questions that can be answered through scientific investigations.  
- Design and conduct a scientific investigation.  
- Use appropriate mathematics, tools, and techniques to gather data and information.  
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- Recognize role of design and testing in the design process.  
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Strand: Physical Science

Topic: Matter and Motion.

1) All matter is made up of small particles called atoms.
   A. Each atom takes up space, has mass, and is in constant motion.
   B. Mass is the amount of matter in an object.
   C. Elements are a class of substances composed of a single kind of atom.
   D. Molecules are the combination of two or more atoms that are joined together chemically.
   E. Compounds are composed of two or more different elements.
   F. Each element and compound has properties, which are independent of the amount of the sample.

2) Changes of state are explained by a model of matter composed of atoms and/or molecules that are in motion.
   A. When substances undergo changes of state, neither atoms nor molecules themselves are changed in structure.
   B. Thermal energy is a measure of motion of the atoms and molecules in a substance.
   C. Mass is conserved when substances undergo changes of state.

3) There are two categories of energy: Kinetic and Potential
   A. Objects and substances in motion have kinetic energy.
   B. Objects and substances can have energy as a result of their position (potential energy).
   C. Objects and substances can have energy as a result of the position of the object or its components (potential energy).

4) An object’s motion can be described by its speed and the direction it is moving.
   A. An object’s position and speed can be measured and graphed as a function of time (no velocity and acceleration rules are to be included).

Scientific Inquiry and Applications
- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate mathematics, tools, and techniques to gather data and information.
- Analyze and interpret data.
- Develop descriptions, models, explanations, and predictions.
- Think critically and logically to connect evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.

Technological and Engineering Design
- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time.
- Recognize role of design and testing in the design process.
- Apply research, innovation and invention to problem-solving.
**Strand: Life Science**

**Topic: Cellular to Multicellular.**

1) Cells are the fundamental unit of life.
   - A. All living things are composed of cells.
   - B. Different body tissues and organs are made of different kinds of cells.
   - C. Organelles have specific functions within the cell.

2) All cells come from pre-existing cells.
   - A. Cells reproduce through cell division.
   - B. Cells reproduction transmits genetic information from one generation to the other (not mitosis or meiosis).
   - C. Cells divide for growth and repair.

3) Cells carry on specific functions that sustain life.
   - A. The basic functions of organisms occur in cells.
   - B. All cells are contained in a cell membrane.
   - C. Cells are made up of specialized parts that transport materials, energy capture and release, protein building, waste disposal, information feedback and movement.

4) Living systems at all levels of organization demonstrate:
   - A. Level of organization within organisms include cells, tissues, organs, organ systems, and whole organisms.
   - B. Organisms function as a whole to perform necessary tasks for survival.
   - C. Organisms are diverse in body plan, symmetry, and internal structures that contribute to their survival.

**Scientific Inquiry and Applications**

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
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**Technological and Engineering Design**

- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time
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### Strand: Earth and Space Science

**Topic: Cellular to Multicellular.**

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

<p>| | |</p>
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| 1) | The hydrologic cycle illustrates the changing states of water as it moves through the lithosphere, biosphere, hydrosphere, and atmosphere.  
A. Thermal energy is transferred as water changes state throughout the cycle.  
B. The cycling of water in the atmosphere is an important part of weather patterns on Earth.  
C. The rate at which water flows through the soil and rock is dependent upon the porosity and permeability of the soil or rock.  
D. Contamination can occur within any step of the hydrologic cycle. |
|   | Scientific Inquiry and Applications  
- Identify questions that can be answered through scientific investigations.  
- Design and conduct a scientific investigation.  
- Use appropriate mathematics, tools, and techniques to gather data and information.  
- Analyze and interpret data.  
- Develop descriptions, models, explanations, and predictions.  
- Think critically and logically to connect evidence and explanations.  
- Recognize and analyze alternative explanations and predictions.  
- Communicate scientific procedures and explanations. |
| 2) | Thermal-energy transfers in the ocean and atmosphere contribute to the formation of currents, which influence global climate patterns.  
A. The sun is the major source of energy for wind, air, and ocean.  
B. As thermal energy transfers occur in the atmosphere and ocean, currents form.  
C. Large bodies of water can influence weather and climate.  
D. The jet stream is an example of an atmospheric current and the Gulf Stream is an example of an oceanic current.  
E. Ocean currents are influenced by factors other than thermal energy, such as water density, mineral content (such as salinity), ocean floor topography and Earth’s rotation.  
F. All of these factors delineate global climate patterns on Earth. |
|   | Technological and Engineering Design  
- Understand and be able to select and use physical and informational technologies.  
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| 3) | The atmosphere has different properties at different elevations and contains a mixture of gases that cycle through the lithosphere, biosphere, hydrosphere and atmosphere.  
A. The atmosphere is held to the Earth by the force of gravity.  
B. There are defined layers of the atmosphere that have specific properties, such as temperature, chemical composition and physical characteristics.  
C. Gases in the atmosphere include nitrogen, oxygen, water vapor carbon dioxide and other trace gases.  
D. Biogeochemical cycles illustrate the movement of specific elements or molecules (such as carbon or nitrogen) through the lithosphere, biosphere, hydrosphere, and atmosphere. |
| 4) | The relative patterns of motion and positions of the Earth, moon and sun cause solar and lunar eclipses, tides, and phases of the moon.  
A. The moon’s orbit and its change of position relative to the Earth and sun result in different parts of the moon being visible from Earth (phases of the moon). |
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<tr>
<td>B.</td>
<td>A solar eclipse is when Earth moves into the shadow of the moon (during new moon).</td>
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<tr>
<td>C.</td>
<td>A lunar eclipse is when the moon moves into the shadow of Earth (during a full moon).</td>
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<tr>
<td>D.</td>
<td>Gravitational force between the Earth and the moon causes daily oceanic tides.</td>
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<tr>
<td>E.</td>
<td>When the gravitational forces from the sun and moon align (at new and full moons), spring tides occur.</td>
</tr>
<tr>
<td>F.</td>
<td>When the gravitational forces of the sun and moon are perpendicular (at first and last quarter moons) neap tides occur.</td>
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**Strand: Physical Science**

**Topic: Conservation of Mass and Energy.**

1) The properties of matter are determined by the arrangement of atoms.
   - A. Elements can be organized into families with similar properties, such as highly reactive metals, less-reactive metals, highly reactive nonmetals and some gases that are almost completely non-reactive.
   - B. Substances are classified according to their properties, such as metals and acids.
   - C. When substances interact to form new substances, the properties of the new substance may be very different from those of the old, but the amount of mass does not change.

2) Energy can be transformed from one form to another.
   - A. When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer.
   - B. When energy is transformed from one form to another, the total amount of energy remains the same.

3) Energy can be transferred through a variety of ways.
   - A. Thermal energy can be transferred through radiation, convection, and conduction.
   - B. Mechanical energy can be transferred when objects push or pull on each other over a distance.
   - C. Electromagnetic waves transfer energy when they interact with matter.
   - D. Electrical energy transfers when an electrical source is connected in a complete electrical circuit to an electrical device.

**Scientific Inquiry and Applications**

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

**Technological and Engineering Design**

- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time.
- Recognize role of design and testing in the design process.
- Apply research, innovation and invention to problem-solving.
Strand: Life Science


1) Matter is transferred continuously between one organism to another and between organisms and their physical environments.
   A. Plants use the energy in light to make sugars out of carbon dioxide and water (photosynthesis). These materials can be used and immediately stored for later use.
   B. Organisms that eat plants break down plant structures to produce the materials and energy they need to survive. Then they are consumed by other organisms.
   C. Energy can transform from one form to another in living things.
   D. Animals get their energy from oxidizing their food, releasing some of its energy as heat.
   E. The total amount of matter and energy remains constant, even though its form and location change.

2) In any particular biome, the number, growth and survival of organisms and populations depend on biotic and abiotic factors.
   A. Biomes are regional ecosystems characterized by distinct types of organisms that have developed under specific soil and climatic conditions.
   B. The variety of physical (abiotic) conditions that exists on Earth gives rise to diverse environments (biomes) and allows for the existence of a wide variety of organisms (biodiversity).
   C. Ecosystems are dynamic in nature; the number and types of species fluctuate over time. Disruptions, deliberate or inadvertent, to the physical (abiotic) or biological (biotic) components of an ecosystem impact the composition of the ecosystem.

Scientific Inquiry and Applications
- Identify questions that can be answered through scientific investigations.
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Technological and Engineering Design
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**Strand: Earth and Space Science**

**Topic: Physical Earth.**

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) The composition and properties of Earth’s interior are identified by the behavior of seismic waves.
   A. The refraction and reflection of seismic waves as they move through one type of material to another is used to differentiate the layers of Earth’s interior.
   B. Earth has an inner and outer core, an upper and lower mantle, and a crust.
   C. The formation of the planet generated heat from gravitational energy and the decay of radioactive elements, which is still present today.
   D. Heat released from Earth’s core drives convection currents throughout the mantle and the crust.

2) Earth’s crust consists of major and minor tectonic plants that move relative to each other.
   A. Historical data and observations such as fossil distribution, paleomagnetism, continental drift and sea-floor spreading contributed to the theory of plate tectonics.
   B. The rigid tectonic plates move with the molten rock and magma beneath them in the upper mantle.
   C. Convection currents in the crust and upper mantle cause the movement of the plates.
   D. The energy that forms convection currents comes from deep within the Earth.
   E. There are three main types of plate boundaries: divergent, convergent, and transform. Each type of boundary results in specific motion and causes events (such as earthquakes or volcanic activity) or features (such as mountain or trenches) that are indicative of that type of boundary.

3) A combination of constructive and destructive geologic processes formed Earth’s surface.
   A. Earth’s surface is formed from a variety of different geologic processes, included but not limited to plate tectonics.

4) Evidence of the dynamic changes of Earth’s surface through time is found in the geologic record.
   A. Earth is approximately 4.6 billion years old. Earth history is based on observations of the geologic record and the understanding that processes observed at present day are similar to those that occurred in the past (uniformitarianism).
   B. There are different methods to determine relative and absolute age of some rock layers in the geologic record.
   C. Within a sequence of undisturbed sedimentary rocks, the oldest rocks are at the bottom (superposition).
   D. The geologic record can help identify past environmental and climate conditions.

**Scientific Inquiry and Applications**
- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate mathematics, tools, and techniques to gather data and information.
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**Technology and Engineering Design**
- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time.
- Recognize role of design and testing in the design process.
- Apply research, innovation and invention to problem-solving.
### Strand: Physical Science

#### Topic: Forces and Motion.

1) Some forces between objects act when the objects are in direct contact or when they are not touching.
   - A. Magnetic, electrical, and gravitational forces can act at a distance.

2) Forces have magnitude and direction.
   - A. The motion of an object is always measured with respect to a reference point.
   - B. Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The net force acting on an object can change the object’s direction and/or speed.
   - C. When the net force is greater than zero, the object’s speed and/or direction will change.
   - D. When the net force is zero, the object remains at rest or continues to move at a constant speed in a straight line.

3) There are different types of potential energy.
   - A. Gravitational potential energy changes in a system as the masses or relative position(s) of objects are changed.
   - B. Objects can have elastic potential and arrangement of the atoms that make up the object.

### Scientific Inquiry and Applications

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate mathematics, tools, and techniques to gather data and information.
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### Technology and Engineering Design

- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time.
- Recognize role of design and testing in the design process.
- Apply research, innovation and invention to problem-solving.
**Strand: Life Science**

**Topic: Interconnections Species and Reproduction.**

1) Reproduction is necessary for the continuation of every species.
   - A. Every organism alive today comes from a long line of ancestors who reproduced successfully every generation.
   - B. Reproduction is the transfer of genetic information from one generation to the next.
   - C. It can occur with mixing of genes from two individuals (sexual reproduction).
   - D. It can occur with the transfer of genes from one individual to the next generation (asexual reproduction).
   - E. The ability to reproduce defines living things.

2) Diversity of species occurs through gradual processes over many generations. Fossil records provide evidence that changes have occurred in number and type of species.
   - A. Fossils provide important evidence of how life and environmental conditions have changed.
   - B. Changes in environmental conditions can affect how beneficial a trait will be for the survival and reproductive success of an organism or an entire species.
   - C. Throughout Earth’s history, extinction of a species has occurred when the environment changes and the individual organisms of that species do not have the traits necessary to survive and reproduce in the changed environment.
   - D. Most species (approximately 99%) that have lived on Earth are now extinct.

3) The characteristics of an organism are a result of inherited traits received from parent(s).
   - A. Expression of all traits is determined by genes and environmental factors to varying degrees. Many genes influence more than one trait, and many traits are influenced by more than one gene.
   - B. During reproduction, genetic information (DNA) is transmitted between parent and offspring.
   - C. In asexual reproduction, the lone parent contributes DNA to the offspring.
   - D. In sexual reproduction, both parents contribute DNA to the offspring.

**Scientific Inquiry and Applications**

- Identify questions that can be answered through scientific investigations.
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**Technology and Engineering Design**

- Understand and be able to select and use physical and informational technologies.
- Understand how all technologies have changed over time.
- Recognize role of design and testing in the design process.
- Apply research, innovation and invention to problem-solving.
Strand: Physical Science (Levels: Honors, practical, functional)

Topic: Physical Science is an introductory-level course that focuses on the systematic study of the fundamental concepts of matter, energy, and motion.

Content Statements: The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) Study of Matter
   A. Classification of matter according to physical and chemical properties.
      1. Students will be able to describe the common physical properties of metals.
         a. Physical: conductivity.
         b. Chemical: reactions with non-metals to produce salts.
      2. Students will be able to identify and describe acids as compounds that exhibit common chemical properties.
         a. Sour taste.
         b. Color changes with litmus and other acid/base indicators.
         c. Tendency to react with bases to produce salt and water.
   B. Classification of matter as a mixture, a pure substance, an element or a compound.
      1. Students will be able to describe a mixture as having more than one kind of element or compound, and recognize that mixtures can have different compositions.
      2. Students will understand that compounds consist of more than one kind of element and to recognize that each compound has:
         a. Unique properties and unchanging composition.
         b. Properties different than those of the elements in the compound.
   C. Differences in physical properties.
      1. Students will be able to explain solids, liquids and gases by the ways the particles of the substances are arranged and by the forces of attraction between particles.
      2. Students will be able to define physical properties: color, solubility, odor, hardness, density, melting point and boiling point, viscosity and malleability.
      3. Students will be able to use physical properties to identify a material, choose a material for a specific purpose, or to separate the substance in a mixture.
   D. Representation of Matter.
      1. Students will understand that the particulate nature of matter is represented by models.
      2. Students will be able to explain the phases of matter using the atomic molecular theory.
      3. Students will be able to use different models to represent information, such as ball-and-stick models or two-dimensional drawings to describe bonding in molecules.
   E. Atoms and Molecules.

Scientific Inquiry and Applications
- Identify questions that can be answered through scientific investigations.
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- Think critically and logically to connect evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.

Technological and Engineering Design
- Demonstrate an understanding of the relationship among people, technology, engineering and the environment.
- Identify a problem or need, consider design criteria and constraints.
- Integrate multiple disciplines when problem-solving.
- Synthesize technological and engineering knowledge and design in problem-solving.
- Apply research, development, experimentation, and redesign based on feedback to problem-solving.
- Build, test, and evaluate a model or prototype that solves a problem or need.
1. Students will understand that atomic structure determines the physical and chemical properties of an element.

2. Students will understand the role, location, charge, and mass of the main subatomic particles:
   a. Protons (relation to atomic number and atomic mass).
   b. Neutrons (relation to atomic mass, atomic stability and isotopes).
   c. Electrons (relation of valence electrons to chemical bonds).

3. Students will understand and explain that nuclear forces hold the nucleus together against the repulsion of protons.

4. Students will be able to explain the behavior of radioactive substances.
   a. Unstable nuclei.
   b. Spontaneous nuclear decay (particles and/or energy).

F. Period trends.
1. Students will understand that the Periodic Table of Elements lists the order of elements by increasing number of protons.

2. Students will understand that the organization of the Periodic Table of Elements illustrates patterns of physical and chemical properties of the elements.
   a. Periods: horizontal rows.
   b. Groups or families: vertical columns.
      i. Families with specific names and properties.

G. Reactions of matter.
1. Students will understand that bonding describes how atoms are arranged in molecules and how atoms rearrange in chemical reactions.

2. Students will be able to describe and diagram the interactions of electrons in bonding.
   a. Ionic bonding: losing and gaining electrons; formation of ions; ionic compounds.
   b. Covalent bonding: sharing of electrons; formation of molecules.
   c. Release of energy (exothermic) or absorption of energy (endothermic) during chemical reactions.

3. Students will understand the Law of Conservation of Mass in terms of:
   a. The number and type of atoms and total mass being the same before and after a chemical reaction.
   b. Heating a sample increases the translational, rotational, and vibrational energy of atoms and/or molecules, resulting in an increase in temperature and/or change of phase.

4. Students will be able to explain that nuclear fission is the decay (breaking down) or large atomic nuclei into small atomic nuclei.

5. Students will be able to explain that nuclear fusion is the
joining of nuclei into a larger nucleus, including:
  a. The release of huge amounts of energy.
  b. Responsible for the formation of stars, formation of all elements in the universe beyond helium, and the energy of the sun.

2) Energy and Waves
   A. Energy basics.
      1. Students will be able to explain kinetic energy as the energy of motion.
      2. Students will be able to explain potential energy.
         b. Electrical: separation of mutually attracting or repelling charges.
      3. Students will be able to explain that thermal energy is associated with the disordered motion of atoms or molecules.
      4. Students will understand energy is a scalar quantity with the unit of Joules (J).
   B. Conservation of energy.
      1. Students will be able to explain that the total initial energy of a closed system is equal to the total final energy of a closed system.
      2. Students will understand that energy is measured relative to a reference point of zero energy and that this reference may be adjusted to different situations.
      3. Students will understand that only the change in the amount of energy can be measured absolutely.
      4. Students will be able to calculate kinetic energy using the formula: \( E_K = \frac{1}{2}mv^2 \).
      5. Students will be able to calculate gravitational potential energy using the formula: \( E_g = mgh \) (\( g = 9.8 \text{ m/s}^2 \); \( h \) = height in meters above the reference point).
   C. Transformation of energy.
      1. Students will understand that work is a method of energy transfer that occurs when an outside force moves an object over a distance, and that the force and displacement must be in the same direction.
      2. Students will calculate work with the equation \( W = F \Delta x \).
      3. Students will understand energy transfer and transformations representations on pie or bar graphs.
### D. Waves.

1. Students will understand that waves transmit energy from one place to another and can transfer energy between objects.
   a. Total amount of energy remains constant.

2. Students will understand the nature of wave speed and be able to calculate quantities associated with the speed of a wave.
   a. A wave travels at a constant speed through a particular uniform material (e.g. water waves at same depth).
   b. Wave speed depends on the medium (e.g. waves travel faster in solids than in gases).
   c. For a particular uniform medium, as frequency \((f)\) increased, the wavelength \((\lambda)\) of a wave is decreased.
   d. \(v_{\text{wave}} = \lambda f\).

3. Students will understand and explain the interaction of waves with the environment.
   a. Absorption: wave encounters a new material, resulting in energy transformation (usually thermal energy).
   b. Reflection: wave bounces off solid barrier.
   c. Refraction: wave changes direction (bends) as it travels from one medium into another medium.
   d. Diffraction: wave bends around small obstacles or openings.
   e. Superposition: waves meet and occupy the same part of the medium will cause an algebraically added displacement. Otherwise, waves will pass through each other and continue travel as before.
   f. Doppler Effect: wavelength and observed frequency depends on the relative motion of the source and the observer.
      i. Toward: wavelength shorter, frequency higher.
      ii. Away: wavelength longer, frequency lower.
3) Motion and Forces
   A. Straight Line Motion Basics.
      1. Students will be able to understand the concept that motion is relative to the observer’s frame of reference and that there is no motionless frame from which to judge all motion.
      2. Students will be able to identify quantities with both magnitude and direction as vector quantities, such as position, displacement, velocity and acceleration.
      3. Students will be able to identify quantities with magnitude only as scalars quantities, such as distance, speed, and time.
   B. Displacement (change in position).
      1. Students will be able to calculate displacement by subtracting the initial position from the final position, \( \Delta x = x_f - x_i \).
      2. Students will understand that motion can be positive or negative depending upon the direction of motion.
      3. Students will be able to describe examples of instances in which the displacement is not equal to the distance traveled.
   C. Velocity (rate at which position changes)
      1. Students will be able to calculate average velocity by dividing displacement by the elapsed time, \( v_{avg} = (x_f - x_i)/(t_f - t_i) \).
      2. Students will understand that motion can be positive or negative, depending upon the direction of motion.
      3. Students will be able to describe examples of instances in which the average speed is not the same as the average velocity.
      4. Students will understand that objects moving with constant velocity have the same displacement for each successive time interval.
      5. Students will understand that velocity changes when an object speeds up, slows down, and/or changes direction.
      6. Students will understand that instantaneous velocity is the velocity of an object at any instant and may not travel for any period of time or cover any distance with that particular velocity.
   D. Acceleration (rate at which velocity changes).
      1. Students will be able to calculate average acceleration by dividing the change in velocity divided by elapsed time, \( v_{avg} = (x_f - x_i)/(t_f - t_i) \).
      2. Students will understand that acceleration can be positive or negative but not the specific description of motion that causes these accelerations.
         a. “Deceleration” not used, as negative signs are not always indicative of “slowing down.”
      3. Students will be able to define “zero acceleration” as either standing still or as moving with a constant velocity.
      4. Students will be able to define “constant acceleration”
as the same change of instantaneous acceleration for equal successive time intervals.

**E. Graphical Representations of Motion.**

1. Students will be able to determine the specifics about speed, direction and change in motion by examining motion graphs with positive x-values and limited to constant velocity or constant acceleration.

2. Students will understand the shape of specific velocity descriptions when depicted on a position vs. time graph.
   a. Constant velocity: straight line.
   b. Zero velocity (at rest): straight horizontal line.
   c. Acceleration: curved line.

3. Students will be able to calculate average velocity by determining the slope of a line on a position vs. time graph.
   a. Positive slope: motion in a positive direction.
   b. Negative slope: motion in a negative direction.

4. Students will understand that shape of specific acceleration descriptions when depicted on a velocity vs. time graph.
   a. Constant acceleration: straight line.
   b. Zero acceleration.
   i. At rest: straight horizontal line on the zero y-axis.
   ii. Constant velocity: straight horizontal line on non-zero y-axis.
   iii. Non-constant acceleration: curved line.

5. Students will be able to calculate average acceleration by determining the slope of a line on a velocity vs. time graph.

**F. Newton’s Laws of Motion.**

1. Students will be able to use forces to understand patterns of motion through Newton’s Laws.
   a. Students will be able to define force as a vector quantity, having both magnitude and direction.
   b. Students will understand that the unit of force is a Newton (N).
      i. One Newton of force will cause a 1 Kg object to accelerate at a rate of $1 \text{ m/s}^2$ ($1 \text{ N} = 1 \text{ Kg} \cdot \text{m/s}^2$).

2. Students will understand that an object does not accelerate (remains at rest or maintains a constant velocity) unless an unbalanced force acts on it.
   a. Students will understand that the S.I. unit of mass is a kilogram (Kg).
   b. Students will be able to define inertia as the resistance to a change in motion and that the mass of an object is directly related to inertia.

3. Students will understand that the rate at which an object changes its speed or direction (acceleration) is directly proportional to the vector sum of the applied forces (net force) and inversely proportional to the mass.
   a. Students will be able to perform calculations using
### Newton’s Second Law of Motion,  
\[ a = \frac{F_{\text{net}}}{m}. \]

b. Students will understand that when the net force acting on an object is zero, the object will not accelerate.
   
i. Moving objects remain moving without change in speed or direction.
   
ii. Objects at rest will remain stationary.

c. Students will be able to calculate weight (gravitational force) from mass.
   
i. Weight of objects near Earth’s surface can be calculated with the equation  
   
\[ F_g = mg, \text{ where } g = 9.8 \text{ m/s}^2. \]

### G. Types of Forces.

1. Students will understand that force pairs are part of a single interaction.

2. Students will be able to define friction as a force between two surfaces that oppose sliding.
   
a. Students will understand that the friction force on an object always points in a direction opposite to the object’s relative motion.
   
b. Students will be able to calculate friction from force diagrams.

3. Students will be able to define a normal force as existing between two solid objects when their surfaces are pressed together due to other forces acting on one or both objects.
   
a. Students will understand that a normal force is always a push directed at right angles from the surface of the interacting objects.

4. Students will understand that a tension force occurs when a non-sack rope, wire, cord, or similar device, pulls on another object.
   
a. Students will understand that the tension force always points in the direction the device is pulling.

5. Students will understand that gravitational, magnetic, and electrical force occur continually even when objects are not touching or the objects are not present at all and are called forces at a distance.
   
a. Students will be able to describe the field model as a representation of forces at a distance.
   
b. Students will understand that when an object with the appropriate property enters the field, the field exerts a force on it.
      
i. Appropriate properties: mass for gravitational fields, charge for electric fields, magnetic object for magnetic fields.
      
ii. The stronger the field, the larger the magnitude of force exerted by the field.

### 4) Earth and The Universe

A) Origin of The Universe.

1. Students will understand that mathematical models and computer simulations are used to study indirect evidence in order to form a scientific account of the
universe.

a. Visual, radio, and x-ray telescopes collect information from the entire electromagnetic spectrum.

b. Computers interpret data and computation.

c. Space probes retrieve data and materials.

d. Particle accelerators emit energies that simulate conditions prior to the birth of stars.

2. Students will understand that the Big Bang Theory places the origin of the universe approximately 13.7 billion years ago.

B) Formation of Galaxies.

1. Students will be able to explain that gravitational attraction caused the coalescence of our solar system out of materials from exploding stars about five billion years ago.

2. Students will understand that our universe has been expanding ever since the Big Bang.

3. Students will be able to explain that the lightest elements were mostly removed by radiation from the newly-formed Sun on the inner planets of Mercury, Venus, Earth, and Mars.

4. Students will be able to explain that the lightest elements compose atmospheres of icy, dense gas on the outer planets of Jupiter, Saturn, Uranus, Neptune, and Pluto.

5. Students will understand that every living and non-living thing in and on Earth is made of material from the original Big Bang explosion.

6. Students will understand that Earth’s history can be inferred from evidence of past events.

a. Students will develop an understanding of geologic time as a relative time scale used to unravel and chronicle both Earth’s and life’s evolution.

b. Students will use an absolute time scale to interpret times of event occurrence and to model processes, such as tectonic deformation or cycles of the global climate system.

7. Students will be able to define and describe galaxies as conglomerations of billions or hundreds of billions of stars, gas, and dust.

a. Students will be able to classify galaxies into three basic shapes: elliptical, spiral, and irregular, and can be either giant or small.

b. Students will understand that our galaxy is called the Milky Way.

i. Spiral galaxy.

ii. Located about 2/3 of the way out from the center of our galaxy and within the plane of our galaxy disk.

iii. “Milky” appearance due to dust and many stars.

c. Students will be able to explain that the motion of galaxies is measured using the Doppler Shift of
### Light.
1. Galaxies farther away have greater red shift.
2. A shift of light from a galaxy to the red end of the spectrum indicates that the galaxy and observer are moving farther away from each other.

### C) Stars.
1. Students will understand that stars, like the Sun, transform matter into energy in nuclear reactions in their cores.
2. Students will be able to explain and describe the life cycle of a star as an unceasing, continual process.
   a. Stars condense by gravity out of clouds of the lightest elements.
   b. Density and temperature in the core of new stars increases until lighter elements fuse into heavier elements.
   c. Immense energy from stellar fusion over millions of years causes the massive stars to explode into clouds of heavy elements from which other star and planets orbiting them later condense.
   d. Most stars are in systems of two or more stars orbiting around one another.
   e. Stars differ from each other in size, temperature and age.
3. Students will understand that the processes of helium fusion from hydrogen nuclei and other processes in stars have led to the formation of all the other elements.

### D) Earth as a System
1. Students will be able to describe Earth as a system containing a fixed amount of each stable chemical atom or elements, most existing in different chemical forms.
2. Students will be able to describe the biogeochemical cyclical movement of elements within and between the lithosphere, atmosphere, hydrosphere, and biosphere.
   a. Movement is driven by Earth’s internal and external sources of energy.
   b. Movement is often accompanied by a change in the physical and chemical properties of matter.
      i. Example: carbon (\(1\)) found in carbonate rocks (limestone), coal and other fossil fuels; found in \(\text{CO}_2\) (atmospheric gas or dissolved in water); found in complex molecules in organisms.
   c. Movement occurs at different rates, depending on the material and the thermal energy changes.
      i. Earth’s atmosphere and oceans absorb and distribute matter and energy.
      ii. Earth’s lithosphere is a system of large plates that move matter and energy.
      iii. Climate results from the interaction among the atmosphere, hydrosphere, lithosphere, and biosphere.
3. Students will understand that Earth works as a complex, dynamic system of interacting components involving the geosphere, atmosphere, hydrosphere, biosphere, and cyrosphere.

4. Students will be able to explain the mechanisms involved in weathering, erosion, and plate tectonics.

5. Students will understand that the unique characteristics of Earth are based on its position in our solar system.
   a. A major period of planetary differentiation (when more dense materials sink to the center while less dense materials stay on the surface) occurred approximately 4.6 billion years ago.
   b. Earth, Venus, and Mars are in the habitable zone of our sun.
   c. Energy transfers from the sun to Earth through electromagnetic radiation that peaks in the visible light part of the spectrum.
   d. Earth’s revolution around the sun, as well as Earth’s rotation and tilt of axis, affect the amount of energy received at any given location, resulting in daily and seasonal weather conditions.
**Strand: Life Science**

**Topic/Course: Biology (Levels: Honors, CP, Practical, Functional, AP)**

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) Heredity - focuses on the explanation of genetic patterns of inheritance.

   A. Cellular Genetics is an explanation of genes that includes the following topics:
      1. The student will build on his/her knowledge that living things are a result of one or two parents and traits are passed on to the next generation through reproduction.
         a. Students can also define traits by the instructions encoded in many discrete genes and genes come in more than one form called alleles.
      2. The students will define and appropriately use the term genes as segments of DNA molecules on chromosomes.
      3. The students will build an understanding that genes can be altered by inserting, deleting, or substituting DNA segments.
         a. The altered gene is passed in to every cell that develops from it.
      4. Students will identify features of genes that will increase, decrease, or have no observable effect on the offspring’s success in its environment.
      5. Students will differentiate gene mutations that occur in body cells and those that occur in gametes which can be passed on to offspring.
   
   B. Body cells of an individual can be very different:
      1. Students will use mitosis to explain that all cells are descended from a single cell and have essentially the same genetic instructions.
      2. Students will understand that different genes are active in different types of cells, influenced by the cell’s environment and past history.
      3. The students will use the sequence of DNA bases in a chromosome to determine the sequence of amino acids in a protein.
         a. The code is universal.
         b. All organisms use transcription and translation to accomplish protein synthesis.

Mendel’s Laws of Inheritance

1. Students will build on their knowledge by comparing asexual and sexual reproduction.
   a. Describe advantages and disadvantages.
   b. Describe the sorting and recombination of meiosis which results in a variance in traits of the offspring of any two parents.
2. Mendel’s First Law – Law of Segregation
   a. The student will explain the allelic relationship for the
expression of the trait.

b. The student will solve genetic problems including incomplete dominance, sex-linked traits, and dihybrid crosses.
   i. Students will evaluate the genetic problems using Chi-Squares.

c. The student will define and properly use the following terms: homozygous, heterozygous, phenotype, genotype, dominance, and recessive.

d. The student will explain variations to Mendel’s First law such as incomplete dominance and co-dominance.

   a. The students will define the Law of Independent Assortment.
   b. The students will use dihybrid crosses to explore linkage groups.

4. Outside of Mendel’s Laws
   a. Students will explore pleiotropic genes which affect more than one trait using simple real world examples.
   b. Students will explore epistasis in which traits are affected by more than one gene using simple real world examples.
   c. Additionally, students will understand that genes modify or regulate the expression of other genes.

2) Evolution – focuses on unity and diversity of life.

   A. Building on previous knowledge:
      1. From elementary school, living things can only survive, when their basic needs are met and comparing fossils to current life forms.
      2. From middle school, the diversity of species through gradual process.

   B. The students will use biological evolution to explain the natural origins for the diversity of life.
      1. Students will shift their focus from thinking in terms of selection of individuals to changing proportions of a trait in populations.
      2. Students will define and use the following terms with respect to changing populations: gene flow, mutation, speciation, natural selection, and genetic drift.
      3. Students will use the Modern Synthesis to explain that evolution works at the level of genes, phenotypes, and population.
      4. Students will compare historical perspectives of evolution by the study of the theory’s development from the time of Darwin and his contemporaries to current scientific work.

   C. The basic idea of biological evolution is that the Earth’s present-day species descended from earlier, common ancestral species.
      1. Students will consider that modern ideas about evolution provide a natural explanation for the diversity of life on Earth.
         a. Students will compare the fossil record and existing
species.
  b. Students will use recent molecular sequence data to support their hypotheses on the lineages of organisms based on morphological comparisons.
2. Students will compare evolution from two perspectives:
   a. From a long-term perspective, evolution is the descent with modification of different lineages from common ancestors.
   b. From a short-term perspective, evolution is the ongoing adaption of organisms to environmental challenges and changes.
D. Populations evolve over time.
   1. Students will understand that different phenotypes result from new combinations of existing genes or from mutations of genes in reproductive cells.
   2. Students will understand that evolution is the consequence of the interactions of:
      a. The potential for a population to increase its numbers
      b. The genetic variability of offspring due to mutation and recombination of genes
      c. Finite supply of resources required for life
      d. The differential survival and reproduction of individuals with the best phenotypes.
   3. Students will understand that inheritable characteristics influence how likely an organism is to survive and reproduce in a particular environment.
   4. Students will understand that when an environment changes the survival value of inherited characteristics may change.

3) Diversity and Interdependence of Life – focuses on the study of diversity and similarity at the molecular level of organisms and investigates the effects of physical and chemical constraints on all biological relationships and systems.

A. Building on previous knowledge:
   1. From elementary school, the interactions of organisms within their environment (food webs) and the Law of Conservation of matter and Energy.
   2. From middle school, geochemical cycles and the flow of energy through organisms.
B. Organisms transform energy and matter at all levels of biological organization, from molecules to ecosystems.
   1. The student will explore the concept of energy flow as unidirectional in ecosystems and the molecules involved in energy flow through living systems.
   2. Students will explore the cycles of matter involved in energy flow.
   3. Students may use food webs/food chains to help explain real world relationships or events within an ecosystem.
C. Students will understand that the cell is a system that conducts a variety of functions associated with life.
   1. Every cell is covered by a membrane that controls what
can enter and leave the cell.

2. Compare primitive (prokaryotic) and eukaryotic cells.

3. Describe the complex network of proteins that provide organization and shape.

4. Within cells are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback, and movement.
   a. Most cells in multicellular organisms perform some specific functions that others do not.

D. Composition of living cells.
1. Students will understand that a living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur.

2. Students will understand the importance of carbon based on:
   a. Small size and four available bonding electrons can join to other carbon atoms in chains and rings to form large and complex molecules, such as proteins, carbohydrates, lipids, and nucleic acids.

E. Regulation of cell functions.
1. Students will understand that complex interactions among different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division.

2. Students will understand that most cells function within a narrow range of temperature and pH.
   a. At low temperatures, reaction rates are slow
   b. At high temperatures and/or extremes of pH the structure of most proteins can be irreversibly changed.
   c. Small changes in pH can alter how molecules interact.

F. Students will understand the structure and function of proteins.
1. The sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein.

2. Proteins catalyze most chemical reaction in cells.

3. Protein molecules are long, folded chains made from a combination of 22 amino acid subunits.

4. The function of each protein molecule depends on its specific sequence of amino acids and the shape resulting from that sequence.
Strand: Physical Science

Topic: Chemistry: Levels (Honors, CP, AP)

Content Statements: The content to be learned. This is the “what” that should be accessible for students at each grade level to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

1) Classifying Matter
   A. The quantitative measurements of matter.
      1. Students will be able to quantitatively measure the 5 standard units of the SI/metric system: length, mass, temperature, time, and moles.
      2. Students will be able to use metric prefixes to convert units to useful sizes.
      3. Students will be able to combine standard units into derived units such as area, volume, speed, density, molarity, etc.
         a. Students will be able to distinguish among commonly mistaken concepts such as mass vs. weight, and mass vs. volume.
      4. Students will be able to report measurements and the results of calculations involving measurements in the proper number of significant figures, and using scientific notation when applicable and needed.
      5. Students will be able to set up problems using dimensional analysis, to obtain results in the correct units.
      6. Students will be able to explain why all measurements contain some degree of uncertainty and how that uncertainty is expressed using significant figures.
      7. Students will be able to identify sources of error within their measurements and determine the magnitude of those errors using percent error and percent yield calculations.
   B. The qualitative characteristics of matter.
      1. Students will be able to recognize and describe the characteristics of the four basic states of matter (solid, liquid, gas, plasma) and Bose-Einstein condensates.
      2. Students will be able to distinguish among and explain how subatomic particles make up atoms, and how atoms bond together to make molecules.
      3. Students will be able to classify matter into pure substances (elements and pure compounds) and mixtures.
         a. Students will be able to describe atoms as the simplest particles of an element and molecules as the simplest particles of a pure compound.
         b. Students will be able to classify mixtures as homogeneous and heterogeneous, and identify the characteristics of each.
      4. Students will be able to explain the behaviors and physical properties of different forms of matter in terms of the strengths of the intramolecular bonds, intermolecular attractions (hydrogen bonds, permanent

Scientific Inquiry and Applications
- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate mathematics, tools, and techniques to gather data and information.
- Analyze and interpret data.
- Develop descriptions, models, explanations, and predictions.
- Think critically and logically to connect evidence and explanations.
- Recognize and analyze alternative explanations and predications.
- Communicate scientific procedures and explanations.

Technological and Engineering Design
- Demonstrate an understanding of the relationship among people, technology, engineering and the environment.
- Identify a problem or need, consider design criteria and constraints.
- Integrate multiple disciplines when problem-solving.
- Synthesize technological and engineering knowledge and design in problem-solving.
- Apply research, development, experimentation, and redesign based on feedback to problem-solving.
- Build, test, and evaluate a model or prototype that solves a problem or need.
dipole-dipole, induced dipole-dipole, and London dispersion forces), and the kinetic energy that particles of matter have in different states.

2) The Structure of Matter
   A. Atomic Structure.
      1. Students will be able to describe an atom in terms of a tiny nucleus which accounts for most of the mass of the atom, containing protons and neutrons, and which is surrounded by a cloud of electrons, which accounts for most of the atom’s volume.
      2. Students will be able to describe and compare the three sub-atomic particles in terms of their charges and relative masses.
      3. Students will be able to correlate the number of protons within an atom’s nucleus with the atomic number of the atom, and therefore the element’s identity.
      4. Students will be able to recognize that in a neutral atom, the numbers of protons and electrons are equal.
      5. Students will recognize that ions form from atoms when the atoms lose or gain electrons but never protons.
      6. Students will be able to write the notation for an atom or ion, indicating the number of protons (atomic number), total of protons and neutrons (mass number), and charge (number of electrons gained or lost).
      7. Students will be able to describe isotopes of atoms as atoms of the same element with differing numbers of neutrons.
      8. Students will be able to calculate the atomic mass of an element from the percent abundances of the element’s isotopes using the weighted average technique.
      9. Students will be able to describe the development of the atomic theory from the start of Democritus, Dalton’s description of atoms as small indestructible spheres of different masses, Thomson’s discovery of the electron, Rutherford’s discovery of the nucleus, and Bohr’s theory of the energy levels for electrons.
     10. Students will be able to describe the arrangement of electrons within an atom (quantum mechanical model) into energy levels (shells), sublevels (subshells), and orbitals.
     11. Students will be able to write the electron configuration for any atom using the principles described immediately above and the Aufbau chart (diagonal rule chart).
     12. Students will be able to relate the arrangement of electrons within atoms to the structure of the periodic table and its blocks or regions (s, p, d, and f).
     13. Students will be able to correlate the electron configuration of an atom to that atom’s chemical properties, and describe how similarities in the electron configurations of elements within a chemical family result in similarities in chemical properties including reactivity and bonding to other atoms.
     14. Students will be able to describe the dual nature of light (particle-like and wave-like behaviors, although light and
sub-atomic particles are neither fully describable as waves or particles), and will be able to describe the relationships among the speed of light, wavelength, frequency, and the energy of the light.

15. Students will be able to define the ground state as the condition where all of an atom’s electrons are in their lowest possible energy states, and that movement of an electron between energy levels depends upon the absorption or emission of specific amounts of light energy corresponding to the differences in energy between energy levels within the atom.

16. Students will be able to correlate the emission spectrum of a simple atom (H) to the downward movements of electrons within that atom, and will determine the amounts of energy involved in the movement of the electrons.

B. Periodic Table
1. Students will be able to recognize that metals are found on the left side of the table, non-metals on the right, and metalloids or semi-metals along the “stair-step line” in between. Students will be able to identify families and regions of the periodic table (including being able to define and use the terms family, column, or group and period or rows) including the alkali metals, alkaline earth metals, halogens, noble or inert gases, transition metals, lanthanides or rare earth metals, and the actinides or man-made radioactive metals.

2. Students will be able to describe that both families and periods have predictable trends of chemical properties, including but not limited to atomic radii, ion sizes, ionization energies, electron affinities, electronegativities, metallic character, and valences or oxidation states.

3. The Interactions of Matter
A. Chemical Bonding
1. Students will be able to describe that an atom’s ability to bond to other atoms depends upon the number of valence electrons that atom possesses.

2. Students will be able to describe ionic bonds as the electrostatic bonds between a metal atom, which loses one or more electrons, and a non-metal atom, which gains one or more electrons, in order to fill its valence shell.

3. Students will be able to describe the physical and chemical properties of ionic compounds, including higher melting and boiling points, lower vapor pressure, and crystalline lattice structure.

4. Students will be able to describe covalent bonds as the shared pairs of electrons between non-metal atoms which result in a full valence shell for each atom. Students will be able to use the electronegativities of the bonding atoms to predict whether a covalent bond will be a polar or non-polar covalent bond.

5. Students will be able to describe the physical and
chemical properties of covalently bonded compounds, including lower melting and boiling points and higher vapor pressures.

6. Students will be able to describe covalent molecules as forming the structures of living things (proteins, DNA, etc.) and of useful materials such as polymers.

7. Students will be able to describe that, in metals, the outermost electrons are held so loosely that they are able to easily move among atoms, resulting in the characteristic properties of metals, such as malleability and electrical conductivity.

8. Students will be able to use the Octet Rule and the number of valence electrons which each atom in a molecule has, to calculate the number of covalent bonds within that molecule, and then arrange the atoms and bonds in such a way as to arrive at a correct Lewis structure.

9. Students will be able to use the electronegativities of the atoms in a simple covalent molecule and the possible number of bonds each atom can form to determine which atom should be the “central” atom.

10. Students will be able to predict the geometry of the simple covalent molecule around the “central” atom, as linear, bent, planar triangular, trigonal pyramidal, tetrahedral. Students may also be introduced to expanded octet geometries such as trigonal bipyramidal, octahedral, and their derivatives.

11. Students will be able to apply their knowledge of molecular geometries and bond polarities to determine the overall molecular polarity of a covalent molecule.

12. Students will be able to define intermolecular attractions (hydrogen bonds, permanent dipole-dipole interactions, and induced dipole-dipole interactions), and predict the effects that strong and weak intermolecular attractions have on the properties of substances including melting and boiling points, volatility, and vapor pressure.

13. Students will be able to correctly name simple binary ionic compounds, ionic compounds which contain multivalent ions, ionic compounds which contain polyatomic ions, and simple covalent compounds.

14. Students will be able to correctly derive the formula of an ionic or covalent compound from its name, or from the charges of its constituent ions. Students will also be able to correctly name a compound, given a correct formula for the compound.
B. Chemical Reactions

1. Students will be able to recognize that a chemical reaction results in the formation of a new substance(s) that have different chemical properties than the original materials.

2. Students will be able to define and/or identify the reactants and products in a chemical reaction.

3. Students will be able to classify reactions as synthesis (combination), decomposition, single replacement, double replacement, and combustion.

4. Students will be able predict the product(s) of a chemical reaction, based upon the types of reactants and the classification of the reaction.

5. Students will be able to balance a chemical reaction, if the formulas of the reactants and products are correctly written.

6. Students will be able to explain that an input of energy is needed to initiate all chemical reactions. This energy is the activation energy.

7. Students will be able to explain that in order for a chemical reaction to occur, the reactant molecules must collide with a specific orientation and with enough energy.

8. Students will be able to explain that as the concentration of a reactant in a solution increases, or as the pressure of a gas increases, these collisions become more frequent, and the rate of reaction will increase.

9. Students will be able to explain that as the temperature of a reaction increases, the fraction of molecules with the minimum necessary energy for reaction will increase, so the rate of reaction will also likely increase.

10. Students will be able to define the terms endo- and exothermic, and explain that endothermic reactions take in energy as they proceed toward products and exothermic reactions give off energy. Students will be able to explain that the making of bonds between atoms gives off energy, placing the atoms into a more stable condition, and conversely, an input of energy is needed to cause the breaking of bonds. The energy balance of a reaction is the net of these two processes.

11. Students will be able to explain that all reactions are reversible, although in some reactions movement toward the products is favored when the reaction gives off a large amount of energy.

12. Students will be able to calculate a rate constant for a reaction from the balanced chemical equation.

13. Students will be able to define the terms catalyst and enzyme and explain that these lower the activation energy needed for a reaction to occur, thereby increasing the rate of reaction.

14. Students will be able to define the term equilibrium as the condition where the concentrations of reactants and products are not changing.
15. Students will be able to explain how if a system in equilibrium is perturbed by changes in concentration of reactants or products, temperature, or pressure, or the use of a catalyst, the system will respond so as to minimize the perturbation (Le Châtelier’s Principle.)

16. Students will be able to identify acids as compounds which are able to donate protons or to accept electron pairs when dissolved in aqueous solution. Students will be able to define bases as compounds which donate hydroxide ions to aqueous solutions, or act as proton acceptors or electron pair donors.

17. Students will be able to explain that free protons do not exist in aqueous solutions, but that the protons combine with water molecules to form hydronium ions, \( H_3O^+ \).

18. Students will be able to define a neutralization reaction as the reaction between an acid and a base, which results in the production of a molecule of water and a salt.

19. Students will be able to define \( pH \) as the \( -\log[H^+] \), \( pOH \) as the \( -\log[OH^-] \), and calculate the \( pH \) or \( pOH \) of a solution given the molarity of the acid or base dissolved in water.

20. Students will be able to titrate acid and base solutions, determining the molarity of one if the molarity of the other is known.

21. Students will be able to determine the molar mass of an acid by titrating the acid with a base solution of known molarity.

C. Stoichiometry

1. Students will be able to define a mole as \( 6.022 \times 10^{23} \) particles, whether the “particle” is an atom of an element, or molecule of a chemical compound.

2. Students will be able to accurately convert a given mass of a compound to the moles of that compound, and vice-versa. Similarly, students will be able to convert among moles, grams, liters of a gas (at S.T.P.), and number of particles (which may be atoms or molecules.)

3. Students will be able to determine the molar mass of an element, from the grams and moles of the element involved in a chemical reaction.

4. Students will be able to use the chemical formula of a compound to determine the mass percent of any element which is a constituent of that compound.

5. Students will be able to determine the empirical formula of an ionic or covalent compound from the mass of each constituent element in the compound.

6. Students will be able to determine the molecular formula of a covalent compound from the compound’s molar mass and empirical formula.

7. Students will be able to determine the number of waters of hydration in a hydrated compound from the masses of the hydrated and anhydrous forms of the compound.

8. Students will be able to identify the substance given and the substance sought (target) in a stoichiometry word problem.
9. Students will be able to determine the mole ratio between any two substances within a balanced chemical reaction.

10. Students will be able to correctly set up and solve a stoichiometry equation, determining the mass of one or more products, given the mass of one reactant. Students will also be able to solve a stoichiometry equation if one or more reactants or products is a gas, whether at conditions of S.T.P. or some other temperature and/or pressure.

11. Students will be able to predict which reactant in a chemical reaction is the limiting reactant, given the masses of all reactants, and will be able to determine the masses of all products which will be formed.

12. Students will be able to determine the percent yield of a chemical reaction, given the actual yield and having calculated the stoichiometric (theoretical) yield.

D. Laws of Conservation

1. Students will be able to explain that when a chemical reaction occurs, the atoms in the reactant molecules rearrange, forming new molecules, but that no atoms are created or destroyed in the process. (Law of Conservation of Mass)

2. Similarly students will be able to explain that, in a closed system, the total amount of energy does not change, although the energy itself may change forms (for example, chemical energy stored within the bonds of molecules may change into heat, light, and/or mechanical energy.)

3. Students will be able to explain that endothermic chemical reactions take in heat from their surroundings or need an input of heat or other form of energy in order to take place, and that exothermic chemical reactions give off heat or other form of energy to their surroundings.

4. Students will be able to define the temperature of a material as the average kinetic energy of the material’s particles, where \( KE = \frac{1}{2} (\text{mass} \times \text{velocity}^2) \). Students will also be able to explain that the thermal energy in a sample of a substance is the total kinetic energy of the particles in the sample, including translational, rotational, and vibrational motion.

5. Students will be able to explain that as the temperature of a substance increases, that the particles vibrate faster if a solid, or translate/rotate (generally “move faster”) if a liquid or gas. It is the increased motion of the particles that generally cause the expansion of a sample of the substance; the sizes of the particles themselves do not change. Furthermore, students will be able to explain that an increase in temperature results in a decrease in density for a substance, as the particles’ increased motion causes the particles to move farther apart.

6. Students will be able to explain that melting,
evaporation, boiling, and sublimation are all endothermic processes, requiring an input of energy, and that freezing, condensation, and deposition from the vapor phase are all exothermic changes.

7. Students will be able to calculate the thermal energy taken in or given off by a substance as the substance (in any phase) changes temperature, or as the substance changes phases.

8. Students will be able to calculate the specific heat capacity of a substance from the amount of heat a sample of the substance transfers to a known mass of water.

9. Students will be able to state the five points of the kinetic-molecular theory of gases.

10. Students will be able to define pressure as the force due to the collisions between gas molecules and a surface divided by the surface area over which the collisions occur.

11. Students will be able to convert among different pressure units, including but not limited to inches of Hg, mm of Hg, torr, atmospheres, and kiloPascals.

12. Students will be able to explain Avogadro’s Law, that 1 mole of any gas occupies a volume of 22.4 L at S.T.P., due to the relatively large distances between gas molecules.

13. Students will be able to use the basic gas laws to determine how pressure, temperature, and/or volume of a closed system respond, if one or two of the other factors is changed.

14. Students will be able to use the ideal gas law to determine the pressure, temperature, volume, or moles of gas in a system, if the other factors are known or can be measured.

15. Students will be able to re-arrange the ideal gas law to determine the molar mass or density of a gas for any set of temperature, pressure, volume, and moles or mass.

16. Students will be able to calculate the partial pressure of an individual gas within a mixture of gases, if the total volume and temperature are known, and the moles or mass of the individual gas. (Dalton’s Law of Partial Pressures)

17. Students will be able to compare the relative rates of diffusion of any two gases using Graham’s Law of Diffusion.

E. Nuclear Chemistry

1. Students will be able to explain that the nucleus of an atom is held together by the nuclear strong force, which acts over incredibly short distances and is moderated by neutrons.

2. Students will be able to explain that the number of neutrons in an atom’s nucleus affect the atom’s mass and the stability of the nucleus: for small atoms, there must be as many neutrons as protons; for larger atoms, there will be more neutrons than protons; but too many...
neutrons can also make a nucleus unstable.

3. Students will be able define atoms with the same number of protons, but different numbers of neutrons as “isotopes”, and atoms with unstable nuclei as “radioisotopes.”

4. Students will be able to calculated the weighted average atomic mass of an element, given the % abundances and mass numbers of each of the element’s isotopes.

5. Students will be able to explain that atoms with unstable nuclei will decay, in the process releasing an alpha particle (Helium nucleus), a beta particle (high energy electron), or a gamma ray. Alternatively, some nuclei will fission into two less massive nuclei. The decay process makes the resulting nucleus(nuclei) more stable.

6. Students will be able to explain that the rate of decay can be expressed as the “half-life” of the element, i.e., the time needed for half of the atoms in a sample to decay. Students will further be able to explain that the half-life of a radioisotope is constant and unique to the decay of that radioisotope.

7. Students will be able to explain that, because the half-life of a given radioisotope is constant, that the percentage of the original atoms which remain can be used to determine how much time has passed. This process is called radioactive dating and is often used to determine the age of a material or artifact of biological or geological origin.

8. Students will be able to determine what percentage of the original number of radioactive atoms remain after a given period of time, or how much time has passed given the percentage of atoms which remain, when also given the half-life of the atom.

9. Students will be able to write nuclear equations involving alpha, beta, and gamma decay. Students will also be able to write nuclear equations involving the fission of a heavy nucleus into two lighter ones, or the fusion of two light nuclei into a heavier nucleus.

10. Students will be able to explain the “mass defect” concept, that the mass of a nucleus is slightly less than the masses of the individual particles which make up that nucleus. Students will be able to explain that this difference in mass is converted to energy during nuclear fusion reactions, and that this process fuels the sun.

11. Students will be able to explain that whenever a nuclear reaction occurs, mass may be converted directly into energy, and that the amount of energy emitted may be quite a bit larger than is typical for a chemical reaction.

12. Students will be able to explain that the energy emitted during nuclear reactions can be controlled using the proper materials and design, and that the energy can be harnessed to provide more useful forms of energy such as electricity. This is the basis of a nuclear reactor.

13. Students will be able to explain the basic operation of a nuclear reactor. Students will also be able to describe
<p>| | |</p>
<table>
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</table>
| that radioactive waste can be produced during normal operations, and that this waste must be disposed of in an environmentally responsible manner. Students will also be able to explain that disposal of such waste presents formidable engineering, technical, and safety problems, and that not everyone agrees upon the best way to accomplish the disposal.  
14. Students will be able to describe that all atoms of elements heavier than boron were produced in the cores of stars, or during the nucleosynthesis process which accompanies the supernova explosions of large stars, and that this process continues even in the present. Students will be able to explain that H, He, and some Li, Be, and B atoms were produced during the creation of the universe, the Big Bang. |   |
<table>
<thead>
<tr>
<th>Strand: Physical Science</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic: Physics: Levels Honors, CP</td>
<td></td>
</tr>
<tr>
<td><strong>Content Statements:</strong> The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.</td>
<td></td>
</tr>
</tbody>
</table>

1) **Motion**
   A. Concept of displacement, velocity and acceleration as vector quantities.
      1. Students will be able to define and identify these vector quantities.
      2. Students will be able to relate and differentiate these vector quantities to scalar quantities.
   B. Mathematical calculations (kinematics equations) and graphical interpretation involving:
      1. Students will be able to calculate average velocity.
      2. Students will understand the concept of constant velocity.
      3. Students will understand the concept of instantaneous velocity.
      4. Students will be able to calculate acceleration.
      5. Students will be able to define and use the concept of displacement.
      6. Students will understand and calculate uniform acceleration and/or free-fall using:
         a. Initial velocity
         b. Final velocity
         c. Time interval
         d. Displacement
   C. Motion graph interpretation and generalization.
      1. Students will understand the concepts of positive and negative x- and y-values.
      2. Students will understand and explain motion in stages.
      3. Students will understand, devise and calculate graphs in terms of:
         a. Shapes of graphs
         b. Slopes
         c. Areas under curves
         d. Tangent lines
      4. Students will recognize, develop and solve equations from graphs.

2) **Forces, Momentum and Motion**
   A. Concept of force as a vector quantity.
      1. Students will be able to define force.
      2. Students will understand the relationship of force to apparent weight (Earth and Universe).
      3. Students will be able to understand and explain Newton’s Law of Universal Gravitation.
         a. Calculations involving gravity anywhere in the Universe
         b. Gravitational constant:

**Scientific Inquiry and Applications**
- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate mathematics, tools, and techniques to gather data and information.
- Analyze and interpret data.
- Develop descriptions, models, explanations, and predictions.
- Think critically and logically to connect evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.

**Technological and Engineering Design**
- Demonstrate an understanding of the relationship among people, technology, engineering and the environment.
- Identify a problem or need, consider design criteria and constraints.
- Integrate multiple disciplines when problem-solving.
- Synthesize technological and engineering knowledge and design in problem-solving.
- Apply research, development, experimentation, and redesign based on feedback to problem-solving.
- Build, test, and evaluate a model or prototype that solves a problem or need.
c. Gravity as a weak force
d. Gravity as a direct relationship to the product of masses
e. Gravity as an inverse-square relationship to the distance between masses

4. Students will be able to define and calculate other forces such as but not limited to:
a. Spring forces
b. Air resistance (drag)
c. Friction (static and kinetic)

B. Newton’s Laws of Motion.
1. Students will be able to define mass and explain the relationship of mass to inertia as the resistance to change in motion (Newton’s First Law).
2. Students will be able to understand and calculate the direct relationship between acceleration and force (Newton’s Second Law).
3. Students will be able to understand and calculate the inverse relationship between acceleration and mass.
4. Students will analyze two-dimensional motion.
a. Projectile motion (parabolic pathway)
b. Terminal velocity (free-fall with significant drag)

5. Students will understand the concept of forces in systems of objects as action and reaction.
a. Momentum and impulse as vector quantities
b. Conservation of momentum
c. Elastic and inelastic collisions of objects

3) Energy, Energy Transformations and Energy Conservation
A. Energy Concepts.
1. Students will be able to understand, define and perform calculations involving kinetic energy.
2. Students will be able to understand, define and perform calculations involving gravitational potential energy.
3. Students will be able to understand, define and perform calculations involving work.

1. Students will be able to explain and calculate spring potential energy.
2. Students will understand the concept of energy transfer (thermal energy and heat).
3. Students will be able to understand and calculate power (rate at which work is done; rate at which energy is transferred).

4) Waves
A. Relationship between frequency, wavelength and speed.
B. Wave Behavior.
1. Absorption
2. Superposition
3. Reflection
4. Refraction (boundaries between mediums)
5. Diffraction
6. Doppler Effect/Shift
## Strand: Environmental Science

### Topic: Interconnected Spheres of Earth

**Content Statements:** The content to be learned. This is the “what” that should be accessible for students at each grade level to prepare them to learn about and use knowledge, principles, and processes with increasing complexity in subsequent grades. The new statewide assessments will be aligned to these content statements with implementation during the 2014-2015 school year.

<table>
<thead>
<tr>
<th>1) Historical Environmental Issues and Information</th>
<th>Scientific Inquiry and Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Understand the differences between renewable and non-renewable resources.</td>
<td>• Identify questions that can be answered through scientific investigations.</td>
</tr>
<tr>
<td>B. How has increase in human population affected the resilience of our renewable resources and availability of our non-renewable resources.</td>
<td>• Design and conduct a scientific investigation.</td>
</tr>
<tr>
<td>C. Describe the advances in technology which allow us to test the quality of our water, air, and soil.</td>
<td>• Use appropriate mathematics, tools, and techniques to gather data and information.</td>
</tr>
<tr>
<td>D. Understand what laws have been passed to curb the misuse and abuse of our environment at the local, state, national, and international levels.</td>
<td>• Analyze and interpret data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2) Patterns and Cycles on Earth</th>
<th>• Develop descriptions, models, explanations, and predictions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Explain how human and natural contamination to the earth as a whole, as well as the different spheres of life (hydrosphere, atmosphere, biosphere and lithosphere) is interconnected between the spheres of life.</td>
<td>• Think critically and logically to connect evidence and explanations.</td>
</tr>
<tr>
<td>B. Elaborate on the physical and chemical changes within each of Earth’s spheres may or may not have a deleterious effect on the environment including the different causes and effects of climate and changes in climate through Earth’s history.</td>
<td>• Recognize and analyze alternative explanations and predications.</td>
</tr>
<tr>
<td>C. Using actual data, elaborate on the movement of both matter and energy and the effect this movement may have on ocean and atmospheric currents and conditions.</td>
<td>• Communicate scientific procedures and explanations.</td>
</tr>
<tr>
<td>D. Emphasize the interconnectedness of the Earth’s spheres and the understanding of the complex relationships between each.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3) Concepts and Principles of Environmental Science</th>
<th>Technological and Engineering Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Understand the inherent need to integrate different sciences (biology, chemistry, physics etc.) to better understand influences to ecosystems. These influences may or may not keep an ecosystem in equilibrium.</td>
<td>• Demonstrate an understanding of the relationship among people, technology, engineering and the environment.</td>
</tr>
<tr>
<td>B. Describe how energy transfer and transformation has an effect on the environment and how those effects change a population.</td>
<td>• Identify a problem or need, consider design criteria and constraints.</td>
</tr>
<tr>
<td>C. Elaborate the data collection methods and locations (in the field vs. in the laboratory) and how laboratory investigations may or may not be relevant to real world applications.</td>
<td>• Integrate multiple disciplines when problem-solving.</td>
</tr>
<tr>
<td>D. Be able to expand on the influence of evolution and natural selection on an organisms ability and need to adapt in a sustainable environment. Also, what risk factors are considered in sustainable environments.</td>
<td>• Synthesize technological and engineering knowledge and design in problem-solving.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4) Global Issues</th>
<th>• Apply research, development, experimentation, and redesign based on feedback to problem-solving.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Understand current litigations as they pertain to ecological factors. Also, understand how data collection contributes to</td>
<td>• Build, test, and evaluate a model or prototype that solves a problem or need.</td>
</tr>
</tbody>
</table>
Elaborate on how the human impact on the environment can be compounded by historical events or previous populations and that these long-term changes may not be totally understood by contemporary populations.

5) Earth’s Resources
   A. Investigate the environmental “pros and cons” associated with the different renewable and non-renewable resources at all levels of society.
   B. Understand what deleterious effects using both biotic and abiotic resources may contain. These effects may take place in the extraction, storage, use, and disposal of the resource.
   C. Investigate the effectiveness and efficiency for different types of energy resources at a local, state, national, and global level.
   D. Relate Earth’s resources to a global scale using technology to collect global resource data for comparative classroom study.
<table>
<thead>
<tr>
<th>Strand: Astronomy</th>
<th>10, 11, 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic: The Visible Sky.</td>
<td></td>
</tr>
<tr>
<td>Content Statements:</td>
<td>The sky and constellations, motions of the sun, motions of the moon, motions of the planets.</td>
</tr>
<tr>
<td>Learning statements:</td>
<td></td>
</tr>
<tr>
<td>☐ Identify Sky Landmarks</td>
<td></td>
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<tr>
<td>☐ Identify Factors In Daily Motion of the Sky</td>
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<tr>
<td>☐ Estimate Angles in the Sky</td>
<td></td>
</tr>
<tr>
<td>☐ Name notable Constellations</td>
<td></td>
</tr>
<tr>
<td>☐ Name 20 Brightest Stars</td>
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</tr>
<tr>
<td>☐ Construct and Use a Planisphere</td>
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<tr>
<td>☐ Explain Differences in Sky Motions at Different Latitudes</td>
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<tr>
<td>☐ Explain Latitude and Longitude</td>
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<tr>
<td>☐ Explain Right Ascension and Declination</td>
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</tr>
<tr>
<td>☐ Use a Sky Chart to Locate Stars and Constellations</td>
<td></td>
</tr>
<tr>
<td>☐ Explain Daily and Annual Motions of the Sun at Different Latitudes and Seasons</td>
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</tr>
<tr>
<td>☐ Explain Physical Basis for Seasons</td>
<td></td>
</tr>
<tr>
<td>☐ Explain Precession of the Earth’s Axis</td>
<td></td>
</tr>
<tr>
<td>☐ Explain the Orbit and Daily and Monthly Motions of the Moon</td>
<td></td>
</tr>
<tr>
<td>☐ Identify, Draw, and Explain the Geometry Resulting in Phases of the Moon</td>
<td></td>
</tr>
<tr>
<td>☐ Describe the Types of and Causes of Eclipses</td>
<td></td>
</tr>
<tr>
<td>☐ Describe Daily and Annual Motions of the Planets</td>
<td></td>
</tr>
<tr>
<td>☐ Distinguish Between Inferior and Superior Planets</td>
<td></td>
</tr>
<tr>
<td>☐ Describe and Identify the Causes of Planetary Retrograde Motion</td>
<td></td>
</tr>
<tr>
<td>☐ Plot a Planet’s Retrograde Motion on a Star Chart</td>
<td></td>
</tr>
<tr>
<td>☐ Describe the Relative Placement and Distances of the Planets from the Sun</td>
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</tr>
</tbody>
</table>
Unit: The Visible Sky (Continued)

Instructional Objectives:

<table>
<thead>
<tr>
<th>Scientific Inquiry</th>
<th>Scientific Knowledge</th>
<th>Conditions for Learning</th>
<th>Applications for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The learner will</td>
<td>The learner will</td>
<td>The learner will be</td>
<td>The learner will be</td>
</tr>
<tr>
<td>1. Examine relationships in nature, offer alternative explanations for the</td>
<td>1. Formulate models and hypotheses for patterns in the natural world (e.g.,</td>
<td>1. Collecting and analyzing observations made over extended periods of time and</td>
<td>1. Extending the limits of human capabilities using technological enhancements.</td>
</tr>
<tr>
<td>observations and collect evidence that can be used to help judge among expectations.</td>
<td>constellations)</td>
<td>comparing these to scientific theories.</td>
<td>2. Differentiating between observations and inferences in the exploration of evidence</td>
</tr>
<tr>
<td>2. Select, invent, and use tools, including analog and digital instruments, to make</td>
<td>2. Formulate models and hypotheses about patterns in the natural world.</td>
<td>related to personal, scientific, and community issues.</td>
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<tr>
<td>and record direct measurements.</td>
<td>3. Formulate hypotheses and models that may account for observable events.</td>
<td></td>
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<tr>
<td>3. Observe and document events and characteristics of complex systems.</td>
<td>4. Formulate models and hypotheses about change over time.</td>
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<tr>
<td>4. Explain the influence of perspective (e.g., Spatial, temporal, and social) on</td>
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<tr>
<td>observation and subsequent interpretations.</td>
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<tr>
<td>5. Construct and test models of physical, biological, social, and geological systems.</td>
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<tr>
<td>6. Modify personal opinions, interpretations, and conclusions based on new</td>
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<tr>
<td>information</td>
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<tr>
<td>7. Demonstrate various logical connections between related concepts.</td>
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<tr>
<td>8. Suggest new questions as a result of reflection on and discussions about their own</td>
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<tr>
<td>scientific investigations.</td>
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</table>

LCS Science Course of Study June 2011
**Topic:** Models of the Cosmos and History of Astronomy

**Content Statements:** Characteristics of scientific models, earliest models (the geocentrist), Galileo and Newton, light and telescopes.

<table>
<thead>
<tr>
<th>Learning objectives:</th>
</tr>
</thead>
<tbody>
<tr>
<td>List Essential Features of a Scientific Model – Explain the Limitations of a Scientific Model</td>
</tr>
<tr>
<td>Describe the Basis for Babylonian Astronomy – Explain Why the Geocentric Model was Dismissed by the Greeks – Describe the Basic Heliocentric Model of the Cosmos – Differentiate between Force and Natural Motion – Explain heliocentric stellar parallax – Explain the Philosophical Assumptions of Pythagoras, Plato, Aristotle, Hipparchus, Ptolemy – Describe Deferents, Epicycles, Eccentrics, Equants, and How They Were Used to Refine Models of Celestial Motions.</td>
</tr>
<tr>
<td>Describe the Copernican Heliocentric Model – Compare the Copernican Heliocentric Model to the Earlier Geocentric Models – Describe the Basis for Planetary Retrograde Motion According to the Copernican Model – Geometrically or Trigonometrically Determine the Relative Distance of Mercury from the Sun – Differentiate Between Sidereal and Synodic Periods – Define Opposition, conjunction, and Elongation of Planets – List Tycho’s and Kepler’s contributions to the geocentric model – Identify the parts of an eclipse – List and apply Kepler’s 3 laws to the orbital motions of planets</td>
</tr>
<tr>
<td>Describe Galileo’s telescopic discoveries – Contrast Galileo’s and Newton’s cosmologies with those of Copernicus and Kepler – Define and give examples of physical parameters like velocity and acceleration – List and apply Newton’s 3 Laws of Motion and the Law of Gravitation to astronomical situations</td>
</tr>
<tr>
<td>Describe the internal structure of the atom – Describe and apply Kirchhoff’s rules to spectra – Relate light’s wavelength, frequency, and energy to the electromagnetic spectrum – Describe energy and the Law of Conservation of Energy – Identify the parts of a refracting and reflecting telescope – Describe the 3 main functions of a telescope and be able to calculate these from relevant data – Describe f-ratio and chromatic aberration – Discuss the advantages and limitations of telescopes used at visible and non-visible wavelengths – research space-based and ground-based observations and report findings</td>
</tr>
</tbody>
</table>
### Instructional Objectives:

<table>
<thead>
<tr>
<th>Scientific Inquiry</th>
<th>Scientific Knowledge</th>
<th>Conditions for Learning</th>
<th>Applications for Learning</th>
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<tr>
<td>The learner will</td>
<td>The learner will</td>
<td>The learner will</td>
<td>The learner will</td>
</tr>
<tr>
<td>1. Discuss societal controversies that surround scientific issues</td>
<td>1. Formulate descriptions of the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects</td>
<td>1. Examining the intellect, perspectives, and ethics of notable scientists</td>
<td>1. Analyzing the contributions of advances in technology through history to his/her everyday life.</td>
</tr>
<tr>
<td>2. Examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations</td>
<td>2. Formulate models and hypotheses for patterns in the natural world</td>
<td>2. Creating presentations of scientific understandings using diverse modes of expression</td>
<td>2. Extending the limits of human capabilities using technological enhancements</td>
</tr>
<tr>
<td>3. Trace the development of various theories, focusing on supporting evidence and modification with new evidence.</td>
<td>3. Formulate an understanding of the historical development of the model of the universe</td>
<td>3. Formulating processes for determining when questions are appropriate for scientific investigations</td>
<td></td>
</tr>
<tr>
<td>4. Explain the influence of perspective on observation and subsequent interpretations</td>
<td>4. Formulate models and hypotheses about patterns in the natural world</td>
<td>4. Analyzing the historical context which leads to and has leads to scientific theories</td>
<td></td>
</tr>
<tr>
<td>5. Explore discrepant events and develop and test explanations of what was observed</td>
<td>5. Formulate explanations for the range of energies within and between various phenomena</td>
<td>5. Seeking information on topics of personal scientific interest from a variety of sources</td>
<td></td>
</tr>
<tr>
<td>6. Modify personal opinions, interpretations, explanations, and conclusions based on new information</td>
<td>6. Formulate explanations for the historical development of description of motions, interactions, and transformations of matter and energy</td>
<td>6. Listening attentively and critically to presentations of scientific information made by others</td>
<td></td>
</tr>
<tr>
<td>7. Demonstrate various logical connections between related concepts</td>
<td>7. Formulate hypotheses and models that may account for observable events</td>
<td>7. Relating historical accounts of science to the cultural context in which they were written</td>
<td></td>
</tr>
<tr>
<td>8. Account for discrepancies between theories and observations</td>
<td>8. Formulate models of molecular, atomic, ionic, and subatomic structures and the physical implications of these structures</td>
<td>8. Examining ambiguous results and formulating explanations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Formulate estimates for a wide range of measurements and scales</td>
<td>9. Synthesizing scientific information from a variety of sources</td>
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</tbody>
</table>
## Topic: The Solar System

### Content Statements:
The Earth/Moon systems, terrestrial planets and moons, jovian planets and moons, origin of the solar system and non-planetary bodies.

### Learning objectives:

- Describe the processes of accretion and differentiation in the formation of planets
- List the physical properties of earth (mass, density, volume, surface gravity, escape speed)
- Describe the earth’s internal structure and magnetic field
- List the essential elements of the dynamo theory
- Explain the causes of auroras
- Name the driving forces for plate tectonics and the types of plate boundaries found on earth
- Describe mid-ocean ridges and subduction zones
- Explain the difference between continental drift and plate tectonic
- Describe the structure, composition, and evolution of the earth’s atmosphere and its protective effect on life
- List the physical properties of the moon
- Describe the moon’s orbit
- Define synchronous rotation and its cause
- Name and describe the major continents, and some large surface features on Venus
- Compare and contrast the evolution of Venus’ surface with that of the earth
- Explain why Venus’ surface is considered to be young, despite lack of plate tectonics
- Describe the basis for the Doppler Effect and apply it to astronomical situations
- Compare and contrast the physical properties, interior construction, magnetism, and atmosphere of Mars with the other terrestrial planets
- Name and describe the major surface features on Mars
- Compare and contrast the evolution of Mars’ surface with that of the earth
- Give evidence for the past existence of water on Mars
- Compare and contrast the Jovian planets to the terrestrial planets, emphasizing the major differences
- List the physical properties of Jupiter, Saturn, Uranus, Neptune
- Contrast the Jovian planets in terms of their atmospheres, internal structures, and unique atmospheric features (such as the Great Red Spot of Jupiter)
- Describe the structure of the rings of Saturn and explain their formation and maintenance
- Explain why Pluto is neither terrestrial nor Jovian in structure or composition
- Compare and contrast the physical properties and unique surface features of the four Galilean moons of Jupiter to each other and to the moon and Mercury
- Compare the magnetospheres of the Jovian planets to those of the earth and decide whether they support the dynamo model
- List the physical properties of the moons of Saturn, especially Titan
- Compare and contrast Saturn’s moon with the Galilean moons and earth’s moon
- Describe and compare the general properties, internal structures, locations, and orbits of comets, asteroids, meteoroids, and meteorites
- Describe how the compositions of these bodies give clues to the origin of the solar system
- Describe the nebular model of solar system formation and the problem of angular momentum conversation
- Explain why the terrestrial planets formed closer to the sun, while the gas giants formed further from the sun
### Instructional Objectives:

<table>
<thead>
<tr>
<th>Scientific Inquiry</th>
<th>Scientific Knowledge</th>
<th>Conditions for Learning</th>
<th>Applications for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The learner will</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations</td>
<td>1. Formulate models and hypotheses for patterns in the natural world</td>
<td>1. Conducting formal scientific debates in the classroom</td>
<td>1. Solving unique problems using the results of systematic analyses</td>
</tr>
<tr>
<td>2. Explore discrepant events and develop and test explanations of what was observed</td>
<td>2. Formulate explanations for the influences of objects and organisms on each other over time</td>
<td>2. Analyzing the historical context which leads to and has lead to scientific theories</td>
<td>2. Differentiating between observations and inferences in the exploration of evidence related to scientific issues</td>
</tr>
<tr>
<td>3. Demonstrate various logical connections between related concepts</td>
<td>3. Formulate and interpret explanations for change phenomena</td>
<td>3. Listening attentively and critically to presentations of scientific information made by others</td>
<td></td>
</tr>
<tr>
<td>4. Account for discrepancies between theories and observations</td>
<td>4. Formulate explanations and representations of the production, transmission, and conservation of energy in physical systems</td>
<td>4. Working as a contributing member of a collaborative research group</td>
<td></td>
</tr>
<tr>
<td>5. Investigate, assess, and comment on strengths and weaknesses of the descriptive and predictive powers of science</td>
<td>5. Formulate models and hypotheses about patterns in the natural world</td>
<td>5. Examining ambiguous results and formulating explanations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Formulate interpretations of the relationship between energy exchange and the interfaces between components within systems</td>
<td>6. Synthesizing scientific information from a variety of sources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Formulate hypotheses and models that may account for observable events</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>8. Formulate models and hypotheses about change over time</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>9. Formulate estimates for a wide range of measurements and scales</td>
<td></td>
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</tr>
</tbody>
</table>

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Lancaster City Schools
Science Course of Study

Unit: The Solar System (continued)
**Topic:** Stars  
**Content Statements:** our sun, characteristics of starts and the HR diagram, star birth, star lives, star death

**Learning objectives:**
- Describe how the sun’s mass, size, density, luminosity, surface temperature, and distance from earth have been determined
- Describe the internal structure of the sun and the sun’s corona
- Explain how the sun’s opacity affects radiation flow from the core to the surface
- Describe the sun’s spectrum
- List the steps in hydrogen fusion (proton-proton chain) and in the fusion of heavier nuclei (CNO cycle)
- Explain the neutrino problem
- Explain the physical nature and causes of sunspots, prominences, flares, coronal holes and ejections, and the solar wind
- Make an observation of sunspots on a clear day
- Outline how astronomers determine a star’s physical parameters (surface temperature, chemical composition, size, mass, density, and luminosity)
- Describe the relationship between surface temperature and color
- Describe the relationship between surface temperature, size and luminosity
- Describe the inverse square law and the relationship between luminosity and a star's distance from earth
- Sketch a Hertzprung-Russell Diagram and use it to identify the four main populations of stars
- Use the HR Diagram to infer the luminosities, surface temperatures, and sizes of stars
- Describe the relationship between a star’s mass and its lifetime
- Describe interstellar gas, dust, molecular clouds, and nebulae
- Explain reddening due to interstellar dust
- Describe the role of dust in the formation of molecules
- Describe the idea of gravitational collapse/contraction and the role of rotation in star formation
- Compare and contrast the possible processes for the formation of massive and solar-mass stars
- Give evidence that star formation is going on in our solar system now
- Describe the role of bipolar outflows in star formation
- Describe T-Tauri stars
- Use the HR Diagram to explain the major steps in stellar evolution
- Explain why stars must evolve as their consume their hydrogen fuel
- Compare and contrast the evolution of solar-mass and heavy stars
- List the differences in thermonuclear reactions in stars of different masses
- Compare and contrast open to globular star clusters
- Indicate how mass and chemical composition influence stellar evolution
- Explain nucleosynthesis
- Explain the physical characteristics of white dwarfs, brown dwarfs, neutron stars and degenerate stars
- Give evidence that pulsars are rapidly-rotating neutron stars
- Compare and contrast novas with supernovas
- Outline the role of binary star systems in nova explosions
- Outline models for supernova explosions and describe how supernovas affect the interstellar medium, and possibly life
- Differentiate between Type I and Type II supernovae
- Give evidence that the Crab Nebula is a supernova remnant
- Describe synchrotron radiation and its causes
- Describe the physical characteristics and formation processes of black holes
- Give evidence for the actual existence of black holes
Unit: Stars

### Instructional Objectives:

<table>
<thead>
<tr>
<th>Scientific Inquiry</th>
<th>Scientific Knowledge</th>
<th>Conditions for Leaving</th>
<th>Applications for Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>The learner will 1. Examine relationships in nature, offer alternative explanations for the observations, and collect evidence that can be used to help judge among explanations 2. Observe and document events and characteristics of complex systems 3. Explain the influence of perspective on observation and subsequent interpretations 4. Formulate taxonomic schemes based upon multivariate models that help to explain similarities and differences in form, distribution, behavior, and origin of objects 5. Demonstrate various logical connections between related concepts 6. Recognize and utilize classification systems for particles, elements, compounds, phenomena, organisms, and others for exploring and predicting properties and behaviors 7. Investigate, assess, and comment on strengths and weaknesses of the descriptive and predictive powers of science</td>
<td>The learner will 1. Formulate models and hypotheses for patterns in the natural world 2. Formulate and interpret explanations for changes phenomena over time (e.g., stellar evolution) 3. Formulate explanations and representations of the production, transmission, and conservation of energy in physical systems 4. Formulate explanations for the range of energies within and between various phenomena 5. Formulate hypotheses and models that may account for observable events</td>
<td>The learner will 1. Creating presentations of scientific understandings using diverse modes of expression 2. Analyzing the historical context which leads to and has lead to scientific theories 3. Seeking information on topics of personal scientific interest from a variety of sources 4. Listening attentively and critically to presentations of scientific information made by others 5. Constructing models and simulations of the component structures and functions of living and non-living entities 6. Synthesizing scientific information from a variety of sources</td>
<td>The learner will be 1. Using appropriate technologies to prepare and present the findings of investigation incorporating tables, graphs, diagrams, and text 2. Differentiating between observations and inferences in the exploration of evidence related to scientific issues</td>
</tr>
</tbody>
</table>
Topic: Galaxies and Cosmology

Content Statements: The Milky Way Galaxy, other galaxies and Hubble's Law, cosmic violence, cosmology, life in the Universe

Learning objectives:

- Explain why the galaxy's structure is difficult to determine from our location inside it – List those objects used to define the galaxy's spiral arms – Explain the period luminosity relationship for Cepheid Variable stars – Give evidence that the galaxy does have a spiral structure – Describe the overall structure of the galaxy – Sketch the rotational curves of the galaxy – approximate the mass of the galaxy – Give evidence that much of the galaxy's mass exists as dark matter – Describe the sun's orbit around the galactic center – Describe the evolution of spiral arms according to the density wave model – Explain the evolution of the galaxy – Provide evidence for the possible existence of a super massive black hole in the core of the galaxy
- List characteristics of and contrast spiral, elliptical and irregular galaxies – Describe methods used to estimate the distance to other galaxies – Explain how it was decided that spiral nebulae are external to our galaxy – Explain the significance of Hubble's Law, the Hubble constant, and the methods used to estimate the Hubble constant – Estimate the uncertainties and error in the Hubble constant – Define and describe a cluster and a supercluster of galaxies – Discuss the evidence for the existence of dark matter within and between clusters and superclusters of galaxies
- Outline the evidence for violent activity within galaxies – Compare and contrast the nuclei of active galaxies to those of normal galaxies – List characteristics of quasars and state a physical model for their existence – discuss the significance of red shifting in quasar spectra – Give evidence that quasars are the active nuclei of distant galaxies and that they may be based on supermassive black holes – Outline a method used to estimate the distances to quasars – Describe jets that arise from the nuclei of active galaxies and propose a model for their existence
- State the assumptions of modern cosmology and the observations that both support it and detract from it – Describe the Big Bang cosmological model – Explain the significance of the cosmic background radiation in terms of the Big Bang model – Outline and give evidence for the process of elemental particles and element formation in the Big Bang model – Describe a model of galaxy formation and explain possible problems with the model – Explain the dark matter problem in relation to cosmology and the Big Bang model
- Identify key characteristics of life as we know it – State the modern chemical idea of the origin of life – Outline a model for the chemical evolution of the newly-formed earth, the processes that resulted in chemicals used in life, and the beginnings of the simplest life – Describe how life affected the earth environment – Sketch a timeline from the origin of the universe to the present, highlighting critical physical, chemical, and biological events that resulted in human life – Evaluate the possibility of life on other planets, especially within our solar system – List the assumptions and components of the Drake equation – Assess the possibility of planets around other stars – Argue for or against the wisdom of attempting to search for extraterrestrial life, and strategies that might be used to do so
### Instructional Objectives:

<table>
<thead>
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<th>Scientific Inquiry</th>
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<tr>
<td>The learner will:</td>
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</tr>
<tr>
<td>1. Discuss societal controversies that surround scientific issues</td>
<td>1. Formulate and interpret explanations for change phenomena</td>
<td>1. Examining the intellect, perspectives, and ethics of notable scientists</td>
<td>1. Analyzing the contributions of advances in technology through history to his/her everyday life</td>
</tr>
<tr>
<td>2. Trace the development of various theories, focusing on supporting evidence and modification with new evidence</td>
<td>2. Formulate models and hypotheses about patterns in the natural world</td>
<td>2. Conducting formal scientific debates in the classroom</td>
<td>2. Comparing school-based science perspectives with those gained through cutting-edge technological applications</td>
</tr>
<tr>
<td>3. Formulate taxonomic schemes based upon multivariate models that help to explain similarities and differences in form, distribution, behavior, and origin of objects</td>
<td>3. Formulate estimates for the range of energies within and between various phenomena</td>
<td>3. Analyzing the historical context which leads to and has lead to scientific theories</td>
<td>3. Developing an informed point of view that allows for validation or refutation of the scientific statements and claims of advocates before pursuing courses of action</td>
</tr>
<tr>
<td>4. Demonstrate various logical connections between related concepts</td>
<td>4. Formulate hypotheses and models that may account for observable events</td>
<td>4. Seeking information on topics of personal scientific interest from a variety of sources</td>
<td>4. Differentiating between observations and inferences in the exploration of evidence related to personal, scientific and community issues</td>
</tr>
<tr>
<td></td>
<td>5. Formulate and interpret representations of time from origin to present accounting for phenomena of scale</td>
<td>5. Respecting the scientific thinking of others and self</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. Synthesizing scientific information from a variety of sources</td>
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</tr>
</tbody>
</table>
# Lancaster City Schools
## Science Course of Study

### Course: Anatomy / Physiology

#### Topic: Anatomy, Physiology, and Pathology

**Content Statements: Basic Chemistry**

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify elements on periodic table</td>
</tr>
<tr>
<td>2. Design simple chemical formulas</td>
</tr>
<tr>
<td>3. Contrast atoms verses molecules</td>
</tr>
<tr>
<td>4. Define synthesis, decomposition, and exchange reactions</td>
</tr>
<tr>
<td>5. Define diffusion, filtration, and osmosis</td>
</tr>
<tr>
<td>6. Differentiate between acids and bases</td>
</tr>
</tbody>
</table>

#### Topic: Anatomy, Physiology, and Pathology

**Content Statements: General Knowledge of Human Body**

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Define anatomy and physiology and explain their relationship</td>
</tr>
<tr>
<td>2. Describe the anatomical position</td>
</tr>
<tr>
<td>3. Identify body directions, planes, and cavities</td>
</tr>
<tr>
<td>4. Name major organ systems and their functions</td>
</tr>
<tr>
<td>5. Classify major organs by the organ system they are within</td>
</tr>
<tr>
<td>6. Define cell composition, shape and size</td>
</tr>
<tr>
<td>7. Identify regions and organelles and explain their function</td>
</tr>
<tr>
<td>8. Identify life processes of cell division and transportation</td>
</tr>
<tr>
<td>9. Identify the four major tissue types, their function and subtypes</td>
</tr>
<tr>
<td>10. Define neoplasm and distinguish between benign and malignant</td>
</tr>
<tr>
<td>11. Describe effect of aging across the lifespan</td>
</tr>
</tbody>
</table>

#### Topic: Anatomy, Physiology, and Pathology

**Content Statements: General Knowledge of the integumentary system**

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. List the functions of the integumentary system</td>
</tr>
</tbody>
</table>
### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the skeletal system

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. List functions of the skeletal system</td>
</tr>
<tr>
<td>2. Name methods of classifying bone</td>
</tr>
<tr>
<td>3. Identify bone types within each classification method</td>
</tr>
<tr>
<td>4. Explain the structure and function of a long bone</td>
</tr>
<tr>
<td>5. Describe the composition of bone</td>
</tr>
<tr>
<td>6. Define function and dysfunction of bone marrow</td>
</tr>
<tr>
<td>7. Explain the process of bone formation and growth</td>
</tr>
<tr>
<td>8. Identify major bones of the human skeleton</td>
</tr>
<tr>
<td>9. Define types of bone markings and their associated terms</td>
</tr>
<tr>
<td>10. Define joint and describe the typical structure of a joint</td>
</tr>
<tr>
<td>11. Compare the movement allowed by each type of joint</td>
</tr>
<tr>
<td>12. Identify the various methods of correction for fractures</td>
</tr>
<tr>
<td>13. Identify common disorders and injuries of bones and joints</td>
</tr>
</tbody>
</table>

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### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the muscular system
### Learning statements:
1. Identify types of muscle tissue
2. Describe muscle contraction
3. Define the parts of a muscle and explain major muscle types
4. Define muscle tone, isotonic and isometric contractions
5. Name types of movements produced by skeletal muscle contractions
6. Identify common abnormal conditions of the muscles
7. Identify origin insertion and function of muscles
8. Describe common disorders and injured muscles

### Topic: Anatomy, Physiology, and Pathology

### Content Statements: General Knowledge of the nervous system

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Describe the general functions of the nervous system</td>
</tr>
<tr>
<td>2. Identify the main parts of the nervous system</td>
</tr>
<tr>
<td>3. Name principal cell types that compose the nervous system</td>
</tr>
<tr>
<td>4. Describe the neuron, its function, and the existing types of neurons</td>
</tr>
<tr>
<td>5. Describe the neuralgia, its function, and the existing types of neuralgia</td>
</tr>
<tr>
<td>6. Define ganglia, nuclei, tracts and nerves, noting their differences</td>
</tr>
<tr>
<td>7. Describe the events of the nerve impulse</td>
</tr>
<tr>
<td>8. Identify parts of the brain</td>
</tr>
<tr>
<td>9. Describe structures and functions of the various parts of the brain and spinal cord</td>
</tr>
<tr>
<td>10. Explain function of the autonomic nervous system and its divisions</td>
</tr>
<tr>
<td>11. Describe common disorders and injuries of the nervous system</td>
</tr>
</tbody>
</table>

### Topic: Anatomy, Physiology, and Pathology

### Content Statements: General Knowledge of the circulatory / cardiovascular system
### Learning statements:

1. Identify the structures and functions of the heart
2. Trace the pathway of blood through the heart
3. Describe routes of blood circulation
4. Define blood pressure, pulse, systole, diastole and cardiac system
5. List factors that influence heart rate
6. Identify the structure and function of the blood vessels – arteries, veins and capillaries
7. Identify major blood vessels
8. Identify structures involved in fetal circulation
9. Identify several pulse points
10. Identify major components of blood
11. Identify the blood types
12. Describe the blood clotting process
13. Describe common disorders of the circulatory/cardiovascular system

### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the lymphatic system

- Name the structures composing the lymphatic system
- Identify the functions of the lymphatic system
- Explain the relationship between the lymphatic system and the cardiovascular system
- Explain the immune response in relationship to the lymphocytes
- Define antigens
- Define antibodies and ways in which antibodies act against antigens
- Differentiate between active and passive immunity
- Describe common disorders of the lymphatic system
### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the respiratory system

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify major respiratory system organs and structures describing the function of each</td>
</tr>
<tr>
<td>2. Describe the function of major respiratory system organs and structures</td>
</tr>
<tr>
<td>3. Define cellular respiration, external respiration, internal respiration, ventilation, expiration and inspiration</td>
</tr>
<tr>
<td>4. Describe the process of gas exchange in the lungs and the tissues</td>
</tr>
<tr>
<td>5. Explain role of the respiratory muscles in breathing</td>
</tr>
<tr>
<td>6. Identify brain areas involved in the control of respiration</td>
</tr>
<tr>
<td>7. Explain respiratory volumes and capacities</td>
</tr>
<tr>
<td>8. Describe a common disorders and injuries of the respiratory system</td>
</tr>
</tbody>
</table>

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### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the digestive system

<table>
<thead>
<tr>
<th>Learning statements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify the structures and functions of the digestive system</td>
</tr>
<tr>
<td>2. Describe the mechanisms of mastication, swallowing, vomiting and defecation</td>
</tr>
<tr>
<td>3. Define anabolism and catabolism</td>
</tr>
<tr>
<td>4. Define basal metabolic rate and total metabolic rate</td>
</tr>
<tr>
<td>5. Describe common disorders of the digestive system</td>
</tr>
</tbody>
</table>
### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the endocrine system

#### Learning statements:
1. Differentiate between endocrine and exocrine glands
2. Identify major endocrine glands and hormones produced by each
3. Explain response of body systems to hormones
4. Describe common endocrine gland disorders

---

### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the endocrine system

#### Learning statements:
5. Differentiate between endocrine and exocrine glands
6. Identify major endocrine glands and hormones produced by each
7. Explain response of body systems to hormones
8. Describe common endocrine gland disorders

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### Topic: Anatomy, Physiology, and Pathology

#### Content Statements: General Knowledge of the urinary system
Learning statements:
1. Identify components of the urinary system
2. Explain the functioning of the urinary system
3. Identify nitrogenous waste found in the urine
4. Explain how water and electrolyte balance is maintained by the body
5. Define micturition
6. Explain how micturition occurs
7. Describe common disorders of the urinary system

Topic: Anatomy, Physiology, and Pathology

Content Statements: General Knowledge of the reproductive system

Learning statements:
1. Explain the general function of the reproductive system
2. Identify major organs of the reproductive system
3. Describe the phases of the menstrual cycle
4. Explain the process of meiosis, spermatogenesis, and oogenesis
5. Identify stages of embryonic development
6. Explain the physiology of childbirth
7. Describe common disorders of the reproductive system

Topic: Anatomy, Physiology, and Pathology
### Content Statements: General Knowledge of the Senses

**Learning statements:**
1. Identify major structures and functions of vision, hearing, balance, smell, taste, and touch
2. Define refraction, accommodation, real image, and emmetropic
3. Describe common disorders and injuries of the senses

### Topic: Anatomy, Physiology, and Pathology

### Content Statements: General Knowledge of Immunology

**Learning statements:**
1. Explain the immune response in relationship to the lymphocytes
2. Define antigens and antibodies
3. Explain the differences among the five major classes of antibodies
4. Describe the relationship between antigens and antibodies
5. Differentiate between active and passive immunity
6. Describe common immunodeficiency’s, allergies, and autoimmune disorders
<table>
<thead>
<tr>
<th>Course: Integrated Science</th>
<th>10, 11, 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topic: Grades 9 / 10 Current Science Standards</td>
<td></td>
</tr>
</tbody>
</table>
Earth and Space Sciences
Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth’s systems, processes that shape Earth and Earth’s history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

Benchmark A: Explain how evidence from stars and other celestial objects provide information about the processes that cause changes in the composition and scale of the physical universe.

Grade Nine
The Universe
1. Describe that stars produce energy from nuclear reactions and that processes in stars have led to the formation of all elements beyond hydrogen and helium.

2. Describe the current scientific evidence that supports the theory of the explosive expansion of the universe, the Big Bang, over 10 billion years ago.

Grade Ten
No indicators present for this benchmark.

Benchmark B: Explain that many processes occur in patterns within the Earth’s systems.

Grade Nine
Earth Systems
4. Explain the relationships of the oceans to the lithosphere and atmosphere (e.g., transfer of energy, ocean currents and landforms).

Grade Ten
Earth Systems
1. Summarize the relationship between the climatic zone and the resultant biomes. (This includes explaining the nature of the rainfall and temperature of the mid-latitude climatic zone that supports the deciduous forest.)

Earth and Space Sciences
2. Explain climate and weather patterns associated with certain geographic locations and features (e.g., tornado alley, tropical hurricanes and lake effect snow).

Benchmark C: Explain the 4.5 billion-year-history of Earth and the 4 billion-year-history of life on Earth based on observable scientific evidence in the geologic record.

Grade Nine
The Universe
3. Explain that gravitational forces govern the characteristics and movement patterns of the planets, comets and asteroids in the solar system.

Grade Ten
Earth Systems
3. Explain how geologic time can be estimated by multiple methods (e.g., rock sequences, fossil correlation and radiometric dating).
4. Describe how organisms on Earth contributed to the dramatic change in oxygen content of Earth’s early atmosphere.

Benchmark D: Describe the finite nature of Earth’s resources and those human activities that can conserve or deplete Earth’s resources.

Grade Nine

Grade Ten
Earth Systems
5. Explain how the acquisition and use of resources, urban growth and waste disposal can accelerate natural change and impact the quality of life.
6. Describe ways that human activity can alter biogeochemical cycles (e.g., carbon and nitrogen cycles) as well as food webs and energy pyramids (e.g., pest control, legume rotation crops vs. chemical fertilizers).
**Benchmark E:** Explain the processes that move and shape Earth’s surface.

**Grade Nine**

*Processes That Shape Earth*

5. Explain how the slow movement of material within Earth results from:
   a. thermal energy transfer (conduction and convection) from the deep interior;
   b. the action of gravitational forces on regions of different density.

6. Explain the results of plate tectonic activity (e.g., magma generation, igneous intrusion, metamorphism, volcanic action, earthquakes, faulting and folding).

7. Explain sea-floor spreading and continental drift using scientific evidence (e.g., fossil distributions, magnetic reversals and radiometric dating).

**Grade Ten**

No indicators present for this benchmark.

**Benchmark F:** Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of Earth and space sciences.

**Grade Nine**

*Historical Perspectives and Scientific Revolutions*

8. Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., heliocentric theory and plate tectonics theory).

**Grade Ten**

*Historical Perspectives and Scientific Revolutions*

7. Describe advances and issues in Earth and space science that have important long-lasting effects on science and society (e.g., geologic time scales, global warming, depletion of resources and exponential population growth).
Life Sciences
Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Benchmark A: Explain that cells are the basic unit of structure and function of living organisms, that once life originated all cells come from pre-existing cells, and that there are a variety of cell types.

Grade Nine
No indicators present for this benchmark.

Grade Ten
Characteristics and Structure of Life
1. Explain that living cells
   a. are composed of a small number of key chemical elements (carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur)
   b. are the basic unit of structure and function of all living things
   c. come from pre-existing cells after life originated, and
   d. are different from viruses
2. Compare the structure, function and interrelatedness of cell organelles in eukaryotic cells (e.g., nucleus, chromosome, mitochondria, cell membrane, cell wall, chloroplast, cilia, flagella) and prokaryotic cells.
### Benchmark B: Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development.

**Grade Nine**

No indicators present for this benchmark.

**Grade Ten**

3. Explain the characteristics of life as indicated by cellular processes including
   a. homeostasis
   b. energy transfers and transformation
   c. transportation of molecules
   d. disposal of wastes
   e. synthesis of new molecules

4. Summarize the general processes of cell division and differentiation, and explain why specialized cells are useful to organisms and explain that complex multicellular organisms are formed as highly organized arrangements of differentiated cells.

### Benchmark C: Explain the genetic mechanisms and molecular basis of inheritance.

**Grade Nine**

No indicators present for this benchmark.

**Grade Ten**

5. Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism.

6. Explain that a unit of hereditary information is called a gene, and genes may occur in different forms called alleles (e.g., gene for pea plant height has two alleles, tall and short).
Course: Integrated Science

Topic: Grades 9 / 10 Current Science Standards

7. Describe that spontaneous changes in DNA are mutations, which are a source of genetic variation. When mutations occur in sex cells, they may be passed on to future generations; mutations that occur in body cells may affect the functioning of that cell or the organism in which that cell is found.

8. Use the concepts of Mendelian and non-Mendelian genetics (e.g., segregation, independent assortment, dominant and recessive traits, sex-linked traits and jumping genes) to explain inheritance.

Benchmark D: Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological).

Grade Nine

No indicators present for this benchmark.

Grade Ten

9. Describe how matter cycles and energy flows through different levels of organization in living systems and between living systems and the physical environment. Explain how some energy is stored and much is dissipated into the environment as thermal energy (e.g., food webs and energy pyramids).

10. Describe how cells and organisms acquire and release energy (photosynthesis, chemosynthesis, cellular respiration and fermentation).

11. Explain that living organisms use matter and energy to synthesize a variety of organic molecules (e.g., proteins, carbohydrates, lipids and nucleic acids) and to drive life processes (e.g., growth, reacting to the environment, reproduction and movement).

Life Sciences
Course: Integrated Science
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**Benchmark E:** Explain how evolutionary relationships contribute to an understanding of the unity and diversity of life.

**Grade Nine**

No indicators present for this benchmark.

**Grade Ten**

*Diversity and Interdependence of Life*

12. Describe that biological classification represents how organisms are related with species being the most fundamental unit of the classification system. Relate how biologists arrange organisms into a hierarchy of groups and subgroups based on similarities and differences that reflect their evolutionary relationships.

13. Explain that the variation of organisms within a species increases the likelihood that at least some members of a species will survive under gradually changing environmental conditions.

14. Relate diversity and adaptation to structures and their functions in living organisms (e.g., adaptive radiation).

**Benchmark F:** Explain the structure and function of ecosystems and relate how ecosystems change over time.

**Grade Nine**

No indicators present for this benchmark.

**Grade Ten**

*Diversity and Interdependence of Life*

15. Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather).

16. Relate how distribution and abundance of organisms and populations in ecosystems are limited by the ability of the ecosystem to recycle materials and the availability of matter, space and energy.

17. Conclude that ecosystems tend to have cyclic fluctuations around a state of approximate equilibrium that can change when climate changes, when one or more new species appear as a result of immigration or when one or more species disappear.

*Life Sciences*
Benchmarks

Benchmark G: Describe how human activities can impact the status of natural systems.

Grade Nine

No indicators present for this benchmark.

Grade Ten

18. Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.

19. Illustrate how uses of resources at local, state, regional, national, and global levels have affected the quality of life (e.g., energy production and sustainable vs. nonsustainable agriculture).
Benchmark H: Describe a foundation of biological evolution as the change in gene frequency of a population over time. Explain the historical and current scientific developments, mechanisms and processes of biological evolution.

Grade Nine

No indicators present for this benchmark.

Grade Ten

Evolutionary Theory

20. Recognize that a change in gene frequency (genetic composition) in a population over time is a foundation of biological evolution.

21. Explain that natural selection provides the following mechanism for evolution; undirected variation in inherited characteristics exist within every species. These characteristics may give individuals an advantage or disadvantage compared to others in surviving and reproducing. The advantaged offspring are more likely to survive and reproduce. Therefore, the proportion of individuals that have advantageous characteristics will increase. When an environment changes, the survival value of some inherited characteristics may change.

22. Describe historical scientific developments that occurred in evolutionary thought (e.g., Lamarck and Darwin, Mendelian Genetics and modern synthesis).

23. Deleted

Benchmark I: Explain how natural selection and other evolutionary mechanisms account for the unity and diversity of past and present life forms.

Grade Nine

No indicators present for this benchmark.
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Grade Ten

Evolutionary Theory

24. Analyze how natural selection and other evolutionary mechanisms (e.g., genetic drift, immigration, emigration, mutation) and their consequences provide a scientific explanation for the diversity and unity of past life forms, as depicted in the fossil record, and present life forms.

25. Explain that life on Earth is thought to have begun as simple, one celled organisms approximately 1 billion years ago. During most of the history of Earth only single celled microorganisms existed, but once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.

Benchmark J: Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of life sciences.

Grade Nine

No indicators present for this benchmark.

Grade Ten

Historical Perspectives and Scientific Revolutions

26. Use historical examples to explain how new ideas are limited by the context in which they are conceived. These ideas are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., biological evolution, germ theory, biotechnology and discovering germs).

27. Describe advances in life sciences that have important long-lasting effects on science and society (e.g., biological evolution, germ theory, biotechnology and discovering germs).

28. Analyze and investigate emerging scientific issues (e.g., genetically modified food, stem cell research, genetic research and cloning).
Physical Sciences
Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy, motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Benchmark A: Describe that matter is made of minute particles called atoms and atoms are comprised of even smaller components. Explain the structure and properties of atoms.

Grade Nine

*Nature of Matter*

1. Recognize that all atoms of the same element contain the same number of protons, and elements with the same number of protons may or may not have the same mass. Those with different masses (different numbers of neutrons) are called isotopes.

2. Illustrate that atoms with the same number of positively charged protons and negatively charged electrons are electrically neutral.

4. Show that when elements are listed in order according to the number of protons (called the atomic number), the repeating patterns of physical and chemical properties identify families of elements. Recognize that the periodic table was formed as a result of the repeating pattern of electron configurations.

5. Describe how ions are formed when an atom or a group of atoms acquire an unbalanced charge by gaining or losing one or more electrons.

Grade Ten

No indicators present for this benchmark.
**Benchmark B:** Explain how atoms react with each other to form other substances and how molecules react with each other or other atoms to form even different substances.

**Grade Nine**

*Nature of Matter*

6. Explain that the electric force between the nucleus and the electrons hold an atom together. Relate that on a larger scale, electric forces hold solid and liquid materials together (e.g., salt crystals and water).

7. Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing balanced chemical equations).

8. Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral.

**Grade Ten**

No indicators present for this benchmark.

**Benchmark C:** Describe the identifiable physical properties of substances (e.g., color, hardness, conductivity, density, concentration and ductility). Explain how changes in these properties can occur without changing the chemical nature of the substance.

**Grade Nine**

*Nature of Matter*

9. Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors).

10. Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.

**Grade Ten**

No indicators present for this benchmark.
Benchmark D: Explain the movement of objects by applying Newton's three laws of motion.

Grade Nine

Forces and Motion

21. Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.

22. Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.

23. Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. ($F_{net} = ma$. Note that weight is the gravitational force on a mass.)

24. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.

25. Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).

Grade Ten

No indicators present for this benchmark.

Benchmark E: Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored).

Grade Nine

Nature of Energy

12. Explain how an object's kinetic energy depends on its mass and its speed ($KE = \frac{1}{2}mv^2$).

13. Demonstrate that near Earth's surface an object's gravitational potential energy depends upon its weight ($mg$ where $m$ is the object's mass and $g$ is the acceleration due to gravity) and height ($h$) above a reference surface ($PE = mgh$).
Course: Integrated Science

Topic: Grades 9 / 10 Current Science Standards

### Grade Ten

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<td>F</td>
<td>Explain how energy may change form or be redistributed but the total quantity of energy is conserved.</td>
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### Grade Nine

**Nature of Matter**

3. Describe radioactive substances as unstable nuclei that undergo random spontaneous nuclear decay emitting particles and/or high energy wavelike radiation.

**Nature of Energy**

11. Explain how thermal energy exists in the random motion and vibrations of atoms and molecules. Recognize that the higher the temperature, the greater the average atomic or molecular motion, and during changes of state the temperature remains constant.

14. Summarize how nuclear reactions convert a small amount of matter into a large amount of energy. (Fission involves the splitting of a large nucleus into smaller nuclei; fusion is the joining of two small nuclei into a larger nucleus at extremely high energies.)

15. Trace the transformations of energy within a system (e.g., chemical to electrical to mechanical) and recognize that energy is conserved. Show that these transformations involve the release of some thermal energy.

16. Illustrate that chemical reactions are either endothermic or exothermic (e.g., cold packs, hot packs and the burning of fossil fuels).

17. Demonstrate that thermal energy can be transferred by conduction, convection or radiation (e.g., through materials by the collision of particles, moving air masses or across empty space by forms of electromagnetic radiation).

### Grade Ten

No indicators present for this benchmark.
Course: Integrated Science

Topic: Grades 9 / 10 Current Science Standards

**Benchmark G:** Demonstrate that waves (e.g., sound, seismic, water and light) have energy and waves can transfer energy when they interact with matter.

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**Grade Nine**

*Nature of Energy*

18. Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays).

19. Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.

20. Describe how waves can superimpose on one another when propagated in the same medium. Analyze conditions in which waves can bend around corners, reflect off surfaces, are absorbed by materials they enter, and change direction and speed when entering a different material.

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**Grade Ten**

No indicators present for this benchmark.
Lancaster City Schools
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Course: Integrated Science
Topic: Grades 9 / 10 Current Science Standards

Benchmark H: Trace the historical development of scientific theories and ideas, and describe emerging issues in the study of physical sciences.

Grade Nine

26. Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., atomic theory, quantum theory and Newtonian mechanics).

27. Describe advances and issues in physical science that have important, long-lasting effects on science and society (e.g., atomic theory, quantum theory, Newtonian mechanics, nuclear energy, nanotechnology, plastics, ceramics and communication technology).

Grade Ten

No indicators present for this benchmark.
The Science Department uses a variety of best-practice methods of evaluation. Some of those procedures are:

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