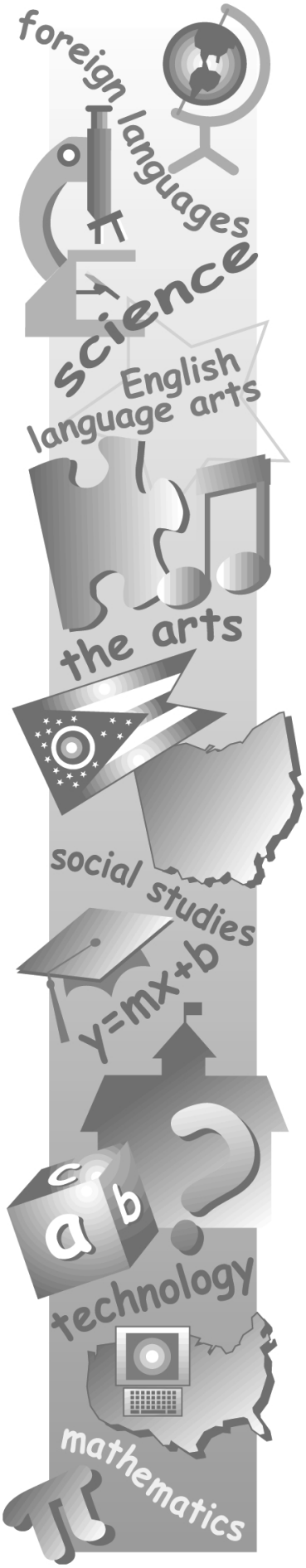

Department of Education

Academic Content Standards

Science

ADOPTED
December 10, 2002

Center for Curriculum and Assessment
Office of Curriculum and Instruction

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The 124th General Assembly enacted Section 3301.07.9 of the revised code. Section B states that "…All school districts may utilize the state standards and the model curriculum established by the state board, together with other relevant resources, examples, or models to ensure that students have the opportunity to attain the academic standards. Upon request, the department of education shall provide technical assistance to any district in implementing the model curriculum. Nothing in this section requires any school district to utilize all or any part of a model curriculum developed under this division."

The Ohio Administrative Code 3301-35-04 specifies "(B) The school district or school shall implement a comprehensive district-wide curriculum and instructional program that is characterized by systematic planning, articulation and evaluation. The district's curriculum shall be developed with input from and dialogue with parents, community members and other stakeholders. (5) Courses of study shall define the key components of a district's curriculum and instruction. Each course of study shall: (vii) Be guided by Ohio's state-adopted model curriculum programs, or other curricular models, and objectives assessed by the state proficiency tests."

K-12 Science

Overview

K-12 Science

Introduction

The Ohio Science Academic Content Standards provide all students in the K-12 program with a set of clear and rigorous expectations. The Science Standards focus on what all Ohio students need to know and be able to do for scientific literate citizenship, regardless of age, gender, cultural or ethnic background, disabilities or aspirations in science.

The Science Standards include science concepts, processes, and ways of thinking. All Ohio students can apply these skills and understanding to make informed personal decisions, to accurately communicate with a variety of audiences, to be become life-long learners, and to make successful transitions to post-secondary education and the work force. The standards also include expectations for all Ohio students to safely and effectively use technological tools for learning and doing science. The Ohio Science Academic Content Standards are listed below:

Content Standards:
- Physical Sciences
- Life Sciences
- Earth and Space Sciences
- Science and Technology
- Scientific Inquiry
- Scientific Ways of Knowing

The Ohio Science Standards identify essential expectations for students: concepts, principles, theories, and understanding how science is done. The science standards describe broad areas of content such as the interdependence of organisms, the interactions of matter and energy, objects in the sky, and the nature of scientific knowledge. The six standards address essential knowledge and skills in science that people may use in solving problems creatively, thinking critically, working cooperatively in teams, using technology effectively, and valuing life-long learning.

The Ohio Science Academic Standards provide for teaching and learning opportunities that include accurate and technically precise science information, scientific inquiry, technological design, communication and understanding of science concepts, analysis of data, and application of concepts.

Students' success in meeting the expectations of the standards depends on teaching and learning as an active inquiry process. This means that all teachers need the opportunity to teach science as something in which students are actively engaged. When participating in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. This includes engaging all students' thinking with relevant, real-world activities that extend students' thinking and communication skills, and develop students' science process skills.

The Science Standards enhance development of students' understanding of science concepts by combining science inquiry and technology studies with mathematical reasoning/analysis and language skills. Scientific literacy enables students to use scientific principles and processes in making personal decisions and to participate in discussions of scientific issues that affect society. Science instruction can

also integrate knowledge and skills from other disciplines such as mathematics, English language arts, social studies, and other disciplines to develop conceptual frameworks that lead to broader understandings.

The following terms and definitions are used in this document:

Standard:	An overarching goal or theme in science. The standard statement describes, in broadest terms, what all students should know and be able to do as a result of the K-12 program.
Benchmark:	A specific statement of what all students should know and be able to do at a specified time in their schooling. Benchmarks are used to measure a student's progress toward meeting the standard. Science benchmarks are defined for grade bands K-2, 3-5, 6-8, 9-10, and 11-12.
Grade-level Indicator:	A specific statement of the knowledge and/or skills that a student is expected to demonstrate at each grade level. These indicators serve as checkpoints that monitor progress toward the benchmarks.

Scope and Sequence

Kindergarten

Kindergarten provides students with the opportunity to develop the scientific skills of wondering, questioning, investigating and communicating, to enable them to begin to develop a sense of the world. Kindergartners learn through discovery about changes on Earth, in the sky, plants, animals, their habitats, and non-living things in their local community. Through hands-on exploration, students learn the characteristics of objects, tools, materials, how they move, and whether or not they are natural or man-made. Students explore the different ways people learn about science and interact with living things and the environment to promote respect for nature. Students show knowledge of scientific concepts through demonstration of verbal, non-verbal, skills and activities.

Grade 1

Science instruction in the first grade builds upon the science skills developed in kindergarten and from the child's life experiences. Students have increasing opportunities to explore how living things change, how they interact with their environment, and how they acquire food. Students discover that many objects are made of different parts and characteristics. Students learn ways objects change, move, the materials of which they are composed, and their physical properties. Students recognize and realize that natural resources are limited and can be extended by recycling or decreasing use. First graders explore ways people learn about science through questioning, comparing, investigating, and observing.

Grade 2

Second graders continue to relate science concepts and skills to their life experiences. They compare similarities and differences between people, animals, and plants. Living system functions and the interactions they have with their physical environment are explained. Focus is placed upon habits, and the interdependence and survival of plants and animals in Ohio. Weather changes both short term and long term are observed, described, and measured. Second graders discover how cycles are present in their everyday lives through investigations of Earth and sky, sound and light, and plants and animals. Students recognize the purpose, process and effects of technology, simple equipment and instruments used in learning about science. Students develop an awareness of repeated scientific investigations and understand that under the same conditions the results are similar or the same.

Grade 3

The scientific skills of observation, measuring, and classification serve as focal points for the third grade. Students learn to read and interpret simple tables and graphs, conduct safe investigations in which they collect and analyze data, and communicate the results. Third graders explore the properties and composition of rocks and soils and the interaction of forces and motion. They also compare the life cycles of animals, classifications of animals according to their characteristics, descriptions of their habitat, and adaptations to their environment. Students examine results of technology and explore careers in science as well as scientific contributions from a diversity of cultures.

Grade 4

Fourth graders continue to safely conduct investigations, choose appropriate tools, measure, collect, formulate conclusions, and communicate findings. They draw inferences from simple experiments and study the physical and chemical changes of matter. Properties of materials and the discovery of new materials formed by combining two or more materials are explored. Students expand the study of life cycles of plants by examining characteristics, growth, and functions. Students gather information on the weather and its patterns and how weather impacts the Earth's surface - land, air, and water. They explore how utilizing technology affects human lives and how technology and inventions change to meet people's needs.

Grade 5

Earth and space sciences are investigated in more detail in grade five. Earth's characteristics, resources and location in the Solar System are identified and those implications explored. Students also learn about the interrelationship of organisms and ecosystems and simple food chains and food webs. Energy and energy transfer through an electrical current are addressed. Fifth graders describe and illustrate the design process and describe the positive and negative impacts of human activity and technology on the environment. Students observe, measure, and collect data when conducting a scientific investigation; students use this information to formulate inferences and conclusions; and students develop skills to communicate the results.

Grade 6

Students in grade six continue to conduct investigations and begin to apply mathematical skills in evaluating and analyzing variables of data. They identify basic skills of the scientific inquiry processes such as how thinking scientifically is helpful in daily life and how technological advances affect the quality of life. Students research how men and women of other countries and cultures contribute to science. Sixth grade students identify rocks, their distinct properties, formation and characteristic properties of the minerals that form them. They learn to recognize that a cell continually divides to create new cells, that reproduction occurs, that similar cells have special functions, and that characteristics of an organism are a result of inherited traits. Students acquire knowledge of the uses, properties, and chemical processes of the small particles that compose matter. They learn the renewable and nonrenewable sources of energy.

Grade 7

Students learn to describe interactions of matter and energy throughout the lithosphere, hydrosphere, and the atmosphere. They continue to develop skills of scientific inquiry, explain how matter can change forms, and describe how energy is potential or kinetic and takes many forms. Students apply math skills to evaluate and analyze variables and data from investigations as they draw conclusions from scientific evidence. Seventh-grade students are able to recognize that technology can create environmental and economic conflicts, affect the quality of life, and that science and technology cannot answer all questions and cannot solve all human problems. The students access knowledge to explain how energy entering the ecosystems, as sunlight, supports the life of organisms through photosynthesis and the transfer of energy through the interactions of organisms and the environment.

Grade 8

Students in the eighth grade explore space and plate tectonics as they continue to draw conclusions from scientific evidence that support theories related to the change of the Earth's surface. They acquire knowledge to describe how positions and motions of objects in the universe cause predictable and cyclic events. Students explain that the universe is composed of vast amounts of matter and that it is held together by gravitational force. They explore equipment to study the universe - telescopes, probes, satellites, and spacecraft. Motion of objects, effects of forces on objects, and how waves (sound, water and earthquake) transfer energy are explored. Students will be able to explain how extinction of a species occurs when the environment changes and its adaptive characteristics are insufficient to allow survival. Students design a solution to a problem or design and build a product, given certain constraints. Technological influences on the quality of life are also explored.

Grade 9

The ninth-grade year addresses physical science and related principles in Earth and space sciences. Physical science concepts include the nature of matter and energy; identifiable physical properties of substances; and properties of forces that act on objects. Ninth graders learn about forces and motions, structures and properties of atoms, how atoms react with each other to form other substances, and how molecules react with each other or other atoms. Earth and space science topics include processes that move and shape the Earth; Earth's interaction with the Solar System; and gravitational forces and the weather. Students continue to develop a deeper understanding of the processes of scientific inquiry and how these processes use evidence to support conclusions based on logical reasoning. Students investigate ways in which science and technologies combine to meet human needs and solve human problems. Ninth graders trace the historical development of scientific theories and ideas, explore scientific theories, and develop their scientific literacy to become knowledgeable citizens.

Grade 10

The tenth-grade year emphasizes the concepts, principles and theories that enable people to understand the living environment. Students study life science concepts such as cells and their structure and function, the genetic and molecular bases of inheritance, biological evolution and the diversity and interdependence of life. Students explain the Earth's history using geologic evidence, identify the Earth's resources, and explore processes that shape the Earth. The flow of energy and the cycling of matter through biological and ecological systems are addressed in the tenth grade. Embedded throughout this study, are the basic science processes of inquiry, modeling investigations, and the nature of science. Students learn to trace the historical development of scientific theories, ideas, ethical guidelines in science, the interdependence of science and technology, and the study of emerging issues.

Grade 11

In grade eleven students draw on their previous experience and connect the Earth , space, life and physical science into a coherent study of the environment. Emphasis is placed on the interactions between humans and the Earth, ecosystems, biological evolution, populations, and diversity. Students also explore matter and energy relationships. The human interactions with science and technology are discussed, as well as how man has modified current ecosystems and natural systems. Students have the opportunity to use basic science processes of inquiry, scientific investigation, and the nature of science to examine past events and current situations and to develop and revise scientific predictions, ideas or theories.

Grade 12

Grade twelve focuses on advanced topics in biological and physical sciences. Biological topic clusters include cell specialization, biotechnology, DNA, and biological evolutionary change. In the physical sciences, students study equilibrium of systems, electromagnetic radiation, isotopes, radioactive decay, concepts of forces and motion as applied to large and small objects, and energy levels. Integrated with

these topics are historical perspectives, the process of inquiry, nature of science, ethical practices, and use of appropriate technology. Twelfth graders learn to apply principles of forces and motion to mathematically analyze, describe, and predict the net effects of forces and motion of objects or systems. Students explore science research, scientific literature, and the relationship of science and society. The option exists for schools to create and implement a variety of advanced studies at the twelfth grade level.

The Development of Academic Content Standards

Joint Council of the
State Board of Education and
the Ohio Board of Regents
Academic Content Standards

The process for developing academic content standards began in 1997 when the State Board of Education and the Ohio Board of Regents created a Joint Council to oversee the implementation of recommendations made by the Secondary and Higher Education Remediation Advisory Commission. The boards began to build a common long-term agenda for pre-K through 16 education.

The Joint Council started its work by establishing a set of common expectations for what all students should know and be able to do upon completion of high school. The initial work established common expectations in six content areas: (1) the arts, (2) English language arts, (3) foreign languages, (4) mathematics, (5) science, and (6) social studies. These drafts were transformed into Ohio's academic content standards.

The Joint Council assembled advisory groups to assist in completing preliminary planning for the process to draft Ohio's new academic content standards. This preliminary planning included review of exemplary world-class standards from the United States and other countries and the formulation of strategic policy recommendations. The recommendations assured that the drafting and refining of academic content standards would respect Ohio's history for sharing responsibility for curriculum decisions with Ohio's diverse learning communities.

Writing Teams were made up of representatives from all twelve regions served by the Ohio Department of Education's Regional Professional Development Centers and included educators from each grade level, K-12, as well as career-technical, special education and gifted education. Ohio's diverse ethnicity, geography, types of school districts and colleges and universities were represented on the writing teams. Parent and business and industry representatives also were represented on the writing teams. All original members of the teams who wrote the Common Expectations were invited back to join the writing teams.

When the writing teams completed the draft academic content standards documents, these documents were subjected to a period of extensive public engagement and rigorous review. Focus group meetings and electronic feedback via the web page allowed all stakeholders to express their opinions. The writing teams reviewed the public feedback and made revision recommendations to respond to the issues raised by feedback. The draft standards presented to the State Board of Education for adoption reflect the final recommendations of this writing process and include grade-level indicators of progress (K-12), benchmarks that will serve as checkpoints at key grade bands, philosophies and guiding assumptions.

Development and Implementation Timeline

Based on Amended Substitute Senate Bill 1

	English Language Arts	Mathematics	Science	Social Studies	Technology Foreign Languages The Arts
Development ↑					
(1) Assemble Advisory Committee	↓	↓	↓	↓	State Board adoption of these content areas will follow the adoption of English Language Arts, Mathematics, Science and Social Studies
(2) Identify Writing Team					
(3) Develop Draft Standards and Benchmarks					
(4) Convene Writing Team					
(5) Seek Focused Input					
(6) Engage the Public					
(7) Revise Draft Standards and Benchmarks ↓					
(8) Adoption of Academic Content Standards by the State Board of Education	December 2001	December 2001	December 2002	December 2002	
Implementation ↑					
(9) Develop products and services	↓	↓	↓	↓	
(10) Design Curriculum Models					
(11) Present for Public Review					
(12) State Board Review					
(13) Adoption of Curriculum Models by State Board of Education ↓	June 2003	June 2003	June 2004	June 2004	
(14) Deliver Curriculum Models; Professional Development	September 2003	September 2003	September 2004	September 2004	

Philosophy and Guiding Assumptions

Ohio's science content standards serve as a basis for what all students should know and be able to do by the time they graduate from high school. The vision for the broad learning goals of Ohio's Science Academic Content Standards provides for a scientifically literate citizen. These standards, benchmarks and grade-level indicators are intended to provide Ohio's educators with a set of common expectations upon which to base science curriculum.

Philosophy of Ohio's Science Academic Content Standards

The intent of Ohio's Science Academic Content Standards is to:

- help students develop an understanding of the unity and diversity of the natural (empirical) world;
- foster an understanding of the nature of science, the development of science processes, the principles of science, and the connections between the physical, life, and Earth and space sciences;
- prepares students to use appropriate scientific processes and principles in making personal decisions;
- enables students to engage intelligently in public discourse about matters of scientific and technological concern; and
- increases their future economic productivity through the use of scientific knowledge, understanding, and skills in their careers.

Assumptions for Science Content Standards

Ohio's Academic Content Standards:

- Set high expectations and provide strong support for science achievement by ALL students.
- Represent scientific knowledge and skills needed to make a successful transition to post-secondary education, the workplace and daily life.
- Reflect sound application of research on how students learn science concepts and processes.
- Align with the national science education standards documents.
- Provide balance among conceptual understanding, procedural knowledge and skills, and application and problem-solving.
- Address scientific content knowledge and processes including technological design, scientific ways of knowing, inquiry, communication, representation, and connections across the domains of science.
- Apply scientific knowledge and processes to individual and societal issues.
- Focus on important scientific concepts that are well-articulated through benchmarks and grade-level indicators.
- Represent rigorous progression across grades and in-depth study within each grade.
- Incorporate use of technology by ALL students in learning science and develop an understanding about the nature of science and technology including technological design.
- Serve as the basis for classroom and state-wide assessments.
- Emphasize the nature, connections, and historical development of scientific knowledge in the physical, life, and Earth and space sciences.

Ohio's K-12

Science Standards

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.

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, of organisms and of living systems are developed as well as a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students also demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

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, as well as motion and the forces affecting motion, the nature of waves and interactions of matter and energy. Students also demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Science and Technology

Students should recognize that science and technology are interconnected and that using technology involves assessment of the benefits, risks, and costs. Students should build scientific and technological knowledge, as well as the skill required to design and construct devices. In addition, they should develop the processes to solve problems and to understand that problems may be solved in several ways.

Scientific Inquiry

Students develop scientific habits of mind as they use the processes of scientific inquiry to ask valid questions, and to gather and analyze information. They understand how to develop hypotheses and make predictions. They are able to reflect on scientific practices as they develop plans of action to create and evaluate a variety of conclusions. Students are also able to demonstrate the ability to communicate their findings to others.

Scientific Ways of Knowing

Students realize that the current body of scientific knowledge must be based on evidence, be predictive, logical, subject to modification, and limited to the natural world. This includes demonstrating an understanding that scientific knowledge grows and advances as new evidence is discovered to support or modify existing theories, as well as to encourage the development of new theories. Students are able to reflect on ethical scientific practices and demonstrate an understanding of how the current body of scientific knowledge reflects the historical and cultural contributions of women and men who provide us with a more reliable and comprehensive understanding of the natural world.

Science

Grade Level Indicators

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 the 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.

Kindergarten

The Universe

1. Observe that the Sun can be seen only in the daytime, but the Moon can be seen sometimes at night and sometimes during the day.

Processes That Shape Earth

2. Explore that animals and plants cause changes to their surroundings.
3. Explore that sometimes change is too fast to see and sometimes change is too slow to see.
4. Observe and describe day-to-day weather changes (e.g., today is hot, yesterday we had rain).
5. Observe and describe seasonal changes in weather.

Grade One

Earth Systems

1. Identify that resources are things that we get from the living (e.g., forests) and nonliving (e.g., minerals, water) environment and that resources are necessary to meet the needs and wants of a population.
2. Explain that the supply of many resources is limited but the supply can be extended through careful use, decreased use, reusing and/or recycling.

Processes That Shape Earth

3. Explain that all organisms cause changes in the environment where they live; the changes can be very noticeable or slightly noticeable, fast or slow. (e.g., spread of grass cover slowing soil erosion, tree roots slowly breaking sidewalks).

Grade Two

The Universe

1. Recognize that there are more stars in the sky than anyone can easily count.
2. Observe and describe how the Sun, Moon and stars all appear to move slowly across the sky.
3. Observe and describe how the Moon appears a little different every day but looks nearly the same again about every four weeks.

Earth Systems

4. Observe and describe that some weather changes occur throughout the day and some changes occur in a repeating seasonal pattern.
5. Describe weather by measurable quantities such as temperature and precipitation.

Grade Three

Earth Systems

1. Compare distinct properties of rocks (e.g., color, layering, texture).
2. Observe and investigate that rocks are often found in layers.
3. Describe that smaller rocks come from the breakdown of larger rocks through the actions of plants and weather.
4. Observe and describe the composition of soil (e.g., small pieces of rock and decomposed pieces of plants and animals, and products of plants and animals).
5. Investigate the properties of soil (e.g., color, texture, capacity to retain water, ability to support plant growth).
6. Investigate that soils are often found in layers and can be different from place to place.

Grade Four

Earth Systems

1. Explain that air surrounds us, takes up space, moves around us as wind, and may be measured using barometric pressure.
2. Identify how water exists in the air in different forms (e.g., in clouds, fog, rain, snow and hail).
3. Investigate how water changes from one state to another (e.g., freezing, melting, condensation, evaporation).
4. Describe weather by measurable quantities such as temperature, wind direction, wind speed, precipitation, and barometric pressure.

5. Record local weather information on a calendar or map and describe changes over a period of time (e.g., barometric pressure, temperature, precipitation symbols, cloud conditions).
6. Trace how weather patterns generally move from west to east in the United States.
7. Describe the weather which accompanies cumulus, cumulonimbus, cirrus and stratus clouds.

Processes That Shape Earth

8. Describe how wind, water and ice shape and reshape Earth's land surface by eroding rock and soil in some areas and depositing them in other areas producing characteristic landforms (e.g., dunes, deltas, glacial moraines).
9. Identify and describe how freezing, thawing and plant growth reshape the land surface by causing the weathering of rock.
10. Describe evidence of changes on Earth's surface in terms of slow processes (e.g., erosion, weathering, mountain building, deposition) and rapid processes (e.g. volcanic eruptions, earthquakes, landslides).

Grade Five

The Universe

1. Describe how night and day are caused by Earth's rotation.
2. Explain that Earth is one of several planets to orbit the Sun, and that the Moon orbits Earth.
3. Describe the characteristics of Earth and its orbit about the Sun (e.g., three-fourths of Earth's surface covered by a layer of water [some of it frozen], the entire planet surrounded by a thin blanket of air, elliptical orbit, tilted axis, spherical planet).
4. Explain that stars are like the Sun, some being smaller and some larger, but so far away that they look like points of light.

Earth Systems

5. Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling but cannot be extended indefinitely.
6. Investigate ways Earth's renewable resources (e.g., fresh water, air, wildlife and trees) can be maintained.

Grade Six

Earth Systems

1. Describe the rock cycle and explain that there are sedimentary, igneous and metamorphic rocks that have distinct properties (e.g., color, texture) and are formed in different ways.
2. Explain that rocks are made of one or more minerals.
3. Identify minerals by their characteristic properties.

Grade Seven

Earth Systems

1. Explain the biogeochemical cycles which move materials between the lithosphere (land), hydrosphere (water) and atmosphere (air).
2. Explain that Earth's capacity to absorb and recycle materials naturally (e.g., smoke, smog, sewage) can change the environmental quality depending on the length of time involved (e.g. global warming).
3. Describe the water cycle and explain the transfer of energy between the atmosphere and hydrosphere.
4. Analyze data on the availability of fresh water that is essential for life and for most industrial and agricultural processes. Describe how rivers, lakes and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unavailable or unsuitable for life.
5. Make simple weather predictions based on the changing cloud types associated with frontal systems.
6. Determine how weather observations and measurements are combined to produce weather maps and that data for a specific location at one point in time can be displayed in a station model.
7. Read a weather map to interpret local, regional and national weather.
8. Describe how temperature and precipitation determine climatic zones (biomes) (e.g., desert, grasslands, forests, tundra, alpine).
9. Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts, hurricanes).

Grade Eight

The Universe

1. Describe how objects in the Solar System are in regular and predictable motions that explain such phenomena as days, years, seasons, eclipses, tides and moon cycles.
2. Explain that gravitational force is the dominant force determining motions in the Solar System and in particular keeps the planets in orbit around the Sun.
3. Compare the orbits and composition of comets and asteroids with that of Earth.
4. Describe the effect that asteroids or meteoroids have when moving through space and sometimes entering planetary atmospheres (e.g., meteor- "shooting star" and meteorite).

5. Explain that the universe consists of billions of galaxies that are classified by shape.
6. Explain interstellar distances are measured in light years (e.g., the nearest star beyond the sun is 4.3 light years away).
7. Examine the life cycle of a star and predict the next likely stage of a star.
8. Name and describe tools used to study the universe (e.g., telescopes, probes, satellites and spacecraft).

Earth Systems

9. Describe the interior structure of Earth and Earth's crust as divided into tectonic plates riding on top of the slow moving currents of magma in the mantle.
10. Explain that most major geological events (e.g., earthquakes, volcanic eruptions, hot spots and mountain building) result from plate motion.
11. Use models to analyze the size and shape of Earth, its surface and its interior (e.g., globes, topographic maps, satellite images).
12. Explain that some processes involved in the rock cycle are directly related to thermal energy and forces in the mantle that drive plate motions.
13. Describe how landforms are created through a combination of destructive (e.g., weathering and erosion) and constructive processes (e.g., crustal deformation, volcanic eruptions and deposition of sediment).
14. Explain that folding, faulting and uplifting can rearrange the rock layers so the youngest is not always found on top.
15. Illustrate how the three primary types of plate boundaries (transform, divergent and convergent) cause different landforms (e.g., mountains, volcanoes, ocean trenches).

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.
3. Explain that gravitational forces govern the characteristics and movement patterns of the planets, comets and asteroids in the Solar System.

Earth Systems

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

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).

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

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.)
2. Explain climate and weather patterns associated with certain geographic locations and features (e.g., tornado alley, tropical hurricanes and lake effect snow).
3. Explain how geologic time can be estimated by multiple methods (e.g., rock sequences, fossil correlation, radiometric dating).
4. Describe how organisms on Earth contributed to the dramatic change in oxygen content of Earth's early atmosphere.
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).

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, exponential population growth).

Grade Eleven

The Universe

1. Describe how the early Earth was different from the planet we live on today, and explain the formation of the Sun, Earth and the rest of the Solar System from a nebular cloud of dust and gas approximately 4.5 billion years ago.

Earth Systems

2. Analyze how the regular and predictable motions of Earth, Sun and Moon explain phenomena on Earth (e.g., seasons, tides, eclipses and phases of the Moon).
3. Explain heat and energy transfers in and out of the atmosphere and its involvement in weather and climate (radiation, conduction, convection and advection).
4. Explain the impact of oceanic and atmospheric currents on weather and climate.
5. Use appropriate data to analyze and predict upcoming trends in global weather patterns (e.g., el Niño and la Niña, melting glaciers and icecaps, changes in ocean surface temperatures).
6. Explain how interactions among Earth's lithosphere, hydrosphere, atmosphere and biosphere have resulted in the ongoing changes of Earth's system.
7. Describe the effects of particulates and gases in the atmosphere including those originating from volcanic activity.
8. Describe the normal adjustments of Earth, which may be hazardous for humans. Recognize that humans live at the interface between the atmosphere driven by solar energy and the upper mantle where convection creates changes in Earth's solid crust. Realize that as societies have grown, become stable and come to value aspects of the environment, vulnerability to natural processes of change has increased.
9. Explain the effects of biomass and human activity on climate (e.g., climatic change, global warming).
10. Interpret weather maps and their symbols to predict changing weather conditions worldwide (e.g., monsoons, hurricanes and cyclones).
11. Analyze how materials from human societies (e.g., radioactive waste, air pollution) affect both physical and chemical cycles of Earth.
12. Explain ways in which humans have had a major effect on other species (e.g., the influence of humans on other organisms occurs through land use, which decreases space available to other species and pollution, which changes the chemical composition of air, soil and water).
13. Explain how human behavior affects the basic processes of natural ecosystems and the quality of the atmosphere, hydrosphere and lithosphere.
14. Conclude that Earth has finite resources and explain that humans deplete some resources faster than they can be renewed.

Historical Prespectices And Scientific Revolutions

15. Use historical examples to show how new ideas are limited by the context in which they are conceived; are often rejected by the social establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., global warming, Heliocentric Theory, Theory of Continental Drift).

16. Describe advances in Earth and space science that have important long-lasting effects on science and society (e.g., global warming, heliocentric theory, plate tectonics theory).

Grade Twelve

The Universe

1. Explain how scientists obtain information about the universe by using technology to detect electromagnetic radiation that is emitted, reflected or absorbed by stars and other objects.

2. Explain how the large-scale motion of objects in the universe is governed by gravitational forces and detected by observing electromagnetic radiation.

3. Explain how information about the universe is inferred by understanding that stars and other objects in space emit, reflect or absorb electromagnetic radiation, which we then detect.

4. Explain how astronomers infer that the whole universe is expanding by understanding how light seen from distant galaxies has longer apparent wavelengths than comparable light sources close to Earth.

Earth Systems

5. Investigate how thermal energy transfers in the world's oceans impact physical features (e.g., ice caps, oceanic and atmospheric currents) and weather patterns.

6. Describe how scientists estimate how much of a given resource is available on Earth.

Science

Grade-Level Indicators

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, of organisms and of living systems are developed as well as a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students also demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Kindergarten

Characteristics and Structure of Life	1. Explore differences between living and non-living things (e.g., plant-rock).
	2. Discover that stories (e.g., cartoons, movies, comics) sometimes give plants and animals characteristics they really do not have (e.g., talking flowers).
Heredity	3. Describe how plants and animals usually resemble their parents.
	4. Investigate variations that exist among individuals of the same kind of plant or animal.
Diversity and Interdependence of Life	5. Investigate observable features of plants and animals that help them live in different kinds of places.
	6. Investigate the habitats of many different kinds of local plants and animals and some of the ways in which animals depend on plants and each other in our community.

Grade One

Characteristics and Structure of Life

1. Explore that organisms, including people, have basic needs which include air, water, food, living space and shelter.
2. Explain that food comes from sources other than grocery stores (e.g., farm crops, farm animals, oceans, lakes and forests).
3. Explore that humans and other animals have body parts that help to seek, find and take in food when they are hungry (e.g., sharp teeth, flat teeth, good nose, sharp vision).

Diversity and Interdependence of Life

4. Investigate that animals eat plants and/or other animals for food and may also use plants or other animals for shelter and nesting.
5. Recognize that seasonal changes can influence the health, survival or activities of organisms.

Grade Two

Characteristics and Structure of Life

1. Explain that animals, including people, need air, water, food, living space and shelter, and plants need air, water, nutrients (e.g., minerals), living space and light to survive.
2. Identify that there are many distinct environments that support different kinds of organisms.
3. Explain why organisms can survive only in environments that meet their needs (e.g., organisms that once lived on Earth have disappeared for different reasons such as natural forces or human-caused effects).

Heredity

4. Compare similarities and differences among individuals of the same kind of plants and animals, including people.

Diversity and Interdependence of Life

5. Explain that food is a basic need of plants and animals (e.g., plants need sunlight to make food and to grow, animals eat plants and/or other animals for food, food chain) and is important because it is a source of energy (e.g., energy used to play, ride bicycles, read, etc.).
6. Investigate the different structures of plants and animals that help them live in different environments (e.g., lungs, gills, leaves and roots).

7. Compare the habitats of many different kinds of Ohio plants and animals and some of the ways animals depend on plants and each other.
8. Compare the activities of Ohio's common animals (e.g., squirrels, chipmunks, deer, butterflies, bees, ants, bats and frogs) during the different seasons by describing changes in their behaviors and body covering.
9. Compare Ohio plants during the different seasons by describing changes in their appearance.

Grade Three

Heredity

1. Compare the life cycles of different animals including birth to adulthood, reproduction and death (e.g., egg-tadpole-frog, egg-caterpillar-chrysalis-butterfly).

Diversity and Interdependence of life

2. Relate animal structures to their specific survival functions (e.g., obtaining food, escaping or hiding from enemies).
3. Classify animals according to their characteristics (e.g., body coverings and body structure).
4. Use examples to explain that extinct organisms may resemble organisms that are alive today.
5. Observe and explore how fossils provide evidence about animals that lived long ago and the nature of the environment at that time.
6. Describe how changes in an organism's habitat are sometimes beneficial and sometimes harmful.

Grade Four

Heredity

1. Compare the life cycles of different plants including germination, maturity, reproduction and death.

Diversity and Interdependence of Life

2. Relate plant structures to their specific functions (e.g., growth, survival and reproduction).
3. Classify common plants according to their characteristics (e.g., tree leaves, flowers, seeds, roots, stems).
4. Observe and explore that fossils provide evidence about plants that lived long ago and the nature of the environment at that time.
5. Describe how organisms interact with one another in various ways (e.g., many plants depend on animals for carrying pollen or dispersing seeds).

Grade Five

Diversity and Interdependence of Life

1. Describe the role of producers in the transfer of energy entering ecosystems as sunlight to chemical energy through photosynthesis.
2. Explain how almost all kinds of animals' food can be traced back to plants.
3. Trace the organization of simple food chains and food webs (e.g., producers, herbivores, carnivores, omnivores and decomposers).
4. Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different types of organisms.
5. Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem, including the kinds and numbers of other organisms present, the availability of food and resources, and the changing physical characteristics of the ecosystem.
6. Analyze how all organisms, including humans, cause changes in their ecosystems and how these changes can be beneficial, neutral or detrimental (e.g., beaver ponds, earthworm burrows, grasshoppers eating plants, people planting and cutting trees, and people introducing a new species).

Grade Six

Characteristics and Structure of Life

1. Explain that many of the basic functions of organisms are carried out by or within cells and are similar in all organisms.
2. Explain that multicellular organisms have a variety of specialized cells, tissues, organs and organ systems that perform specialized functions.
3. Identify how plant cells differ from animal cells (e.g., cell wall, chloroplasts).

Heredity

4. Recognize that an individual organism does not live forever; therefore reproduction is necessary for the continuation of every species and traits are passed on to the next generation through reproduction.
5. Describe that in asexual reproduction all the inherited traits come from a single parent.
6. Describe that in sexual reproduction an egg and sperm unite and some traits come from each parent, so the offspring is never identical to either of its parents.
7. Recognize that likenesses between parents and offspring (e.g., eye color, flower color) are inherited. Other likenesses, such as table manners are learned.

Diversity and Interdependence of Life

8. Describe how organisms may interact with one another.

Grade Seven

Characteristics and Structure of Life

1. Investigate the great variety of body plans and internal structures found in multicellular organisms.

Diversity and Interdependence of Life

2. Investigate how organisms or populations may interact with one another through symbiotic relationships and how some species have become so adapted to each other that neither could survive without the other (e.g., predator–prey, parasitism, mutualistism, commensalism).
3. Explain how the number of organisms an ecosystem can support depends on adequate biotic (living) resources (e.g., plants, animals) and abiotic (non-living) resources (e.g., light, water, soil).
4. Investigate how overpopulation impacts an ecosystem.
5. Explain that some environmental changes occur slowly while others occur rapidly (e.g., forest and pond succession, fires and decomposition).
6. Summarize the ways that natural occurrences and human activity affect the transfer of energy in Earth's ecosystems (e.g., fire, hurricanes, roads, oil spills).
7. Explain that photosynthetic cells convert solar energy into chemical energy that is used to carry on life functions or is transferred to consumers and used to carry on their life functions.

Evolutionary Theory

8. Investigate the great diversity among organisms.

Grade Eight

Heredity

1. Describe that asexual reproduction limits the spread of detrimental characteristics through a species and allows for genetic continuity.
2. Recognize that in sexual reproduction new combinations of traits are produced which may increase or decrease an organism's chances for survival.

Evolutionary Theory

3. Explain how variations in structure, behavior or physiology allow some organisms to enhance their reproductive success and survival in a particular environment.
4. Explain that diversity of species is developed through gradual processes over many generations (e.g., fossil record).
5. Investigate how an organism adapted to a particular environment may become extinct if the environment, as shown by the fossil record, changes.

Grade Nine

(No 9th grade Life Science indicators.)

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.

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.

Heredity

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).

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, jumping genes) to explain inheritance.

Diversity and Interdependence of Life

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).
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).
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.
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, sustainable vs. nonsustainable agriculture).

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. Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this indicator does not mandate the teaching or testing of intelligent design.)

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 4 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.

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, 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, discovering germs).

28. Analyze and investigate emerging scientific issues (e.g., genetically modified food, stem cell research, genetic research, cloning).

Grade Eleven

Characteristics and Structure of Life

1. Describe how the maintenance of a relatively stable internal environment is required for the continuation of life, and explain how stability is challenged by changing physical, chemical and environmental conditions as well as the presence of pathogens.

2. Recognize that chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Some of this energy is released as thermal energy.
3. Relate how birth rates, fertility rates and death rates are affected by various environmental factors.
4. Examine the contributing factors of human population growth that impact natural systems such as levels of education, children in the labor force, education and employment of women, infant mortality rates, costs of raising children, birth control methods, and cultural norms.
5. Investigate the impact on the structure and stability of ecosystems due to changes in their biotic and abiotic components as a result of human activity.

Diversity and Interdependence of Life

6. Predict some possible impacts on an ecosystem with the introduction of a non-native species.
7. Show how populations can increase through linear or exponential growth with corresponding effects on resource use and environmental pollution.
8. Recognize that populations can reach or temporarily exceed the carrying capacity of a given environment. Show that the limitation is not just the availability of space but the number of organisms in relation to resources and the capacity of earth systems to support life.
9. Give examples of how human activity can accelerate rates of natural change and can have unforeseen consequences.
10. Explain how environmental factors can influence heredity or development of organisms.
11. Investigate issues of environmental quality at local, regional, national and global levels such as population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economics, politics and different ways humans view Earth.

Evolutionary Theory

12. Recognize that ecosystems change when significant climate changes occur or when one or more new species appear as a result of immigration or speciation.
13. Describe how the process of evolution has changed the physical world over geologic time.
14. Describe how geologic time can be estimated by observing rock sequences and using fossils to correlate the sequences at various locations. Recognize that current methods include using the known decay rates of radioactive isotopes present in rocks to measure the time since the rock was formed.

Grade Twelve

Characteristics and Structure of Life	1. Recognize that information stored in DNA provides the instructions for assembling protein molecules used by the cells that determine the characteristics of the organism.
	2. Explain why specialized cells/structures are useful to plants and animals (e.g., stoma, phloem, xylem, blood, nerve, muscle, egg and sperm).
	3. Explain that the Sun is essentially the primary source of energy for life. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules.
	4. Explain that carbon-containing molecules can be used to assemble larger molecules with biological activity (including proteins, DNA, sugars and fats). In addition, the energy stored in bonds between the atoms (chemical energy) can be used as sources of energy for life processes.
Heredity	5. Examine the inheritance of traits through one or more genes and how a single gene can influence more than one trait.
	6. Explain how developmental differentiation is regulated through the expression of different genes.
Diversity and Interdependence of Life	7. Relate diversity and adaptation to structures and functions of living organisms at various levels of organization.
	8. Based on the structure and stability of ecosystems and their nonliving components, predict the biotic and abiotic changes in such systems when disturbed (e.g. introduction of non-native species, climatic change, etc.).
	9. Explain why and how living systems require a continuous input of energy to maintain their chemical and physical organization. Explain that with death and the cessation of energy input, living systems rapidly disintegrate toward more disorganized states.
Evolutionary Theory	10. Explain additional components of the evolution theory, including genetic drift, immigration, emigration and mutation.
Historical Perspectives and Scientific Revolutions	11. Trace the historical development of a biological theory or idea (e.g., genetics, cytology and germ theory).
	12. Describe advances in life sciences that have important, long-lasting effects on science and society (e.g., biotechnology).

Science

Grade-Level Indicators

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, as well as motion and the forces affecting motion, the nature of waves and interactions of matter and energy. Students also demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Kindergarten

Nature of Matter

1. Demonstrate that objects are made of parts (e.g., toys, chairs).
2. Examine and describe objects according to the materials that make up the object (e.g., wood, metal, plastic, cloth).
3. Describe and sort objects by one or more properties (e.g., size, color, shape).

Forces and Motion

4. Explore that things can be made to move in many different ways such as straight, zigzag, up and down, round and round, back and forth, or fast and slow.
5. Investigate ways to change how something is moving (e.g., push, pull).

Grade One

Nature of Matter

1. Classify objects according to the materials they are made of and their physical properties.
2. Investigate that water can change from liquid to solid or solid to liquid.
3. Explore and observe that things can be done to materials to change their properties (e.g., heating, freezing, mixing, cutting, wetting, dissolving, bending, exposing to light).
4. Explore changes that greatly change the properties of an object (e.g., burning paper) and changes that leave the properties largely unchanged (e.g., tearing paper).

Forces and Motion

5. Explore the effects some objects have on others even when the two objects might not touch (e.g., magnets).
6. Investigate a variety of ways to make things move and what causes them to change speed, direction and/or stop.

Nature of Energy

7. Explore how energy makes things work (e.g., batteries in a toy, electricity turning fan blades).
8. Recognize that the Sun is an energy source that warms the land, air and water.
9. Describe that energy can be obtained from many sources in many ways (e.g., food, gasoline, electricity or batteries).

Grade Two

Forces and Motion

1. Explore how things make sound (e.g., rubber bands, tuning fork, strings).
2. Explore and describe sounds (e.g., high, low, soft, loud) produced by vibrating objects.
3. Explore with flashlights and shadows that light travels in a straight line until it strikes an object.

Grade Three

Forces and Motion

1. Describe an objects position by locating it relative to another object or the background.
2. Describe an objects motion by tracing and measuring its position over time.
3. Identify contact/noncontact forces that affect motion of an object (e.g., gravity, magnetism, collision).
4. Predict the changes when an object experiences a force (e.g., a push or pull, weight, friction).

Grade Four

Nature of Matter

1. Identify characteristics of a simple physical change (e.g., heating or cooling can change water from one state to another and the change is reversible).
2. Identify characteristics of a simple chemical change. When a new material is made by combining two or more materials, it has chemical properties that are different from the original materials (e.g., burning paper, vinegar and baking soda).
3. Describe objects by the properties of the materials from which they are made and that these properties can be used to separate or sort a group of objects (e.g., paper, glass, plastic, metal).
4. Explain that matter has different states (e.g., solid, liquid and gas) and that each state has distinct physical properties.

Nature of Energy

5. Compare ways the temperature of an object can be changed (e.g., rubbing, heating, bending of metal).

Grade Five

Nature of Energy

1. Define temperature as the measure of thermal energy and describe the way it is measured.
2. Trace how thermal energy can transfer from one object to another by conduction.
3. Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces.
4. Trace how electrical current travels by creating a simple electric circuit that will light a bulb.
5. Explore and summarize observations of the transmission, bending (refraction) and reflection of light.
6. Describe and summarize observations of the transmission, reflection, and absorption of sound.
7. Describe that changing the rate of vibration can vary the pitch of a sound.

Grade Six

Nature of Matter

1. Explain that equal volumes of different substances usually have different masses.
2. Describe that in a chemical change new substances are formed with different properties than the original substance (e.g., rusting, burning).
3. Describe that in a physical change (e.g., state, shape, size) the chemical properties of a substance remain unchanged.
4. Describe that chemical and physical changes occur all around us (e.g., in the human body, cooking, industry).

Nature of Energy

5. Explain that the energy found in nonrenewable resources such as fossil fuels (e.g., oil, coal, natural gas) originally came from the Sun and may renew slowly over millions of years.
6. Explain that energy derived from renewable resources such as wind and water is assumed to be available indefinitely.
7. Describe how electric energy can be produced from a variety of sources (e.g., Sun, wind, coal).
8. Describe how renewable and nonrenewable energy resources can be managed (e.g., fossil fuels, trees, water).

Grade Seven

Nature of Matter

1. Investigate how matter can change forms but the total amount of matter remains constant.

Nature of Energy

2. Describe how an object can have potential energy due to its position or chemical composition and can have kinetic energy due to its motion.
3. Identify different forms of energy (e.g., electrical, mechanical, chemical, thermal, nuclear, radiant and acoustic).
4. Explain how energy can change forms but the total amount of energy remains constant.
5. Trace energy transformation in a simple closed system (e.g., a flashlight).

Grade Eight

Forces and Motion

1. Describe how the change in the position (motion) of an object is always judged and described in comparison to a reference point.
2. Explain that motion describes the change in the position of an object (characterized by a speed and direction) as time changes.
3. Explain that an unbalanced force acting on an object changes that object's speed and/or direction.

Nature of Energy

4. Demonstrate that waves transfer energy.
5. Demonstrate that vibrations in materials may produce waves that spread away from the source in all directions (e.g., earthquake waves, sound waves).

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

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, 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.

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.

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.

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 ($PE = mgh$).

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).

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.

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).

Historical Perspectives and Scientific Revolutions

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, 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 and ceramics and communication technology).

Grade Ten

(No 10th Grade Physical Science indicators.)

Grade Eleven

Nature of Matter

1. Explain that elements with the same number of protons may or may not have the same mass and those with different masses (different numbers of neutrons) are called isotopes. Some of these are radioactive.
2. Explain that humans have used unique bonding of carbon atoms to make a variety of molecules (e.g., plastics).

Forces and Motion

3. Describe real world examples showing that all energy transformations tend toward disorganized states (e.g., fossil fuel combustion, food pyramids, electrical use).
4. Explain how electric motors and generators work (e.g., relate that electricity and magnetism are two aspects of a single electromagnetic force). Investigate that electric charges in motion produce magnetic fields and a changing magnetic field creates an electric field.

Grade Twelve

Nature of Matter

1. Explain how atoms join with one another in various combinations in distinct molecules or in repeating crystal patterns.
2. Describe how a physical, chemical or ecological system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. Large disturbances may cause it to escape that equilibrium and eventually settle into some other state of equilibrium.
3. Explain how all matter tends toward more disorganized states and describe real world examples (e.g., erosion of rocks, expansion of the universe).
4. Recognize that at low temperatures some materials become superconducting and offer little or no resistance to the flow of electrons.

Forces & Motion

5. Use and apply the laws of motion to analyze, describe and predict the effects of forces on the motions of objects mathematically.
6. Recognize that the nuclear forces that hold the nucleus of an atom together, at nuclear distances, are stronger than the electric forces that would make it fly apart.
7. Recognize that nuclear forces are much stronger than electromagnetic forces, and electromagnetic forces are vastly stronger than gravitational forces. The strength of the nuclear forces explains why greater amounts of energy are released from nuclear reactions (e.g., from atomic and hydrogen bombs and in the Sun and other stars).
8. Describe how the observed wavelength of a wave depends upon the relative motion of the source and the observer (Doppler effect). If either is moving towards the other, the observed wavelength is shorter; if either is moving away, the observed wavelength is longer (e.g., weather radar, bat echoes, police radar).

9. Describe how gravitational forces act between all masses and always create a force of attraction. Recognize that the strength of the force is proportional to the masses and weakens rapidly with increasing distance between them.

Nature of Energy

10. Explain the characteristics of isotopes. The nucleus of radioactive isotopes is unstable and spontaneously decays emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large group of identical nuclei decay at a predictable rate.
11. Use the predictability of decay rates and the concept of half-life to explain how radioactive substances can be used in estimating the age of materials.
12. Describe how different atomic energy levels are associated with the electron configurations of atoms and electron configurations (and/or conformations) of molecules.
13. Explain how atoms and molecules can gain or lose energy in particular discrete amounts (quanta or packets); therefore they can only absorb or emit light at the wavelengths corresponding to these amounts.

Historical Perspectives and Scientific Revolutions

14. 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., nuclear energy, quantum theory, theory of relativity).
15. Describe concepts/ideas in physical sciences that have important, long-lasting effects on science and society (e.g., quantum theory, theory of relativity, age of the universe).

Science

Grade Level Indicators

Science and Technology

Students should recognize that science and technology are interconnected and that using technology involves assessment of the benefits, risks and costs. Students should build scientific and technological knowledge, as well as the skill required to design and construct devices. In addition, they should develop the processes to solve problems and understand that problems may be solved in several ways.

Kindergarten

Understanding Technology

1. Explore that objects can be sorted as "natural" or "man-made".
2. Explore that some materials can be used over and over again (e.g., plastic or glass containers, cardboard boxes and tubes).

Abilities To Do Technological Design

3. Explore that each kind of tool has an intended use, which can be helpful or harmful (e.g., scissors can be used to cut paper but they can also hurt you).

Grade One

Understanding Technology

1. Explore that some kinds of materials are better suited than others for making something new (e.g., building materials used in the *Three Little Pigs*).
2. Explain that when trying to build something or get something to work better, it helps to follow directions and ask someone who has done it before.
3. Identify some materials that can be saved for community recycling projects (e.g., newspapers, glass and aluminum).
4. Explore ways people use energy to cook their food and warm their homes (e.g., wood, coal, natural gas, electricity).
5. Identify how people can save energy by turning things off when they are not using them (e.g., lights and motors).

Abilities To Do Technological Design

6. Investigate that tools are used to help make things and some things cannot be made without tools.
7. Explore that several steps are usually needed to make things (e.g., building with blocks).
8. Investigate that when parts are put together they can do things that they could not do by themselves (e.g., blocks, gears and wheels).

Grade Two

Understanding Technology

1. Explain that developing and using technology involves benefits and risks.
2. Investigate why people make new products or invent new ways to meet their individual wants and needs.
3. Predict how building or trying something new might affect other people and the environment.

Abilities To Do Technological Design

4. Communicate orally, pictorially, or in written form the design process used to make something.

Grade Three

Understanding Technology

1. Describe how technology can extend human abilities (e.g., to move things, to extend senses).
2. Describe ways that using technology can have helpful and/or harmful results.
3. Investigate ways that the results of technology may affect the individual, family and community.

Abilities To Do Technological Design

4. Use a simple design process to solve a problem (e.g., identify a problem, identify possible solutions, design a solution).
5. Describe possible solutions to a design problem (e.g., how to hold down paper in the wind).

Grade Four

Understanding Technology

1. Explain how technology from different areas (e.g., transportation, communication, nutrition, healthcare, agriculture, entertainment, manufacturing) has improved human lives.
2. Investigate how technology and inventions change to meet peoples' needs and wants.

Abilities To Do Technological Design

3. Describe, illustrate and evaluate the design process used to solve a problem.

Grade Five

Understanding Technology

1. Investigate positive and negative impacts of human activity and technology on the environment.

Abilities To Do Technological Design

2. Revise an existing design used to solve a problem based on peer review.
3. Explain how the solution to one problem may create other problems.

Grade Six

Understanding Technology

1. Explain how technology influences the quality of life.
2. Explain how decisions about the use of products and systems can result in desirable or undesirable consequences (e.g., social and environmental).
3. Describe how automation (e.g., robots) has changed manufacturing including manual labor being replaced by highly-skilled jobs.
4. Explain how the usefulness of manufactured parts of an object depend on how well their properties allow them to fit and interact with other materials.

Abilities To Do Technological Design

5. Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

Grade Seven

Understanding Technology

1. Explain how needs, attitudes and values influence the direction of technological development in various cultures.
2. Describe how decisions to develop and use technologies often put environmental and economic concerns in direct competition with each other.
3. Recognize that science can only answer some questions and technology can only solve some human problems.

Abilities To Do Technological Design

4. Design and build a product or create a solution to a problem given two constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

Grade Eight

Understanding Technology

1. Examine how science and technology have advanced through the contributions of many different people, cultures and times in history.
2. Examine how choices regarding the use of technology are influenced by constraints caused by various unavoidable factors (e.g., geographic location, limited resources, social, political and economic considerations).

Abilities To Do Technological Design

3. Design and build a product or create a solution to a problem given more than two constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
4. Evaluate the overall effectiveness of a product design or solution.

Grade Nine

Understanding Technology

1. Describe means of comparing the benefits with the risks of technology and how science can inform public policy.

Abilities To Do Technological Design

2. Identify a problem or need, propose designs and choose among alternative solutions for the problem.
3. Explain why a design should be continually assessed and the ideas of the design should be tested, adapted and refined.

Grade Ten

Understanding Technology

1. Cite examples of ways that scientific inquiry is driven by the desire to understand the natural world and how technology is driven by the need to meet human needs and solve human problems.
2. Describe examples of scientific advances and emerging technologies and how they may impact society.

Abilities To Do Technological Design

3. Explain that when evaluating a design for a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced and disposed of in addition to who will sell, operate and take care of it. Explain how the costs associated with these considerations may introduce additional constraints on the design.

Grade Eleven

Understanding Technology

1. Identify that science and technology are essential social enterprises but alone they can only indicate what can happen, not what should happen. Realize the latter involves human decisions about the use of knowledge.
2. Predict how decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment and/or humans.
3. Explore and explain any given technology that may have a different value for different groups of people and at different points in time (e.g., new varieties of farm plants and animals have been engineered by manipulating their genetic instructions to reproduce new characteristics).
4. Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.

5. Investigate that all fuels (e.g., fossil, solar, nuclear) have advantages and disadvantages; therefore society must consider the trade-offs among them (e.g., economic costs and environmental impact).

6. Research sources of energy beyond traditional fuels and the advantages, disadvantages and trade-offs society must consider when using alternative sources (e.g., biomass, solar, hybrid engines, wind, fuel cells).

Grade Twelve

Understanding Technology

1. Explain how science often advances with the introduction of new technologies and how solving technological problems often results in new scientific knowledge.

2. Describe how new technologies often extend the current levels of scientific understanding and introduce new areas of research.

3. Research how scientific inquiry is driven by the desire to understand the natural world and how technological design is driven by the need to meet human needs and solve human problems.

4. Explain why basic concepts and principles of science and technology should be a part of active debate about the economics, policies, politics and ethics of various science-related and technology-related challenges.

Science

Grade-Level Indicators

Scientific Inquiry

Students develop scientific habits of mind as they use the processes of scientific inquiry to ask valid questions and to gather and analyze information. They understand how to develop hypotheses and make predictions. They are able to reflect on scientific practices as they develop plans of action to create and evaluate a variety of conclusions. Students are also able to demonstrate the ability to communicate their findings to others.

Kindergarten

Doing Scientific Inquiry

1. Ask "what if" questions.
2. Explore and pursue student-generated "what if" questions.
3. Use appropriate safety procedures when completing scientific investigations.
4. Use the five senses to make observations about the natural world.
5. Draw pictures that correctly portray features of the item being described.
6. Recognize that numbers can be used to count a collection of things.
7. Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers and other appropriate tools).
8. Measure the lengths of objects using non-standard methods of measurement (e.g., teddy bear counters, pennies).
9. Make pictographs and use them to describe observations and draw conclusions.
10. Make new observations when people give different descriptions for the same thing.

Grade One

Doing Scientific Inquiry

1. Ask "what happens when" questions.
2. Explore and pursue student-generated "what happens when" questions.
3. Use appropriate safety procedures when completing scientific investigations.
4. Work in a small group to complete an investigation and then share findings with others.
5. Create individual conclusions about group findings.
6. Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers, timers, simple balances and other appropriate tools).
7. Make estimates to compare familiar lengths, weights and time intervals.
8. Use oral, written and pictorial representation to communicate work.
9. Describe things as accurately as possible and compare with the observations of others.

Grade Two

Doing Scientific Inquiry

1. Ask "how can I/we" questions.
2. Ask "how do you know" questions (not "why" questions) in appropriate situations and attempt to give reasonable answers when others ask questions.
3. Explore and pursue student-generated "how" questions.
4. Use appropriate safety procedures when completing scientific investigations.
5. Use evidence to develop explanations of scientific investigations. (What do you think? How do you know?)
6. Recognize that explanations are generated in response to observations, events and phenomena.
7. Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers, non-breakable thermometers, timers, rulers, balances, calculators and other appropriate tools).
8. Measure properties of objects using tools such as rulers, balances and thermometers.
9. Use whole numbers to order, count, identify, measure and describe things and experiences.
10. Share explanations with others to provide opportunities to ask questions, examine evidence and suggest alternative explanations.

Grade Three

Doing Scientific Inquiry

1. Select the appropriate tools and use relevant safety procedures to measure and record length and weight in metric and English units.
2. Discuss observations and measurements made by other people.
3. Read and interpret simple tables and graphs produced by self/others.
4. Identify and apply science safety procedures.
5. Record and organize observations (e.g., journals, charts, tables).
6. Communicate scientific findings to others through a variety of methods (e.g., pictures, written, oral and recorded observations).

Grade Four

Doing Scientific Inquiry

1. Select the appropriate tools and use relevant safety procedures to measure and record length, weight, volume, temperature and area in metric and English units.
2. Analyze a series of events and/or simple daily or seasonal cycles, describe the patterns and infer the next likely occurrence.
3. Develop, design and conduct safe, simple investigations or experiments to answer questions.
4. Explain the importance of keeping conditions the same in an experiment.
5. Describe how comparisons may not be fair when some conditions are not kept the same between experiments.
6. Formulate instructions and communicate data in a manner that allows others to understand and repeat an investigation or experiment.

Grade Five

Doing Scientific Inquiry

1. Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others(e.g., thermometers, timers, balances, spring scales, magnifiers, microscopes and other appropriate tools).
2. Evaluate observations and measurements made by other people and identify reasons for any discrepancies.
3. Use evidence and observations to explain and communicate the results of investigations.

4. Identify one or two variables in a simple experiment.
5. Identify potential hazards and/or precautions involved in an investigation.
6. Explain why results of an experiment are sometimes different (e.g., because of unexpected differences in what is being investigated, unrealized differences in the methods used or in the circumstances in which the investigation was carried out, and because of errors in observations).

Grade Six

Doing Scientific Inquiry

1. Explain that there are not fixed procedures for guiding scientific investigations; however, the nature of an investigation determines the procedures needed.
2. Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations.
3. Distinguish between observation and inference.
4. Explain that a single example can never prove that something is always correct, but sometimes a single example can disprove something.

Grade Seven

Doing Scientific Inquiry

1. Explain that variables and controls can affect the results of an investigation and that ideally one variable should be tested at a time; however it is not always possible to control all variables.
2. Identify simple independent and dependent variables.
3. Formulate and identify questions to guide scientific investigations that connect to science concepts and can be answered through scientific investigations.
4. Choose the appropriate tools and instruments and use relevant safety procedures to complete scientific investigations.
5. Analyze alternative scientific explanations and predictions and recognize that there may be more than one good way to interpret a given set of data.
6. Identify faulty reasoning and statements that go beyond the evidence or misinterpret the evidence.
7. Use graphs, tables and charts to study physical phenomena and infer mathematical relationships between variables (e.g., speed, density).

Grade Eight

Doing Scientific Inquiry

1. Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations.
2. Describe the concepts of sample size and control and explain how these affect scientific investigations.
3. Read, construct and interpret data in various forms produced by self and others in both written and oral form (e.g., tables, charts, maps, graphs, diagrams, symbols).
4. Apply appropriate math skills to interpret quantitative data (e.g., mean, median, mode).

Grade Nine

Doing Scientific Inquiry

1. Distinguish between observations and inferences given a scientific situation.
2. Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g., OSHA, Material Safety Data Sheets [MSDS], eyewash, goggles, ventilation).
3. Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.
4. Decide what degree of precision based on the data is adequate and round off the results of calculator operations to the proper number of significant figures to reasonably reflect those of the inputs.
5. Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.
6. Draw logical conclusions based on scientific knowledge and evidence from investigations.

Grade Ten

Doing Scientific Inquiry

1. Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g. OSHA, MSDS, eyewash, goggles, ventilation).
2. Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.
3. Use mathematical models to predict and analyze natural phenomena.

4. Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.
5. Explain how new scientific data can cause any existing scientific explanation to be supported, revised or rejected.

Grade Eleven

Doing Scientific Inquiry

1. Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
2. Evaluate assumptions that have been used in reaching scientific conclusions.
3. Design and carry out scientific inquiry (investigation), communicate and critique results through peer review.
4. Explain why the methods of an investigation are based on the questions being asked.
5. Summarize data and construct a reasonable argument based on those data and other known information.

Grade Twelve

Doing Scientific Inquiry

1. Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
2. Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).
3. Research and apply appropriate safety precautions when designing and/or conducting scientific investigations (e.g., OSHA, MSDS, eyewash, goggles, ventilation).
4. Create and clarify the method, procedures, controls and variables in complex scientific investigations.
5. Use appropriate summary statistics to analyze and describe data.

Science

Grade-Level Indicators

Scientific Ways of Knowing

Students realize that the current body of scientific knowledge must be based on evidence, be predictive, logical, subject to modification, and limited to the natural world. This includes demonstrating an understanding that scientific knowledge grows and advances as new evidence is discovered to support or modify existing theories, as well as to encourage the development of new theories. Students are able to reflect on ethical scientific practices and demonstrate an understanding of how the current body of scientific knowledge reflects the historical and cultural contributions of women and men who provide us with a more reliable and comprehensive understanding of the natural world.

Kindergarten

Nature of Science	1. Recognize that scientific investigations involve asking open-ended questions. (How? What if?)
	2. Recognize that people are more likely to accept your ideas if you can give good reasons for them.
Ethical Practices	3. Interact with living things and the environment in ways that promote respect.
Science and Society	4. Demonstrate ways science is practiced by people everyday (children and adults).

Grade One

Nature of Science	1. Discover that when a science investigation is done the same way multiple times, one can expect to get very similar results each time it is performed.
	2. Demonstrate good explanations based on evidence from investigations and observations.
Science and Society	3. Explain that everybody can do science, invent things and have scientific ideas no matter where they live.

Grade Two

Nature of Science

1. Describe that scientific investigations generally work the same way under the same conditions.
2. Explain why scientists review and ask questions about the results of other scientists' work.

Ethical Practices

3. Describe ways in which using the solution to a problem might affect other people and the environment.

Science and Society

4. Demonstrate that in science it is helpful to work with a team and share findings with others.

Grade Three

Nature of Science

1. Describe different kinds of investigations that scientists use depending on the questions they are trying to answer.

Ethical Practices

2. Keep records of investigations and observations and do not change the records that are different from someone else's work.

Science and Society

3. Explore through stories how men and women have contributed to the development of science.
4. Identify various careers in science.
5. Discuss how both men and women find science rewarding as a career and in their everyday lives.

Grade Four

Nature of Science

1. Differentiate fact from opinion and explain that scientists do not rely on claims or conclusions unless they are backed by observations that can be confirmed.
2. Record the results and data from an investigation and make a reasonable explanation.
3. Explain discrepancies in an investigation using evidence to support findings.

Ethical Practices

4. Explain why keeping records of observations and investigations is important.

Grade Five

Nature of Science

1. Summarize how conclusions and ideas change as new knowledge is gained.
2. Develop descriptions, explanations and models using evidence to defend/support findings.
3. Explain why an experiment must be repeated by different people or at different times or places and yield consistent results before the results are accepted.
4. Identify how scientists use different kinds of ongoing investigations depending on the questions they are trying to answer (e.g., observations of things or events in nature, data collection, controlled experiments).

Ethical Practices

5. Keep records of investigations and observations that are understandable weeks or months later.

Science and Society

6. Identify a variety of scientific and technological work that people of all ages, backgrounds and groups perform.

Grade Six

Nature of Science

1. Identify that hypotheses are valuable even when they are not supported.

Ethical Practices

2. Describe why it is important to keep clear, thorough and accurate records.

Science and Society

3. Identify ways scientific thinking is helpful in a variety of everyday settings.
4. Describe how the pursuit of scientific knowledge is beneficial for any career and for daily life.
5. Research how men and women of all countries and cultures have contributed to the development of science.

Grade Seven

Ethical Practices

1. Show that the reproducibility of results is essential to reduce bias in scientific investigations.
2. Describe how repetition of an experiment may reduce bias.

Science and Society

3. Describe how the work of science requires a variety of human abilities and qualities that are helpful in daily life (e.g., reasoning, creativity, skepticism, openness).

Grade Eight

Nature of Science

1. Identify the difference between description (e.g., observation and summary) and explanation (e.g., inference, prediction, significance, importance).

Ethical Practices

2. Explain why it is important to examine data objectively and not let bias affect observations.

Grade Nine

Nature of Science

1. Comprehend that many scientific investigations require the contributions of women and men from different disciplines in and out of science. These people study different topics, use different techniques and have different standards of evidence but share a common purpose - to better understand a portion of our universe.
2. Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.
3. Demonstrate that reliable scientific evidence improves the ability of scientists to offer accurate predictions.

Ethical Practices

4. Explain how support of ethical practices in science (e.g., individual observations and confirmations, accurate reporting, peer review and publication) are required to reduce bias.

Scientific Theories

5. Justify that scientific theories are explanations of large bodies of information and/or observations that withstand repeated testing.
6. Explain that inquiry fuels observation and experimentation that produce data that are the foundation of scientific disciplines. Theories are explanations of these data.
7. Recognize that scientific knowledge and explanations have changed over time, almost always building on earlier knowledge.

Science and Society

8. Illustrate that much can be learned about the internal workings of science and the nature of science from the study of scientists, their daily work and their efforts to advance scientific knowledge in their area of study.
9. Investigate how the knowledge, skills and interests learned in science classes apply to the careers students plan to pursue.

Grade Ten

Nature of Science

1. Discuss science as a dynamic body of knowledge that can lead to the development of entirely new disciplines.
2. Describe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning, response to criticism and open communication are integral to the process of science.
3. Recognize that science is a systematic method of continuing investigation, based on observation, hypothesis testing, measurement, experimentation, and theory building, which leads to more adequate explanations of natural phenomena.

Ethical Practices

4. Recognize that ethical considerations limit what scientists can do.
5. Recognize that research involving voluntary human subjects should be conducted only with the informed consent of the subjects and follow rigid guidelines and/or laws.
6. Recognize that animal-based research must be conducted according to currently accepted professional standards and laws.

Science and Society

7. Investigate how the knowledge, skills and interests learned in science classes apply to the careers students plan to pursue.

Grade Eleven

Nature of Science

1. Analyze a set of data to derive a hypothesis and apply that hypothesis to a similar phenomenon (e.g., biome data).
2. Apply scientific inquiry to evaluate results of scientific investigations, observations, theoretical models and the explanations proposed by other scientists.
3. Demonstrate that scientific explanations adhere to established criteria, for example a proposed explanation must be logically consistent, it must abide by the rules of evidence and it must be open to questions and modifications.
4. Explain why scientists can assume that the universe is a vast single system in which the basic rules are the same everywhere.

Ethical Practices

5. Recognize that bias affects outcomes. People tend to ignore evidence that challenges their beliefs but accept evidence that supports their beliefs. Scientist attempt to avoid bias in their work.
6. Describe the strongly held traditions of science that serve to keep scientists within the bounds of ethical professional behavior.

Scientific Theories

7. Explain how theories are judged by how well they fit with other theories, the range of included observations, how well they explain observations and how effective they are in predicting new findings.

Science and Society

8. Explain that the decision to develop a new technology is influenced by societal opinions and demands and by cost benefit considerations.

9. Explain how natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.

10. Describe costs and trade-offs of various hazards - ranging from those with minor risk to a few people, to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

11. Research the role of science and technology in careers that students plan to pursue.

Grade Twelve

Nature of Science

1. Give examples that show how science is a social endeavor in which scientists share their knowledge with the expectation that it will be challenged continuously by the scientific community and others.

2. Evaluate scientific investigations by reviewing current scientific knowledge and the experimental procedures used, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence and suggesting alternative explanations for the same observations.

3. Select a scientific model, concept or theory and explain how it has been revised over time based on new knowledge, perceptions or technology.

4. Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator-prey relationships, properties of semiconductors).

5. Describe how individuals and teams contribute to science and engineering at different levels of complexity (e.g., an individual may conduct basic field studies, hundreds of people may work together on major scientific questions or technical problem).

Ethical Practices

6. Explain that scientists may develop and apply ethical tests to evaluate the consequences of their research when appropriate.

Science and Society

7. Describe the current and historical contributions of diverse peoples and cultures to science and technology and the scarcity and inaccessibility of information on some of these contributions.

8. Recognize that individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them.

9. Recognize the appropriateness and value of basic questions "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?"

10. Recognize that social issues and challenges can affect progress in science and technology. (e.g., Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.)

11. Research how advances in scientific knowledge have impacted society on a local, national or global level.

K-12 Science

Benchmarks by Standard

Benchmarks

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 the 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 the Earth and space sciences.

Notes	By the end of the K-2 program:	By the end of the 3-5 program:
	A. Observe constant and changing patterns of objects in the day and night sky. B. Explain that living things cause changes on Earth. C. Observe, describe and measure changes in the weather, both long term and short term. D. Describe what resources are and recognize some are limited but can be extended through recycling or decreased use.	A. Explain the characteristics, cycles and patterns involving Earth and its place in the Solar System. B. Summarize the processes that shape Earth's surface and describe evidence of those processes. C. Describe Earth's resources including rocks, soil, water, air, animals and plants and the ways in which they can be conserved. D. Analyze weather and changes that occur over a period of time.

By the end of the 6-8 program:	By the end of the 9-10 program:	By the end of the 11-12 program:
A. Describe how the positions and motions of the objects in the universe cause predictable and cyclic events.	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.	A. Explain how technology can be used to gather evidence and increase our understanding of the universe.
B. Explain that the universe is composed of vast amounts of matter, most of which is at incomprehensible distances and held together by gravitational force. Describe how the universe is studied by the use of equipment such as telescopes, probes, satellites and spacecraft.	B. Explain that many processes occur in patterns within the Earth's systems.	B. Describe how Earth is made up of a series of interconnected systems and how a change in one system affects other systems.
C. Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution).	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.	C. Explain that humans are an integral part of the Earth's system and the choices humans make today impact natural systems in the future**.**
D. Identify that the lithosphere contains rocks and minerals and that minerals make up rocks. Describe how rocks and minerals are formed and/or classified.	D. Describe the finite nature of Earth's resources and those human activities that can conserve or deplete Earth's resources.	D. Summarize the historical development of scientific theories and, ideas, and describe emerging issues in the study of Earth and space sciences.
E. Describe the processes that contribute to the continuous changing of Earth's surface (e.g., earthquakes, volcanic eruptions, erosion, mountain building and lithospheric plate movements).	E. Explain the processes that move and shape Earth's surface.	
	F. Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of Earth and space sciences.	

Benchmarks

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, of organisms and of living systems are developed as well as a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students also demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Notes	By the end of the K-2 program:	By the end of the 3-5 program:
	A. Discover that there are living things, non-living things and pretend things, and describe the basic needs of living things (organisms). B. Explain how organisms function and interact with their physical environment. C. Describe similarities and differences that exist among individuals of the same kind of plants and animals.	A. Differentiate between the life cycles of different plants and animals. B. Analyze plant and animal structures and functions needed for survival and describe the flow of energy through a system that all organisms use to survive. C. Compare changes in an organism's ecosystem/habitat that affect its survival.

By the end of the 6-8 program:	By the end of the 9-10 program:	By the end of the 11-12 program:
A. Explain that the basic functions of organisms are carried out in cells and groups of specialized cells form tissues and organs; the combination of these cells make up multicellular organisms that have a variety of body plans and internal structures.	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.	A. Explain how processes at the cellular level affect the functions and characteristics of an organism.
B. Describe the characteristics of an organism in terms of a combination of inherited traits and recognize reproduction as a characteristic of living organisms essential to the continuation of the species.	B. Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development.	B. Explain how humans are connected to and impact natural systems.
C. Explain how energy entering the ecosystems as sunlight supports the life of organisms through photosynthesis and the transfer of energy through the interactions of organisms and the environment.	C. Explain the genetic mechanisms and molecular basis of inheritance.	C. Explain how the molecular basis of life and the principles of genetics determine inheritance.
D. Explain how extinction of a species occurs when the environment changes and its adaptive characteristics are insufficient to allow survival (as seen in evidence of the fossil record).	D. Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological).	D. Relate how biotic and abiotic global changes have occurred in the past and will continue to do so in the future.
	E. Explain how evolutionary relationships contribute to an understanding of the unity and diversity of life.	E. Explain the interconnectedness of the components of a natural system.
	F. Explain the structure and function of ecosystems and relate how ecosystems change over time.	F. Explain how human choices today will affect the quality and quantity of life on earth.
	G. Describe how human activities can impact the status of natural systems.	G. Summarize the historical development of scientific theories and ideas within the study of life sciences.

	By the end of the 9-10 program 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. Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this benchmark does not mandate the teaching or testing of intelligent design.) I. Explain how natural selection and other evolutionary mechanisms account for the unity and diversity of past and present life forms. J. Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of life sciences.	

Benchmarks

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, as well as motion and the forces affecting motion, the nature of waves and interactions of matter and energy. Students also demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Notes	By the end of the K-2 program	By the end of the 3-5 program:
	A. Discover that many objects are made of parts that have different characteristics. Describe these characteristics and recognize ways an object may change. B. Recognize that light, sound and objects move in different ways. C. Recognize sources of energy and their uses.	A. Compare the characteristics of simple physical and chemical changes. B. Identify and describe the physical properties of matter in its various states. C. Describe the forces that directly affect objects and their motion. D. Summarize the way changes in temperature can be produced and thermal energy transferred. E. Trace how electrical energy flows through a simple electrical circuit and describe how the electrical energy can produce thermal energy, light, sound and magnetic forces. F. Describe the properties of light and sound energy.

By the end of the 6-8 program:	By the end of the 9-10 program:	By the end of the 11-12 program:
A. Relate uses, properties and chemical processes to the behavior and/or arrangement of the small particles that compose matter.	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.	A. Explain how variations in the arrangement and motion of atoms and molecules form the basis of a variety of biological, chemical and physical phenomena.
B. In simple cases, describe the motion of objects and conceptually describe the effects of forces on an object.	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.	B. Recognize that some atomic nuclei are unstable and will spontaneously break down.
C. Describe renewable and nonrenewable sources of energy (e.g., solar, wind, fossil fuels, biomass, hydroelectricity, geothermal and nuclear energy) and the management of these sources.	C. Describe the identifiable physical properties of substances (e.g., color, hardness, conductivity, density, concentration, ductility). Explain how changes in these properties can occur without changing the chemical nature of the substance.	C. Describe how atoms and molecules can gain or lose energy only in discrete amounts.
D. Describe that energy takes many forms, some forms represent kinetic energy and some forms represent potential energy; and during energy transformations the total amount of energy remains constant.	D. Explain the movement of objects by applying Newton's three laws of motion.	D. Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.
	E. Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored).	E. Summarize the historical development of scientific theories and ideas within the study of physical sciences.

	By the end of the 9-10 program: F. Explain how energy may change form or be redistributed but the total quantity of energy is conserved. G. Demonstrate that waves (e.g., sound, seismic, water, light) have energy and waves can transfer energy when they interact with matter. H. Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of physical sciences.	

Benchmarks

Science and Technology

Students should recognize that science and technology are interconnected and that using technology involves assessment of the benefits, risks and costs. Students should build scientific and technological knowledge as well as the skills required to design and construct devices. In addition, they should develop the processes to solve problems and understand that problems may be solved in several ways.

Notes	By the end of the K-2 program:	By the end of the 3-5 program:
	A. Explain why people, when building or making something, need to determine what it will be made of and how it will affect other people and the environment. B. Explain that to construct something requires planning, communication, problem solving and tools.	A. Describe how technology affects human life. B. Describe and illustrate the design process.

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By the end of the 6-8 program:	By the end of the 9-10 program:	By the end of the 11-12 program:
A. Give examples of how technological advances, influenced by scientific knowledge, affect the quality of life. B. Design a solution or product taking into account needs and constraints (e.g., cost, time, trade-offs, properties of materials, safety, aesthetics).	A. Explain the ways in which the processes of technological design respond to the needs of society. B. Explain that science and technology are interdependent; each drives the other.	A. Predict how human choices today will determine the quality and quantity of life on Earth.

Benchmarks

Scientific Inquiry

Students develop scientific habits of mind as they use the processes of scientific inquiry to ask valid questions and to gather and analyze information. They will understand how to develop hypotheses and make predictions. They are able to reflect on scientific practices as they develop plans of action to create and evaluate a variety of conclusions. Students are also able to demonstrate the ability to communicate their findings to others.

Notes	By the end of the K-2 program:	By the end of the 3-5 program:
	A. Ask a testable question. B. Design and conduct a simple investigation to explore a question. C. Gather and communicate information from careful observations and simple investigation through a variety of methods.	A. Use appropriate instruments safely to observe, measure and collect data when conducting a scientific investigation. B. Organize and evaluate observations, measurements and other data to formulate inferences and conclusions. C. Develop, design and safely conduct scientific investigations and communicate the results.

By the end of the 6-8 program:	By the end of the 9-10 program:	By the end of the 11-12program:
A. Explain that there are differing sets of procedures for guiding scientific investigations and procedures are determined by the nature of the investigation, safety considerations and appropriate tools. B. Analyze and interpret data from scientific investigations using appropriate mathematical skills in order to draw valid conclusions.	A. Participate in and apply the processes of scientific investigation to create models and to design, conduct, evaluate and communicate the results of these investigations.	A. Make appropriate choices when designing and participating in scientific investigations by using cognitive and manipulative skills when collecting data and formulating conclusions from the data.

Benchmarks

Scientific Ways of Knowing

Students realize that the current body of scientific knowledge must be based on evidence, be predictive, logical, subject to modification, and limited to the natural world. This includes demonstrating an understanding that scientific knowledge grows and advances as new evidence is discovered to support or modify existing theories, as well as to encourage the development of new theories. Students are able to reflect on ethical scientific practices and demonstrate an understanding of how the current body of scientific knowledge reflects the historical and cultural contributions of women and men who provide us with a more reliable and comprehensive understanding of the natural world.

Notes	By the end of the K-2 program:	By the end of the 3-5 program:
	A. Recognize that there are different ways to carry out scientific investigations. Realize that investigations can be repeated under the same conditions with similar results and may have different explanations. B. Recognize the importance of respect for all living things. C. Recognize that diverse groups of people contribute to our understanding of the natural world.	A. Distinguish between fact and opinion and explain how ideas and conclusions change as new knowledge is gained. B. Describe different types of investigations and use results and data from investigations to provide the evidence to support explanations and conclusions. C. Explain the importance of keeping records of observations and investigations that are accurate and understandable. D. Explain that men and women of diverse countries and cultures participate in careers in all fields of science.

By the end of the 6-8 program:	By the end of the 9-10 program:	By the end of the 11-12 program:
A. Use skills of scientific inquiry processes (e.g., hypothesis, record keeping, description, explanation).	A. Explain that scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world.	A. Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories.
B. Explain the importance of reproducibility and reduction of bias in scientific methods.	B. Explain how scientific inquiry is guided by knowledge, observations, ideas and questions.	B. Explain how ethical considerations shape scientific endeavors.
C. Give examples of how thinking scientifically is helpful in daily life.	C. Describe the ethical practices and guidelines in which science operates.	C. Explain how societal issues and considerations affect the progress of science and technology.
	D. Recognize that scientific literacy is part of being a knowledgable citizen.	