K-12 Science

Foreword

We are excited to announce that the State Board of Education took another key step in reforming Ohio's education system December 10, 2002, when it unanimously adopted academic content standards in science and social studies. Clear standards delineate what students should know and be able to do in science and social studies. These standards will be an integral component of an aligned system that will ensure no child is left behind.

This enormous undertaking could not have occurred without the hard work and dedication of Ohio's educators and community members. The work on the science and social studies standards began with the seating of advisory committees, which made preliminary decisions that guided the work of the writing teams. Classroom teachers, parents, higher education faculty and business community leaders from across the state worked for several years as writing teams to develop the academic content standards. Seventy percent of the science writing team and 55 percent of the social studies writing team were kindergarten through 12^{th} grade educators. We especially want to extend our gratitude to all the men and women on the standards development teams who gave their time, energy and expertise to create these standards.

The people of Ohio played a key role in the development of the academic content standards. The Office of Curriculum and Instruction at the Ohio Department of Education facilitated the standards writing process and aggressively engaged the public in reviewing drafts of the standards throughout the development process. Thousands of Ohioans gave suggestions that were evaluated and incorporated, as appropriate, by the writing teams into the final adopted standards. We want to thank all of the people who took the time to comment on the standards and participate in the development process.

Ohio's standards in science and social studies were reviewed by national experts who examined the content, developmental appropriateness and curricular considerations of the standards. Overall, the reviewers found Ohio's standards to be clear and comprehensive, setting high expectations for student learning.

The standards adoption fulfills one of the requirements of Amended Substitute Senate Bill 1, which calls for the State Board of Education to develop and adopt clear academic content standards in the areas of science and social studies by the end of 2002. The State Board of Education will use these standards as the basis for the development of achievement and/or diagnostic assessments for grades three through 10. The bill also provides the Department of Education 18 months from the standards adoption to design and produce model curricula aligned to the standards for kindergarten through 12th grade. The curriculum models will be resources that provide specific tools which teachers may use in their classroom planning and instruction as they implement a standards-based education.

The aligned system of standards, curricula and assessments will form the foundation for an accountability system that assists schools, school districts and the state in focusing resources on improving student achievement.

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Jennifer L. Sheets
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Susan Tave Zelman
Susan Tave Zelman
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Overview

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The Ohio science academic content standards provide all students in the kindergarten through 12th grade 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 understandings to make informed personal decisions, to accurately communicate with a variety of audiences, to become lifelong learners, and to make successful transitions to postsecondary 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:
- Earth and Space Sciences
- Life Sciences
- Physical Sciences
- Science and Technology
- Scientific Inquiry
- Scientific Ways of Knowing

The Ohio science standards identify essential expectations for students: concepts, principles, theories and processes of science. 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 lifelong learning.

The Ohio science academic content standards provide teaching and learning opportunities that include accurate and technically-precise scientific 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' with relevant, real-world activities that develop students' knowledge, communication skills and scientific process skills.

ACADEMIC CONTENT STANDARDS

The science standards enhance development of students' understanding of science concepts by combining scientific 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 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 broad terms, what students should know and be able to do as a result of the kindergarten through 12th grade 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.

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-kindergarten 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 12 regions served by the Ohio Department of Education's Regional Professional Development Centers and included educators from each grade level, kindergarten through 12, as well as career-technical educators and educators of exceptional children. Ohio's diverse ethnicity, geography, types of school districts, and colleges and universities were represented on the writing teams. The writing teams also included parent and business/community representatives. 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 in response to the issues raised through 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 (kindergarten through 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 (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					State Board adoption of these content areas will follow the adoption of English Language Arts, Mathematics, Science and Social Studies
Implementation	(8) Adoption of Academic Content Standards by the State Board of Education	December 2001	December 2001	December 2002	December 2002	
	(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	

Science Writing Teams

The Ohio Department of Education wishes to express appreciation and gratitude to the writing teams who contributed expertise and time to the development of Ohio's science academic content standards. Many hours were devoted to research and thoughtful consideration of issues to ensure the standards reflect wise and responsible thinking regarding science teaching and learning. The writing team members represent the many caring and concerned individuals across the state dedicated to their profession and to high quality science education for all Ohio students.

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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. To complete this year, students show knowledge of scientific concepts through demonstration of verbal and non-verbal skills and activities.

Grade One

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 to conclude year one.

Grade Two

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, which will build skills for grade two.

Grade Three

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 Four

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 Five

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 their 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 Six

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 process, 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 and formation and characteristic properties of the minerals that form them. They learn to recognize that a cell continually divides to create new cells, reproduction of cells occur, similar cells have special functions, and 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 as part of the grade six indicators.

Grade Seven

Students learn to describe interactions of matter and energy throughout the lithosphere, hydrosphere and 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. Students access knowledge to explain how energy entering the ecosystems, such as sunlight, supports the life of organisms through photosynthesis and the transfer of energy through the interactions of organisms and the environment.

Grade Eight

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 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 in this grade level.

Grade Nine

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 Earth, Earth's interaction with the solar system, and gravitational forces and 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 10^{th} 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, identifying the Earth's resources, and exploring processes that shape the Earth. The flow of energy and the cycling of matter through biological and ecological systems are addressed in the 10^{th} 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 to become scientifically literate citizens.

Grade 11

In grade 11 students draw on their previous experience and connect Earth, space, life and physical sciences into a coherent study of the environment. Emphasis is placed on the interactions between humans and 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, current situations, and to develop and revise scientific predictions, ideas or theories.

Grade 12

Grade 12 focuses on advanced topics in biological and physical sciences. Biological topic clusters include cell specialization, biotechnology, DNA and evolutionary theory. 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.

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

Physical Sciences

Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Science and Technology

Students 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.

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.

Looking at Ohio's Science Standards and National Standards

The Science Advisory Committee and the Science Writing Team began work on the Ohio science academic standards by examining standards from other states. It became apparent that most states relied heavily on *Benchmarks for Science Literacy* and/or the *National Science Education Standards*. The Ohio's science standards drew from both national documents, state documents, the experience of Ohio teachers and other education professionals.

"America's future, meaning its ability to create a truly just society, to sustain its economic vitality, and to remain secure in a world torn by hostilities, depends more than ever on the character and quality of the education that the nation provides for all of its children." (American Association for the Advancement of Science, p. xiii) Thus begins *Science for All Americans* published in 1990 by the American Association for the Advancement of Science. This book, a report by the National Council on Science and Technology Education, was one of the documents which initiated the work on Science Standards in the United States. In 1993 AAAS published *Benchmarks for Science Literacy*. *Science for All Americans* presented "achievable learning goals" whereas *Benchmarks for Science Literacy* "charted the territory that will have to be traveled to reach those goals" or more specifically "what students should know and be able to do in science, mathematics, and technology at various grade levels." (American Association for the Advancement of Science, p. x)

In a society that has come to depend on and enjoy the fruits of scientific inquiry, scientific literacy has become a necessity not just for a select few but for all. Everyone needs to use scientific information to make choices that arise everyday. Society needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology. Scientific literacy is also of increasing importance in the workplace. More and more jobs demand advanced skills, requiring that people be able to learn, reason, think creatively, make decisions and solve problems. (National Research Council, p.1)

"The *National Science Education Standards* present a vision of a scientifically literate populace. They outline what students need to know, understand and be able to do to be scientifically literate at different grade levels." (National Research Council, p.2) The *National Science Education Standards* was the result of a project approved by the National Research Council. The following pages show in broad strokes the correlation of Ohio standards with the 'benchmarks' in *Benchmarks for Science Literacy* and the 'standards' from *National Science Education Standards*.

American Association for the Advancement of Science. *Science for All Americans*: New York, New York: Oxford University Press, 1990.

National Research Council. *National Science Education Standards*. Washington, D.C.: National Academy Press, 1996.

Ohio's Standards and National Science Education Standards

Ohio Science Academic Content Standards	National Science Education 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.	**Earth and Space Science** • Properties of Earth materials • Objects in the sky • Changes in Earth and sky • Structure of the Earth system • Earth's history • Earth in the solar system • Energy in the Earth system • Geochemical evolution • Origin and evolution of the Earth system • Origin and evolution of the universe
Life Sciences Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.	**Life Science** • Characteristics of organisms • Life cycles of organisms • Organisms and environments • Structure and function in living systems • Reproduction and heredity • Regulation and behavior • Populations and ecosystems • Diversity and adaptations of organisms • The cell • Molecular basis of heredity • Biological evolution • Interdependence of organisms • Matter, energy and organization in living systems **Science in Personal and Social Perspectives** • Characteristics and changes in populations • Changes in environments • Natural hazards • Environmental quality • Natural and human-induced hazards

Ohio Science Academic Content Standards	National Science Education Standards
Physical Sciences Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.	**Physical Science** • Properties of objects and materials • Position and motion of objects • Light, heat, electricity and magnetism • Properties and changes of properties of matter • Motions and forces • Transfer of energy • Structure and properties of matter • Chemical reactions • Conservation of energy and increase in disorder • Interactions of energy and matter
Science and Technology Students 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.	**Science and Technology** • Abilities of technological design • Understanding about science and technology • Abilities to distinguish between natural objects and objects made by humans **Science in Personal and Social Perspectives** • Types of resources • Risks and benefits • Science and technology in society • Science and technology in local, national and global challenges

Ohio Science Academic Content Standards	National Science Education Standards
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.	**Science as Inquiry** • Abilities necessary to do scientific inquiry • Identify questions and concepts that guide scientific investigations • Design and conduct scientific investigations • Use technology and mathematics to improve investigations and communications • Formulate and revise scientific explanations and models using logic and evidence • Recognize and analyze alternative explanations and models • Communicate and defend a scientific argument • Understanding about scientific inquiry
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.	**History and Nature of Science** • Science as a human endeavor • Nature of science • History of science **Science as Inquiry** • Abilities necessary to do scientific inquiry • Identify questions and concepts that guide scientific investigations • Design and conduct scientific investigations • Use technology and mathematics to improve investigations and communications • Formulate and revise scientific explanations and models using logic and evidence • Recognize and analyze alternative explanations and models • Communicate and defend a scientific argument

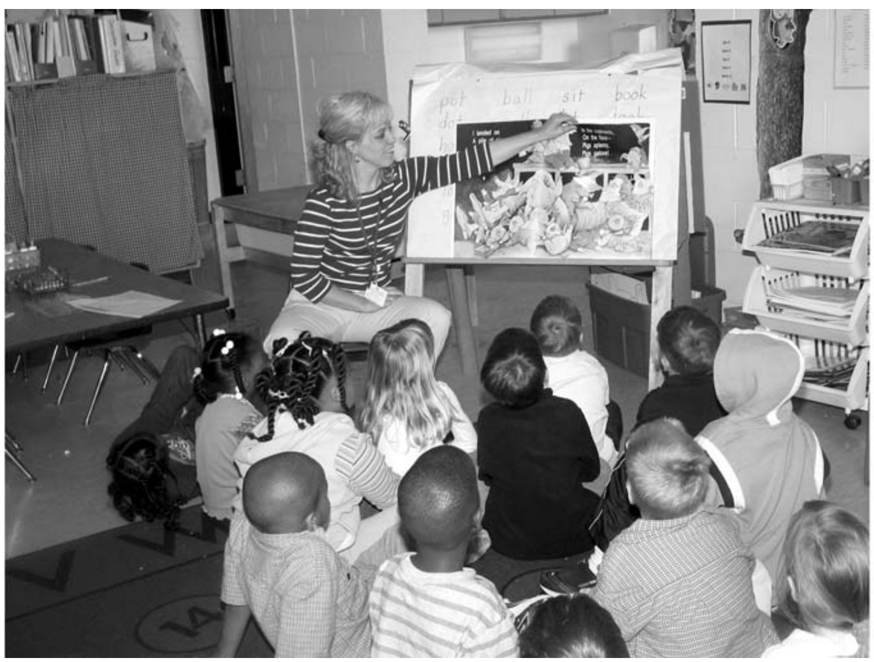
Ohio's Standards and Benchmarks for Science Literacy

Ohio Science Academic Content Standards	Benchmarks for Science Literacy
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.	**The Nature of Science** • Scientific inquiry • The scientific world view **The Physical Setting** • The universe • The Earth • Processes that shape Earth **Historical Perspectives** • Moving the continents
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 will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.	**The Nature of Science** • Scientific inquiry • The scientific world view **The Living Environment** • Diversity of life • Heredity • Cells • Interdependence of life • Flow of matter and energy • Evolution of life

Ohio Science Academic Content Standards	Benchmarks for Science Literacy
Physical Sciences Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.	**The Nature of Science** • Scientific inquiry • The scientific world view **The Nature of Mathematics** • Patterns and relationships **The Physical Setting** • Structure of matter • Energy transformations • Motion • Forces of nature
Science and Technology Students 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.	**The Nature of Science** • Scientific inquiry **The Nature of Technology** • Technology and science • Design and systems • Issues in technology **The Living Environment** • Flow of matter and energy **The Design World** • Agriculture • Materials and manufacturing • Energy sources and use **Common Themes** • Systems

Ohio Science Academic Content Standards	Benchmarks for Science Literacy
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.	**The Nature of Science** • Scientific inquiry • The scientific enterprise **The Nature of Mathematics** • Patterns and relationships **The Designed World** • Communication **The Mathematical World** • Numbers **Common Themes** • Systems
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.	**The Nature of Science** • The scientific world view • The scientific enterprise **The Nature of Mathematics** • Mathematical inquiry **The Mathematical World** • Reasoning

Structure and Format



Academic Content Standards Framework
Science K-12

Standards are made up of several component parts. Those parts are outlined below:

Academic Content Standards

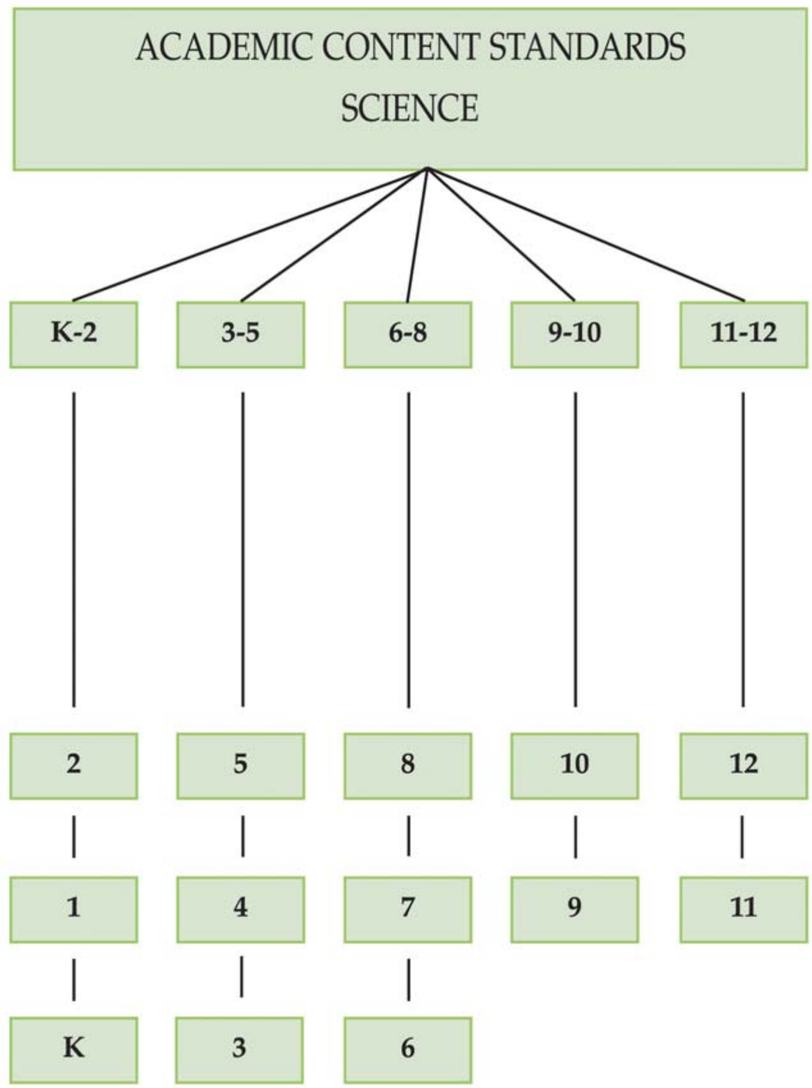
- What all students should know and be able to do
- The overarching goals and themes

Benchmarks

- Key checkpoints that monitor progress toward academic content standards
- Identified by grade-level clusters/bands (K-2, 3-5, 6-8, 9-10, 11-12)
- Grade-level bands will vary across content areas and align with achievement tests where applicable

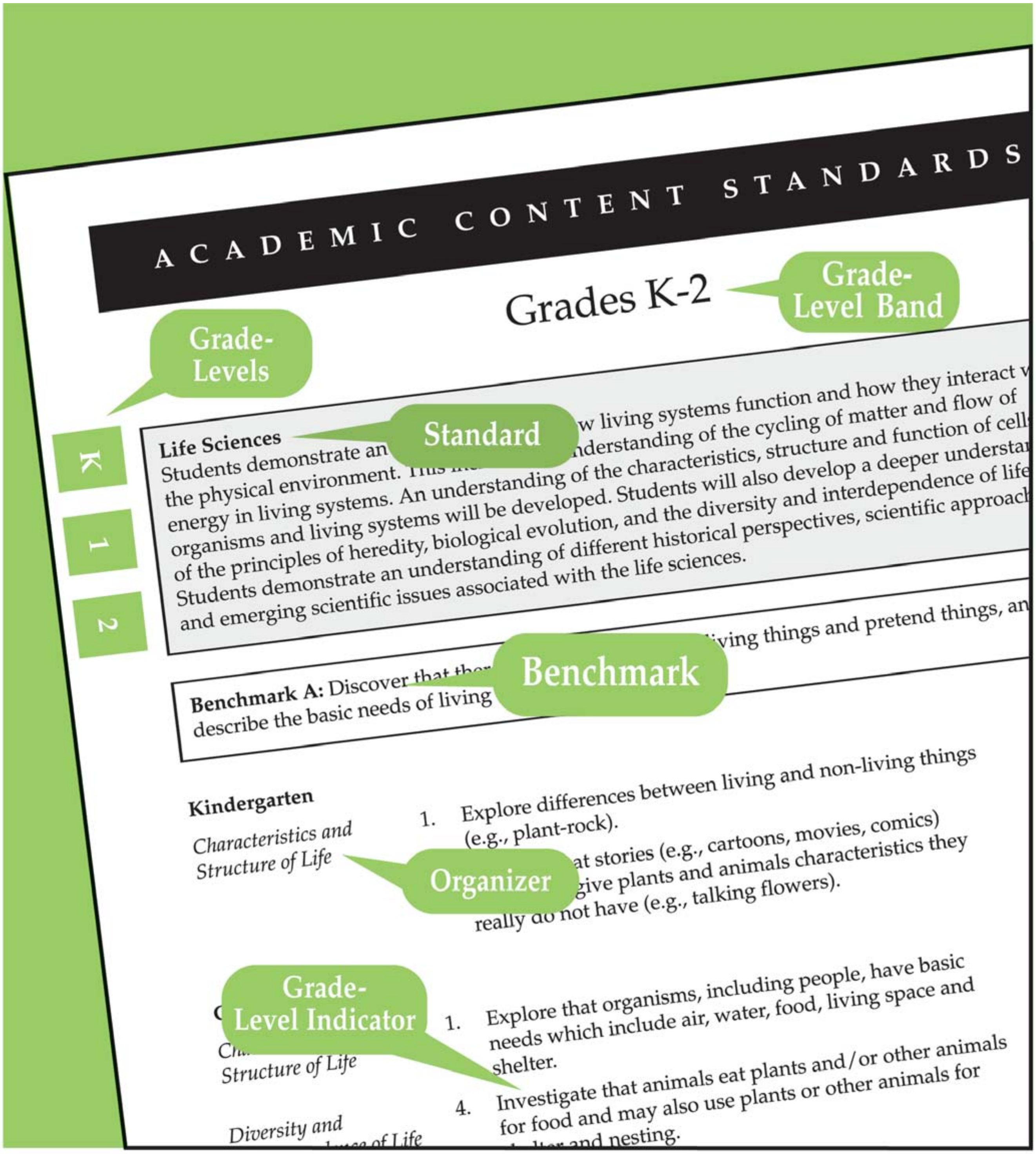
Grade-Level Indicators

- What all students should know and be able to do at each grade-level
- Checkpoints that monitor progress toward the benchmark
- Grade-level indicators will align with diagnostic test where applicable



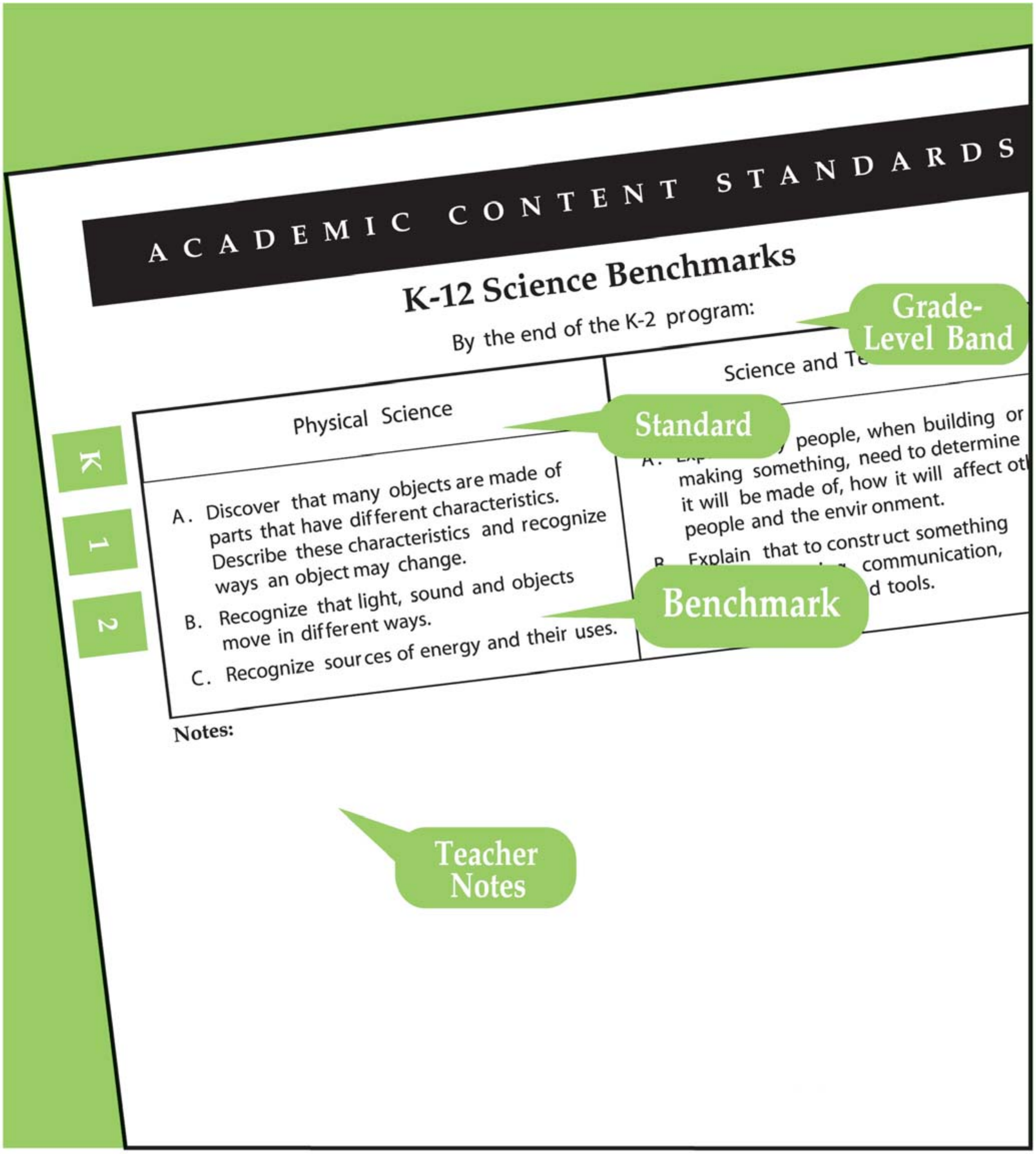
How to Read the Alignment

This section of the document is organized by grade-level bands. Each standard is followed by benchmarks that monitor student progress. Below each benchmark are the supporting indicators for each grade level in the grade band.



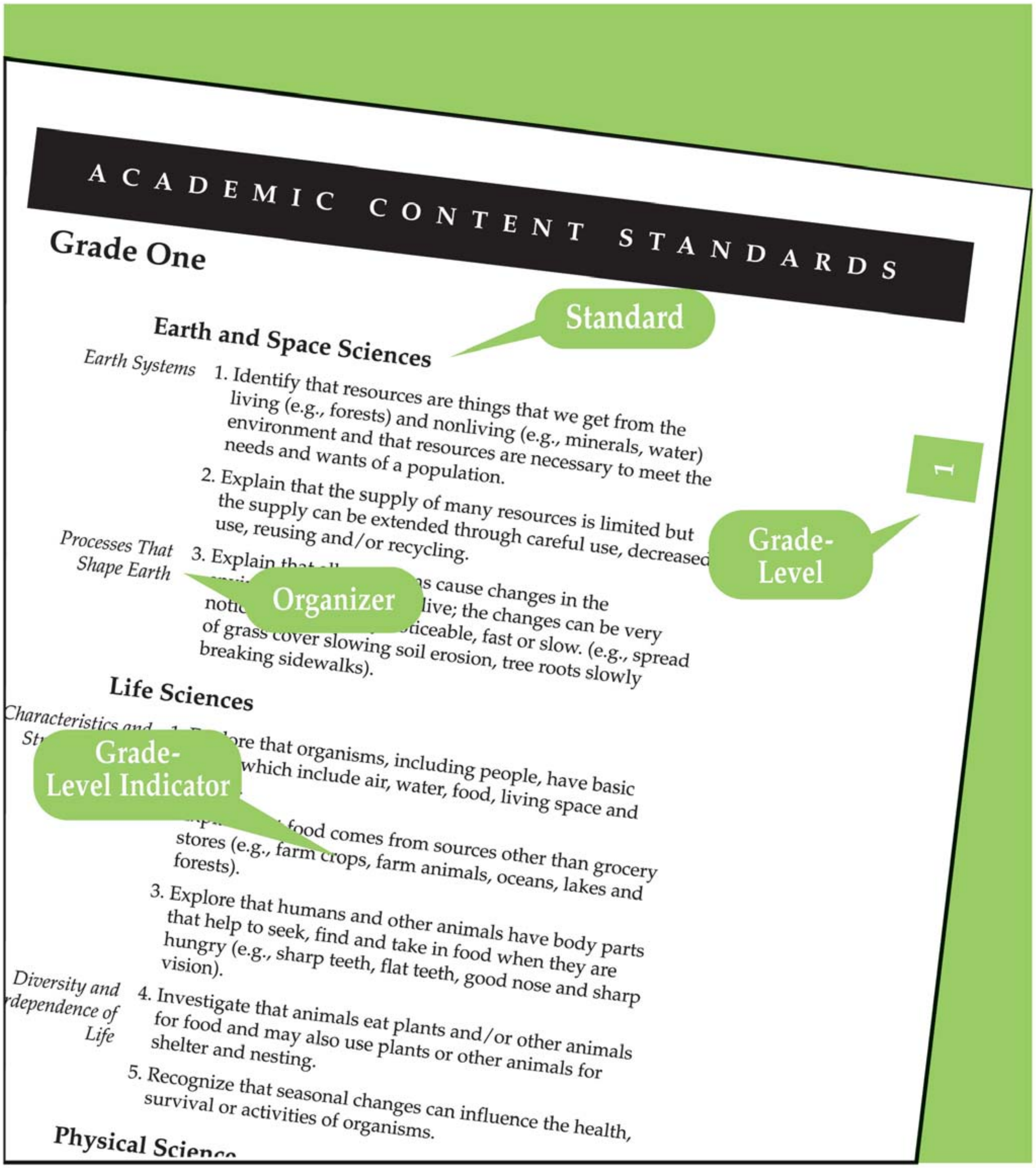
How to Read the Benchmarks

The benchmarks are key checkpoints that monitor student progress toward meeting the science standards. Benchmarks are organized in grade-level bands.



How to Read the Indicators

The grade-level indicators represent specific statements of what all students should know and be able to do at each grade-level. The indicators serve as checkpoints for monitoring progress toward the benchmarks and standards.



K-12 Science

Philosophy and Principles

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;
- Prepare students to use appropriate scientific processes and principles in making personal decisions;
- Enable students to engage intelligently in public discourse about matters of scientific and technological concern; and
- Increase 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 developing an understanding about the nature of science and technology including technological design;
- Serve as the basis for classroom and statewide assessments;
- Emphasize the nature, connections and historical development of scientific knowledge in the physical, life, and Earth and space sciences.

Science for All

The Ohio Department of Education believes that Ohio's academic content standards are for all students. Clearly defined standards delineate what all children, college- and career-bound, should know and be able to do as they progress through the grade levels. Well-defined standards ensure that parents, teachers and administrators will be able to monitor students' development. Students, as stakeholders in their own learning, will be capable of tracking their own learning.

No individual or group should be excluded from the opportunity to learn, and all students are presumed capable of learning. Every Ohio student, regardless of race, gender, ethnicity, socioeconomic status, limited English proficiency, disability or giftedness, shall have access to a challenging, standards-based curriculum.

The knowledge and skills defined in Ohio's academic content standards are within the reach of all students. Students, however, develop at different rates. All children learn and experience success given time and opportunity, but the degree to which the standards are met and the time it takes to reach the standards will vary from student to student.

Students with disabilities shall have Individualized Education Programs (IEP's) aligned with the standards. Students with disabilities are first and foremost students of the general curriculum, yet they may require specific supports and/or services to progress in the curriculum. These supports and services are not intended to compromise the content standards. Rather, they provide students with disabilities the opportunity to maximize their strengths, and participate and progress in the standards-based curriculum.

Students who can exceed the grade-level indicators and benchmarks set forth in the standards must be afforded the opportunity and be encouraged to do so. Students who are gifted may require special services or activities in order to fully develop their intellectual, creative, artistic and academic capabilities or to excel in a specific content area. Again, the point of departure is the standards-based curriculum.

Students with limited English proficiency (LEP) may also need specific supports and adaptive instructional delivery in order to achieve Ohio's academic content standards. An instructional delivery plan for a student with LEP needs to take into account the student's level of English language proficiency as well as his or her cultural experiences.

All children should be provided adjustments when necessary in order to address their individual needs. Identifying and nurturing the talents of all students will enable all children to reach the standards.

K-12 Science

Benchmarks and Indicators 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 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.

By the end of the K-2 program:	By the end of the 3-5 program:	By the end of the 6-8 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.	A. Describe how the positions and motions of the objects in the universe cause predictable and cyclic events. 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. C. Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution). 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. 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).

ACADEMIC CONTENT STANDARDS

By the end of the 9-10 program:	By the end of the 11-12 program:
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. B. Explain that many processes occur in patterns within the Earth's systems. 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. D. Describe the finite nature of Earth's resources and those human activities that can conserve or deplete Earth's resources. 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.	A. Explain how technology can be used to gather evidence and increase our understanding of the universe. B. Describe how Earth is made up of a series of interconnected systems and how a change in one system affects other systems. 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. Summarize the historical development of scientific theories and ideas and describe emerging issues in the study of Earth and space sciences.

Notes:

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

By the end of the K-2 program:	By the end of the 3-5 program:	By the end of the 6-8 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.	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. 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. 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. 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).

Notes:

ACADEMIC CONTENT STANDARDS

By the end of the 9-10 program:	By the end of the 11-12 program:
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. B. Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development. C. Explain the genetic mechanisms and molecular basis of inheritance. D. Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological). E. Explain how evolutionary relationships contribute to an understanding of the unity and diversity of life. F. Explain the structure and function of ecosystems and relate how ecosystems change over time. G. Describe how human activities can impact the status of natural systems. 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. 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.	A. Explain how processes at the cellular level affect the functions and characteristics of an organism. B. Explain how humans are connected to and impact natural systems. C. Explain how the molecular basis of life and the principles of genetics determine inheritance. D. Relate how biotic and abiotic global changes have occurred in the past and will continue to do so in the future. E. Explain the interconnectedness of the components of a natural system. F. Explain how human choices today will affect the quality and quantity of life on earth. G. Summarize the historical development of scientific theories and ideas within the study of life sciences.

Notes:

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

By the end of the K-2 program:	By the end of the 3-5 program:	By the end of the 6-8 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.	A. Relate uses, properties and chemical processes to the behavior and/or arrangement of the small particles that compose matter. B. In simple cases, describe the motion of objects and conceptually describe the effects of forces on an object. 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. 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.

Notes:

ACADEMIC CONTENT STANDARDS

By the end of the 9-10 program:	By the end of the 11-12 program:
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. 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. C. Describe the identifiable physical properties of substances (e.g., color, hardness, conductivity, density, concentration and ductility). Explain how changes in these properties can occur without changing the chemical nature of the substance. D. Explain the movement of objects by applying Newton's three laws of motion. E. Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored). 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 and light) have energy and waves can transfer energy when they interact with matter. H. Trace the historical development of scientific theories and ideas, and describe emerging issues in the study of physical sciences.	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. Recognize that some atomic nuclei are unstable and will spontaneously break down. C. Describe how atoms and molecules can gain or lose energy only in discrete amounts. D. Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems. E. Summarize the historical development of scientific theories and ideas within the study of physical sciences.

Notes:

Benchmarks

Science and Technology

Students 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.

By the end of the K-2 program:	By the end of the 3-5 program:	By the end of the 6-8 program:
A. Explain why people, when building or making something, need to determine what it will be made of, 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.	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 and aesthetics).

Notes:

ACADEMIC CONTENT STANDARDS

By the end of the 9-10 program:	By the end of the 11-12 program:
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.

Notes:

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 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.

By the end of the K-2 program:	By the end of the 3-5 program:	By the end of the 6-8 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.	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.

Notes:

By the end of the 9-10 program:	By the end of the 11-12 program:
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.

Notes:

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.

By the end of the K-2 program:	By the end of the 3-5 program:	By the end of the 6-8 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.	A. Use skills of scientific inquiry processes (e.g., hypothesis, record keeping, description and explanation). B. Explain the importance of reproducibility and reduction of bias in scientific methods. C. Give examples of how thinking scientifically is helpful in daily life.

Notes:

ACADEMIC CONTENT STANDARDS

By the end of the 9-10 program:	By the end of the 11-12 program:
A. Explain that scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world. B. Explain how scientific inquiry is guided by knowledge, observations, ideas and questions. C. Describe the ethical practices and guidelines in which science operates. D. Recognize that scientific literacy is part of being a knowledgeable citizen.	A. Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories. B. Explain how ethical considerations shape scientific endeavors. C. Explain how societal issues and considerations affect the progress of science and technology.

Notes:

K-12 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 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 and 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 and 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 and 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 and 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 and deposition) and rapid processes (e.g. volcanic eruptions, earthquakes and 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 is covered by a layer of water [some of it frozen], the entire planet surrounded by a thin blanket of air, elliptical orbit, tilted axis and 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 and 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 and alpine).
9. Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts and 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 and 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 and 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 and 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 and 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 and 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 and 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 and 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 Perspectives 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 and 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 and 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.

K-12 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, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

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 and 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; 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 and 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 and 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, mutualism and 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 and 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 and 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 Indicators present in this grade for Life Sciences standard.

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 and 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 and 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. Deleted

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 and discovering germs).

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

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

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 the 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).

K-12 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; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

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 and cloth).
3. Describe and sort objects by one or more properties (e.g., size, color and 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 and 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 and 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 and strings).
2. Explore and describe sounds (e.g., high, low, soft and 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 and collision).
4. Predict the changes when an object experiences a force (e.g., a push or pull, weight and 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 and 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 and 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 and 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 and industry).

Nature of Energy

5. Explain that the energy found in nonrenewable resources such as fossil fuels (e.g., oil, coal and 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 and coal).
8. Describe how renewable and nonrenewable energy resources can be managed (e.g., fossil fuels, trees and 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 and 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 and water).
7. Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing balanced chemical equations).
8. Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral.
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 and Newtonian mechanics).

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

Grade Ten

No Indicators present in this grade for Physical Sciences standard.

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 and 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 and 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 and 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 and 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 nuclei of radioactive isotopes are unstable and spontaneously decay 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 and 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).

K-12 Science Grade-Level Indicators

Science and Technology
Students 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., the 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 and 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 and 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 and 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 and 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 or 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 and 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 and 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.

K-12 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 and 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 and 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 and 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 and 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 and 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 and symbols).
4. Apply appropriate math skills to interpret quantitative data (e.g., mean, median and 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 and 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 and 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 and 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.

K-12 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 and 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 and openness).

Grade Eight

Nature of Science 1. Identify the difference between description (e.g., observation and summary) and explanation (e.g., inference, prediction, significance and 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 and 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 and Indicators by Grade Level

K-12 Science Benchmarks

By the end of the K-2 program:

Earth and Space Sciences	Life Sciences
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. 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.

Notes:

K-12 Science Benchmarks

By the end of the K-2 program:

Physical Sciences	Science and Technology
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. Explain why people, when building or making something, need to determine what it will be made of, how it will affect other people and the environment. B. Explain that to construct something requires planning, communication, problem solving and tools.

Notes:

K-12 Science Benchmarks

K
1
2

By the end of the K-2 program:

Scientific Inquiry	Scientific Ways of Knowing
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. 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.

Notes:

Kindergarten

Earth and Space Sciences

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.

Life Sciences

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.

Physical Sciences

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 and cloth).
3. Describe and sort objects by one or more properties (e.g., size, color and 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).

Science and Technology

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).

Scientific Inquiry

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 and 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.

Scientific Ways of Knowing

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

Earth and Space Sciences

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).

Life Sciences

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 and 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.

Physical Sciences

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 and 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 and 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).

Science and Technology

Understanding Technology

1. Explore that some kinds of materials are better suited than others for making something new (e.g., the 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 and 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).

Scientific Inquiry

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 and 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.

Scientific Ways of Knowing

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

Earth and Space Sciences

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.

Life Sciences

Characteristics and Structure of Life

1. Explain that animals, including people, need air, water, food, living space and shelter; 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.

Physical Sciences

Forces and Motion

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

Science and Technology

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.

Scientific Inquiry

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 and 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.

Scientific Ways of Knowing

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.

K-12 Science Benchmarks

By the end of the 3-5 program:

Earth and Space Sciences	Life Sciences
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.	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.

Notes:

K-12 Science Benchmarks

By the end of the 3-5 program:

Physical Sciences	Science and Technology
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.	A. Describe how technology affects human life. B. Describe and illustrate the design process.

Notes:

K-12 Science Benchmarks

By the end of the 3-5 program:

Scientific Inquiry	Scientific Ways of Knowing
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.	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.

Notes:

Grade Three

Earth and Space Sciences

Earth Systems

1. Compare distinct properties of rocks (e.g., color, layering and 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.

Life Sciences

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.

Physical Sciences

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 and collision).
4. Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Science and Technology

Understanding Technology

1. Describe how technology can extend human abilities (e.g., to move things and 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 and design a solution).
5. Describe possible solutions to a design problem (e.g., how to hold down paper in the wind).

Scientific Inquiry

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 and tables).
6. Communicate scientific findings to others through a variety of methods (e.g., pictures, written, oral and recorded observations).

Scientific Ways of Knowing

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

Earth and Space Sciences

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 and 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 and 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 and 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 and deposition) and rapid processes (e.g. volcanic eruptions, earthquakes and landslides).

Life Sciences

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 and 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).

Physical Sciences

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 and 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 and bending of metal).

Science and Technology

Understanding Technology

1. Explain how technology from different areas (e.g., transportation, communication, nutrition, healthcare, agriculture, entertainment and 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.

Scientific Inquiry

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.

Scientific Ways of Knowing

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

Earth and Space Sciences

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 is covered by a layer of water [some of it frozen], the entire planet surrounded by a thin blanket of air, elliptical orbit, tilted axis and 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.

Life Sciences

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).

Physical Sciences

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.

Science and Technology

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.

Scientific Inquiry

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).

Scientific Ways of Knowing

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 and 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.

K-12 Science Benchmarks

By the end of the 6-8 program:

Earth and Space Sciences	Life Sciences
A. Describe how the positions and motions of the objects in the universe cause predictable and cyclic events. 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. C. Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution). 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. 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).	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. 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. 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. 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).

Notes:

K-12 Science Benchmarks

By the end of the 6-8 program:

Physical Sciences	Science and Technology
A. Relate uses, properties and chemical processes to the behavior and/or arrangement of the small particles that compose matter. B. In simple cases, describe the motion of objects and conceptually describe the effects of forces on an object. 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. 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.	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 and aesthetics).

Notes:

K-12 Science Benchmarks

By the end of the 6-8 program:

Scientific Inquiry	Scientific Ways of Knowing
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. Use skills of scientific inquiry processes (e.g., hypothesis, record keeping, description and explanation). B. Explain the importance of reproducibility and reduction of bias in scientific methods. C. Give examples of how thinking scientifically is helpful in daily life.

Notes:

Grade Six

Earth and Space Sciences

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.

Life Sciences

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 and 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.

Physical Sciences

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 and 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 and industry).

Nature of Energy

5. Explain that the energy found in nonrenewable resources such as fossil fuels (e.g., oil, coal and 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 and coal).

8. Describe how renewable and nonrenewable energy resources can be managed (e.g., fossil fuels, trees and water).

Science and Technology

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).

Scientific Inquiry

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.

Scientific Ways of Knowing

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

Earth and Space Sciences

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 and 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 and alpine).
9. Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts and hurricanes).

Life Sciences

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, mutualism and 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 and 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 and 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.

Physical Sciences

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).

Science and Technology

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 or supply of materials and environmental effects).

Scientific Inquiry

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 and density).

Scientific Ways of Knowing

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 and openness).

Grade Eight

Earth and Space Sciences

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 and ocean trenches).

Life Sciences

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.

Physical Sciences

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 and sound waves).

Science and Technology

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.

Scientific Inquiry

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 and symbols).

4. Apply appropriate math skills to interpret quantitative data (e.g., mean, median and mode).

Scientific Ways of Knowing

Nature of Science

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

Ethical Practices

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

K-12 Science Benchmarks

By the end of the 9-10 program:

Earth and Space Sciences	Life Sciences
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. B. Explain that many processes occur in patterns within the Earth's systems. 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. D. Describe the finite nature of Earth's resources and those human activities that can conserve or deplete Earth's resources. 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.	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. B. Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development. C. Explain the genetic mechanisms and molecular basis of inheritance. D. Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological). E. Explain how evolutionary relationships contribute to an understanding of the unity and diversity of life. F. Explain the structure and function of ecosystems and relate how ecosystems change over time. G. Describe how human activities can impact the status of natural systems. 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.

K-12 Science Benchmarks

By the end of the 9-10 program:

Earth and Space Sciences	Life Sciences
	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.

Notes:

K-12 Science Benchmarks

By the end of the 9-10 program:

Physical Sciences	Science and Technology
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. 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. C. Describe the identifiable physical properties of substances (e.g., color, hardness, conductivity, density, concentration and ductility). Explain how changes in these properties can occur without changing the chemical nature of the substance. D. Explain the movement of objects by applying Newton's three laws of motion. E. Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored). 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 and light) have energy and waves can transfer energy when they interact with matter. H. Trace the historical development of scientific theories and ideas, and describe emerging issues in the study of physical sciences.	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.

Notes:

K-12 Science Benchmarks

By the end of the 9-10 program:

Scientific Inquiry	Scientific Ways of Knowing
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. Explain that scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world. B. Explain how scientific inquiry is guided by knowledge, observations, ideas and questions. C. Describe the ethical practices and guidelines in which science operates. D. Recognize that scientific literacy is part of being a knowledgeable citizen.

Notes:

Grade Nine

Earth and Space Sciences

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 and 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).

Life Sciences

No Indicators present for this standard.

Physical Sciences

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 and water).
7. Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing balanced chemical equations).
8. Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral.
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 ($KE=½mv^2$).

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 and Newtonian mechanics).

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

Science and Technology

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.

Scientific Inquiry

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 and 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.

Scientific Ways of Knowing

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

Earth and Space Sciences

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 and 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 and exponential population growth).

Life Sciences

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 and 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 and 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. Deleted
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 and discovering germs).
27. Describe advances in life sciences that have important long-lasting effects on science and society (e.g., biological evolution, germ theory, biotechnology and discovering germs).
28. Analyze and investigate emerging scientific issues (e.g., genetically modified food, stem cell research, genetic research and cloning).

Physical Sciences

No Indicators present for this standard.

Science and Technology

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.

Scientific Inquiry

Doing Scientific Inquiry

1. Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g. OSHA, MSDS, eyewash, goggles and 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.

Scientific Ways of Knowing

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.

K-12 Science Benchmarks

By the end of the 11-12 program:

Earth and Space Sciences	Life Sciences
A. Explain how technology can be used to gather evidence and increase our understanding of the universe. B. Describe how Earth is made up of a series of interconnected systems and how a change in one system affects other systems. 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. Summarize the historical development of scientific theories and ideas and describe emerging issues in the study of Earth and space sciences.	A. Explain how processes at the cellular level affect the functions and characteristics of an organism. B. Explain how humans are connected to and impact natural systems. C. Explain how the molecular basis of life and the principles of genetics determine inheritance. D. Relate how biotic and abiotic global changes have occurred in the past and will continue to do so in the future. E. Explain the interconnectedness of the components of a natural system. F. Explain how human choices today will affect the quality and quantity of life on earth. G. Summarize the historical development of scientific theories and ideas within the study of life sciences.

Notes:

K-12 Science Benchmarks

By the end of the 11-12 program:

Physical Sciences	Science and Technology
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. Recognize that some atomic nuclei are unstable and will spontaneously break down. C. Describe how atoms and molecules can gain or lose energy only in discrete amounts. D. Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems. E. Summarize the historical development of scientific theories and ideas within the study of physical sciences.	A. Predict how human choices today will determine the quality and quantity of life on Earth.

Notes:

K-12 Science Benchmarks

By the end of the 11-12 program:

Scientific Inquiry	Scientific Ways of Knowing
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.	A. Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories. B. Explain how ethical considerations shape scientific endeavors. C. Explain how societal issues and considerations affect the progress of science and technology.

Notes:

Grade Eleven

Earth and Space Sciences

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 and 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 and 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 and 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 Perspectives 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 and 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 and Plate Tectonics Theory).

Life Sciences

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 the 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.

Physical Sciences

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 and 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.

Science and Technology

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 and 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 and fuel cells).

Scientific Inquiry

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.

Scientific Ways of Knowing

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

Earth and Space Sciences

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.

Life Sciences

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).

Physical Sciences

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 and 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 and 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 and 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 nuclei of radioactive isotopes are unstable and spontaneously decay 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 and 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 and Technology

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.

Scientific Inquiry

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 and 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.

Scientific Ways of Knowing

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 and 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

Alignment of Benchmarks and Indicators

Grades K-2

Earth and Space Sciences
Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

Benchmark A: Observe constant and changing patterns of objects in the day and night sky.

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.

Grade One

No indicators present for this benchmark.

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.

Benchmark B: Explain that living things cause changes on Earth.

Kindergarten

Processes That Shape Earth	2.	Explore that animals and plants cause changes to their surroundings.

Grade One

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

No indicators present for this benchmark.

Benchmark C: Observe, describe and measure changes in the weather, both long term and short term.

Kindergarten

Processes That Shape Earth	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

No indicators present for this benchmark.

Grade Two

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.

Benchmark D: Describe what resources are and recognize some are limited but can be extended through recycling or decreased use.

Kindergarten

No indicators present for this benchmark.

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.

Grade Two

No indicators present for this benchmark.

Grades K-2

Life Sciences
Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Benchmark A: Discover that there are living things, non-living things and pretend things, and describe the basic needs of living things (organisms).

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).

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.

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.

Grade Two

Characteristics and Structure of Life

1. Explain that animals, including people, need air, water, food, living space and shelter; plants need air, water, nutrients (e.g., minerals), living space and light to survive.

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.).

K

1

2

Benchmark B: Explain how organisms function and interact with their physical environment.

Kindergarten

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

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 and sharp vision).
5. Recognize that seasonal changes can influence the health, survival or activities of organisms.

Grade Two

Characteristics and Structure of Life

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).
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.

Benchmark C: Describe similarities and differences that exist among individuals of the same kind of plants and animals.

Kindergarten

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.

Grade One

No indicators present for this benchmark.

Grade Two

Heredity

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

Grades K-2

Physical Sciences
Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Benchmark A: Discover that many objects are made of parts that have different characteristics. Describe these characteristics and recognize ways an object may change.

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 and cloth).
3. Describe and sort objects by one or more properties (e.g., size, color and shape).

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 and 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).

Grade Two

No indicators present for this benchmark.

Benchmark B: Recognize that light, sound and objects move in different ways.

Kindergarten

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

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.

Grade Two

Forces and Motion

1. Explore how things make sound (e.g., rubber bands, tuning fork and strings).
3. Explore with flashlights and shadows that light travels in a straight line until it strikes an object.

Benchmark C: Recognize sources of energy and their uses.

Kindergarten

No indicators present for this benchmark.

Grade One

Nature of Energy

7. Explore how energy makes things work (e.g., batteries in a toy and 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

2. Explore and describe sounds (e.g., high, low, soft and loud) produced by vibrating objects.

Grades K-2

Science and Technology
Students 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.

Benchmark A: Explain why people, when building or making something, need to determine what it will be made of, how it will affect other people and the environment.

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).

Grade One

Understanding Technology

1. Explore that some kinds of materials are better suited than others for making something new (e.g., the building materials used in the *Three Little Pigs*).
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 and electricity).
5. Identify how people can save energy by turning things off when they are not using them (e.g., lights and motors).

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.

Benchmark B: Explain that to construct something requires planning, communication, problem solving and tools.

Kindergarten

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	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.
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

Abilities To Do Technological Design	4.	Communicate orally, pictorially, or in written form the design process used to make something.

Grades K-2

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.

Benchmark A: Ask a testable question.

Kindergarten

Doing Scientific Inquiry

1. Ask "what if" questions.
2. Explore and pursue student-generated "what if" questions.

Grade One

Doing Scientific Inquiry

1. Ask "what happens when" questions.
2. Explore and pursue student-generated "what happens when" questions.

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.

Benchmark B: Design and conduct a simple investigation to explore a question.

Kindergarten

Doing Scientific Inquiry

3. Use appropriate safety procedures when completing scientific investigations.
4. Use the five senses to make observations about the natural world.
7. Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers and other appropriate tools).
10. Make new observations when people give different descriptions for the same thing.

Grade One

Doing Scientific Inquiry

3. Use appropriate safety procedures when completing scientific investigations.
6. Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers, timers and simple balances and other appropriate tools).

Grade Two

Doing Scientific Inquiry

4. Use appropriate safety procedures when completing scientific investigations.
7. Use appropriate tools and simple equipment/instruments to safely gather scientific data (e.g., magnifiers, non-breakable thermometers, timers, rulers, balances and calculators and other appropriate tools).
8. Measure properties of objects using tools such as rulers, balances and thermometers.

K

1

2

Benchmark C: Gather and communicate information from careful observations and simple investigation through a variety of methods.

Kindergarten

Doing Scientific Inquiry

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.
8. Measure the lengths of objects using non-standard methods of measurement (e.g., teddy bear counters and pennies).
9. Make pictographs and use them to describe observations and draw conclusions.

Grade One

Doing Scientific Inquiry

4. Work in a small group to complete an investigation and then share findings with others.
5. Create individual conclusions about group findings.
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

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.
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.

Grades K-2

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.

Benchmark 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.

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.

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.

Grade Two

Nature of Science

1. Describe that scientific investigations generally work the same way under the same conditions.

Benchmark B: Recognize the importance of respect for all living things.

Kindergarten

Ethical Practices	3.	Interact with living things and the environment in ways that promote respect.

Grade One

No indicators present for this benchmark.

Grade Two

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

Benchmark C: Recognize that diverse groups of people contribute to our understanding of the natural world.

Kindergarten

Science and Society	4.	Demonstrate ways science is practiced by people everyday (children and adults).

Grade One

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	2.	Explain why scientists review and ask questions about the results of other scientists' work.
Science and Society	4.	Demonstrate that in science it is helpful to work with a team and share findings with others.

Grades 3-5

Earth and Space Sciences
Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

Benchmark A: Explain the characteristics, cycles and patterns involving Earth and its place in the solar system.

Grade Three

No indicators present for this benchmark.

Grade Four

No indicators present for this benchmark.

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 is covered by a layer of water [some of it frozen], the entire planet surrounded by a thin blanket of air, elliptical orbit, tilted axis and 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.

Benchmark B: Summarize the processes that shape Earth's surface and describe evidence of those processes.

Grade Three

No indicators present for this benchmark.

Grade Four

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 and 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 and deposition) and rapid processes (e.g. volcanic eruptions, earthquakes and landslides).

Grade Five

No indicators present for this benchmark.

Benchmark C: Describe Earth's resources including rocks, soil, water, air, animals and plants and the ways in which they can be conserved.

Grade Three

Earth Systems

1. Compare distinct properties of rocks (e.g., color, layering and 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

No indicators present for this benchmark.

Grade Five

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.

Benchmark D: Analyze weather and changes that occur over a period of time.

Grade Three

No indicators present for this benchmark.

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 and 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 and 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.

Grade Five

No indicators present for this benchmark.

Grades 3-5

Life Sciences
Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Benchmark A: Differentiate between the life cycles of different plants and animals.

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).

Grade Four

Heredity

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

No indicators present for this benchmark.

Benchmark 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.

Grade Three

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).

Grade Four

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 and stems).

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).

Benchmark C: Compare changes in an organism's ecosystem/habitat that affect its survival.

Grade Three

Diversity and Interdependence of Life

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

Diversity and Interdependence of Life

4. Observe and explore that fossils provide evidence about plants that lived long ago and the nature of the environment at that time.

Grade Five

Diversity and Interdependence of Life

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).

Grades 3-5

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Physical Sciences
Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Benchmark A: Compare the characteristics of simple physical and chemical changes.

Grade Three

No indicators present for this benchmark.

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).

Grade Five

No indicators present for this benchmark.

Benchmark B: Identify and describe the physical properties of matter in its various states.

Grade Three

No indicators present for this benchmark.

Grade Four

Nature of Matter

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 and metal).
4. Explain that matter has different states (e.g., solid, liquid and gas) and that each state has distinct physical properties.

Grade Five

No indicators present for this benchmark.

Benchmark C: Describe the forces that directly affect objects and their motion.

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 and collision).
4. Predict the changes when an object experiences a force (e.g., a push or pull, weight and friction).

Grade Four

No indicators present for this benchmark.

Grade Five

No indicators present for this benchmark.

Benchmark D: Summarize the way changes in temperature can be produced and thermal energy transferred.

Grade Three

No indicators present for this benchmark.

Grade Four

Nature of Energy

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

Benchmark 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.

Grade Three

No indicators present for this benchmark.

Grade Four

No indicators present for this benchmark.

Grade Five

Nature of Energy

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.

Benchmark F: Describe the properties of light and sound energy.

Grade Three

No indicators present for this benchmark.

Grade Four

No indicators present for this benchmark.

Grade Five

Nature of Energy

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.

Grades 3-5

Science and Technology
Students 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.

3 4 5

Benchmark A: Describe how technology affects human life.

Grade Three

Understanding Technology

1. Describe how technology can extend human abilities (e.g., to move things and 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.

Grade Four

Understanding Technology

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

Grade Five

Understanding Technology

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

Benchmark B: Describe and illustrate the design process.

Grade Three

Abilities To Do Technological Design

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

Grade Four

Abilities To Do Technological Design

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

Grade Five

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.

Grades 3-5

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.

3 4 5

Benchmark A: Use appropriate instruments safely to observe, measure and collect data when conducting a scientific investigation.

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.

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.

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).

Benchmark B: Organize and evaluate observations, measurements and other data to formulate inferences and conclusions.

Grade Three

Doing Scientific Inquiry

2. Discuss observations and measurements made by other people.
3. Read and interpret simple tables and graphs produced by self/others.
5. Record and organize observations (e.g., journals, charts and tables).

Grade Four

Doing Scientific Inquiry

2. Analyze a series of events and/or simple daily or seasonal cycles, describe the patterns and infer the next likely occurrence.

Grade Five

Doing Scientific Inquiry

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.

Benchmark C: Develop, design and safely conduct scientific investigations and communicate the results.

3
4
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Grade Three

Doing Scientific Inquiry

4. Identify and apply science safety procedures.

6. Communicate scientific findings to others through a variety of methods (e.g., pictures, written, oral and recorded observations).

Grade Four

Doing Scientific Inquiry

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

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).

Grades 3-5

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.

Benchmark A: Distinguish between fact and opinion and explain how ideas and conclusions change as new knowledge is gained.

Grade Three

No indicators present for this benchmark.

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.

Grade Five

Nature of Science

1. Summarize how conclusions and ideas change as new knowledge is gained.

Benchmark B: Describe different types of investigations and use results and data from investigations to provide the evidence to support explanations and conclusions.

Grade Three

Nature of Science

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

Grade Four

Nature of Science

3. Explain discrepancies in an investigation using evidence to support findings.

Grade Five

Nature of Science

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 and controlled experiments).

Benchmark C: Explain the importance of keeping records of observations and investigations that are accurate and understandable.

Grade Three

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

Grade Four

Nature of Science	2.	Record the results and data from an investigation and make a reasonable explanation.
Ethical Practices	4.	Explain why keeping records of observations and investigations is important.

Grade Five

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

Benchmark D: Explain that men and women of diverse countries and cultures participate in careers in all fields of science.

Grade Three

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

No indicators present for this benchmark.

Grade Five

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

Grades 6-8

Earth and Space Sciences
Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

Benchmark A: Describe how the positions and motions of the objects in the universe cause predictable and cyclic events.

6

Grade Six

No indicators present for this benchmark.

7

Grade Seven

No indicators present for this benchmark.

8

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).

Benchmark 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.

Grade Six

No indicators present for this benchmark.

Grade Seven

No indicators present for this benchmark.

Grade Eight

The Universe

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).

Benchmark C: Describe interactions of matter and energy throughout the lithosphere, hydrosphere and atmosphere (e.g., water cycle, weather and pollution).

Grade Six

No indicators present for this benchmark.

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 and 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 and alpine).
9. Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts and hurricanes).

Grade Eight

No indicators present for this benchmark.

Benchmark 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.

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

No indicators present for this benchmark.

Grade Eight

No indicators present for this benchmark.

Benchmark 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).

Grade Six

No indicators present for this benchmark.

Grade Seven

No indicators present for this benchmark.

Grade Eight

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 and ocean trenches).

Grades 6-8

Life Sciences
Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Benchmark A: Explain that 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.

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 and chloroplasts).

Grade Seven

Characteristics and Structure of Life

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

Grade Eight

No indicators present for this benchmark.

Benchmark 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.

Grade Six

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.

Grade Seven

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.

Benchmark 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.

Grade Six

Diversity and Interdependence of Life

8. Describe how organisms may interact with one another.

Grade Seven

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 and 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 and soil).
6. Summarize the ways that natural occurrences and human activity affect the transfer of energy in Earth's ecosystems (e.g., fire, hurricanes, roads and 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.

Grade Eight

No indicators present for this benchmark.

Benchmark 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).

Grade Six

No indicators present for this benchmark.

Grade Seven

Diversity and Interdependence of Life

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).

Grade Eight

Evolutionary Theory

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.

Grades 6-8

Physical Sciences
Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Benchmark A: Relate uses, properties and chemical processes to the behavior and/or arrangement of the small particles that compose matter.

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 and 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 and industry).

Grade Seven

Nature of Matter

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

Grade Eight

No indicators present for this benchmark.

Benchmark B: In simple cases, describe the motion of objects and conceptually describe the effects of forces on an object.

Grade Six

No indicators present for this benchmark.

Grade Seven

No indicators present for this benchmark.

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.

Benchmark 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.

Grade Six

Nature of Energy

5. Explain that the energy found in nonrenewable resources such as fossil fuels (e.g., oil, coal and 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 and coal).
8. Describe how renewable and nonrenewable energy resources can be managed (e.g., fossil fuels, trees and water).

Grade Seven

No indicators present for this benchmark.

Grade Eight

No indicators present for this benchmark.

Benchmark 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.

Grade Six

No indicators present for this benchmark.

Grade Seven

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

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 and sound waves).

Grades 6-8

Science and Technology
Students 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.

Benchmark A: Give examples of how technological advances, influenced by scientific knowledge, affect the quality of life.

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.

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.

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).

Benchmark B: Design a solution or product taking into account needs and constraints (e.g., cost, time, trade-offs, properties of materials, safety and aesthetics).

Grade Six

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

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 or supply of materials and environmental effects).

Grade Eight

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.

Grades 6-8

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.

Benchmark 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.

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.

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.

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.

Benchmark B: Analyze and interpret data from scientific investigations using appropriate mathematical skills in order to draw valid conclusions.

Grade Six

Doing Scientific Inquiry

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

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 and density).

Grade Eight

Doing Scientific Inquiry

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 and symbols).
4. Apply appropriate math skills to interpret quantitative data (e.g., mean, median and mode).

Grades 6-8

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.

Benchmark A: Use skills of scientific inquiry processes (e.g., hypothesis, record keeping, description and explanation).

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.

Grade Seven

No indicators present for this benchmark.

Grade Eight

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

Benchmark B: Explain the importance of reproducibility and reduction of bias in scientific methods.

Grade Six

No indicators present for this benchmark.

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.

Grade Eight

Ethical Practices

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

Benchmark C: Give examples of how thinking scientifically is helpful in daily life.

Grade Six

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

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 and openness).

Grade Eight

No indicators present for this benchmark.

Grades 9-10

Earth and Space Sciences
Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

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

Grade Nine

The Universe

1. Describe that stars produce energy from nuclear reactions and that processes in stars have led to the formation of all elements beyond hydrogen and helium.
2. Describe the current scientific evidence that supports the theory of the explosive expansion of the universe, the Big Bang, over 10 billion years ago.

Grade Ten

No indicators present for this benchmark.

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

Grade Nine

Earth Systems

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

Grade Ten

Earth Systems

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

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

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

Grade Nine

The Universe

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

Grade Ten

Earth Systems

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

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

Earth Systems

5. Explain how the acquisition and use of resources, urban growth and waste disposal can accelerate natural change and impact the quality of life.
6. Describe ways that human activity can alter biogeochemical cycles (e.g., carbon and nitrogen cycles) as well as food webs and energy pyramids (e.g., pest control, legume rotation crops vs. chemical fertilizers).

Benchmark E: Explain the processes that move and shape Earth's surface.

Grade Nine

Processes That Shape Earth

5. Explain how the slow movement of material within Earth results from:
   a. thermal energy transfer (conduction and convection) from the deep interior;
   b. the action of gravitational forces on regions of different density.
6. Explain the results of plate tectonic activity (e.g., magma generation, igneous intrusion, metamorphism, volcanic action, earthquakes, faulting and folding).
7. Explain sea-floor spreading and continental drift using scientific evidence (e.g., fossil distributions, magnetic reversals and radiometric dating).

Grade Ten

No indicators present for this benchmark.

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

Grade Nine

Historical Perspectives and Scientific Revolutions

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

Grade Ten

Historical Perspectives and Scientific Revolutions

7. Describe advances and issues in Earth and space science that have important long-lasting effects on science and society (e.g., geologic time scales, global warming, depletion of resources and exponential population growth).

Grades 9-10

Life Sciences
Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

Characteristics and Structure of Life

1. Explain that living cells
   a. are composed of a small number of key chemical elements (carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur)
   b. are the basic unit of structure and function of all living things
   c. come from pre-existing cells after life originated, and
   d. are different from viruses
2. Compare the structure, function and interrelatedness of cell organelles in eukaryotic cells (e.g., nucleus, chromosome, mitochondria, cell membrane, cell wall, chloroplast, cilia, flagella) and prokaryotic cells.

Benchmark B: Explain the characteristics of life as indicated by cellular processes and describe the process of cell division and development.

Grade Nine

No indicators present for this benchmark.

Grade Ten

Characteristics and Structure of Life

3. Explain the characteristics of life as indicated by cellular processes including
   a. homeostasis
   b. energy transfers and transformation
   c. transportation of molecules
   d. disposal of wastes
   e. synthesis of new molecules
4. Summarize the general processes of cell division and differentiation, and explain why specialized cells are useful to organisms and explain that complex multicellular organisms are formed as highly organized arrangements of differentiated cells.

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

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 and jumping genes) to explain inheritance.

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

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).

Benchmark E: Explain how evolutionary relationships contribute to an understanding of the unity and diversity of life.

Grade Nine

No indicators present for this benchmark.

Grade Ten

Diversity and Interdependence of Life

12. Describe that biological classification represents how organisms are related with species being the most fundamental unit of the classification system. Relate how biologists arrange organisms into a hierarchy of groups and subgroups based on similarities and differences that reflect their evolutionary relationships.
13. Explain that the variation of organisms within a species increases the likelihood that at least some members of a species will survive under gradually changing environmental conditions.
14. Relate diversity and adaptation to structures and their functions in living organisms (e.g., adaptive radiation).

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

Diversity and Interdependence of Life

15. Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather).
16. Relate how distribution and abundance of organisms and populations in ecosystems are limited by the ability of the ecosystem to recycle materials and the availability of matter, space and energy.
17. Conclude that ecosystems tend to have cyclic fluctuations around a state of approximate equilibrium that can change when climate changes, when one or more new species appear as a result of immigration or when one or more species disappear.

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

Diversity and Interdependence of Life

18. Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.
19. Illustrate how uses of resources at local, state, regional, national, and global levels have affected the quality of life (e.g., energy production and sustainable vs. nonsustainable agriculture).

Benchmark H: Describe a foundation of biological evolution as the change in gene frequency of a population over time. Explain the historical and current scientific developments, mechanisms and processes of biological evolution.

Grade Nine

No indicators present for this benchmark.

Grade Ten

Evolutionary Theory

20. Recognize that a change in gene frequency (genetic composition) in a population over time is a foundation of biological evolution.
21. Explain that natural selection provides the following mechanism for evolution; undirected variation in inherited characteristics exist within every species. These characteristics may give individuals an advantage or disadvantage compared to others in surviving and reproducing. The advantaged offspring are more likely to survive and reproduce. Therefore, the proportion of individuals that have advantageous characteristics will increase. When an environment changes, the survival value of some inherited characteristics may change.
22. Describe historical scientific developments that occurred in evolutionary thought (e.g., Lamarck and Darwin, Mendelian Genetics and modern synthesis).
23. Deleted

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

Evolutionary Theory

24. Analyze how natural selection and other evolutionary mechanisms (e.g. genetic drift, immigration, emigration, mutation) and their consequences provide a scientific explanation for the diversity and unity of past life forms, as depicted in the fossil record, and present life forms.
25. Explain that life on Earth is thought to have begun as simple, one celled organisms approximately 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.

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

Grade Nine

No indicators present for this benchmark.

Grade Ten

Historical Perspectives and Scientific Revolutions

26. Use historical examples to explain how new ideas are limited by the context in which they are conceived. These ideas are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., biological evolution, germ theory, biotechnology and discovering germs).
27. Describe advances in life sciences that have important long-lasting effects on science and society (e.g., biological evolution, germ theory, biotechnology and discovering germs).
28. Analyze and investigate emerging scientific issues (e.g., genetically modified food, stem cell research, genetic research and cloning).

Grades 9-10

Physical Sciences
Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

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

Grade Nine

Nature of Matter

1. Recognize that all atoms of the same element contain the same number of protons, and elements with the same number of protons may or may not have the same mass. Those with different masses (different numbers of neutrons) are called isotopes.
2. Illustrate that atoms with the same number of positively charged protons and negatively charged electrons are electrically neutral.
4. Show that when elements are listed in order according to the number of protons (called the atomic number), the repeating patterns of physical and chemical properties identify families of elements. Recognize that the periodic table was formed as a result of the repeating pattern of electron configurations.
5. Describe how ions are formed when an atom or a group of atoms acquire an unbalanced charge by gaining or losing one or more electrons.

Grade Ten

No indicators present for this benchmark.

Benchmark B: Explain how atoms react with each other to form other substances and how molecules react with each other or other atoms to form even different substances.

Grade Nine

Nature of Matter

6. Explain that the electric force between the nucleus and the electrons hold an atom together. Relate that on a larger scale, electric forces hold solid and liquid materials together (e.g., salt crystals and water).
7. Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing balanced chemical equations).
8. Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral.

Grade Ten

No indicators present for this benchmark.

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

Grade Nine

Nature of Matter

9. Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors).
10. Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.

Grade Ten

No indicators present for this benchmark.

Benchmark D: Explain the movement of objects by applying Newton's three laws of motion.

Grade Nine

Forces and Motion

21. Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.
22. Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it.
23. Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. (F_{net}=ma. Note that weight is the gravitational force on a mass.)
24. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.
25. Demonstrate the ways in which frictional forces constrain the motion of objects (e.g., a car traveling around a curve, a block on an inclined plane, a person running, an airplane in flight).

Grade Ten

No indicators present for this benchmark.

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

Grade Nine

Nature of Energy

12. Explain how an object's kinetic energy depends on its mass and its speed ($KE=\frac{1}{2}mv^2$).
13. Demonstrate that near Earth's surface an object's gravitational potential energy depends upon its weight (mg where m is the object's mass and g is the acceleration due to gravity) and height (h) above a reference surface ($PE=mgh$).

Grade Ten

No indicators present for this benchmark.

Benchmark F: Explain how energy may change form or be redistributed but the total quantity of energy is conserved.

Grade Nine

Nature of Matter

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

Nature of Energy

11. Explain how thermal energy exists in the random motion and vibrations of atoms and molecules. Recognize that the higher the temperature, the greater the average atomic or molecular motion, and during changes of state the temperature remains constant.
14. Summarize how nuclear reactions convert a small amount of matter into a large amount of energy. (Fission involves the splitting of a large nucleus into smaller nuclei; fusion is the joining of two small nuclei into a larger nucleus at extremely high energies.)
15. Trace the transformations of energy within a system (e.g., chemical to electrical to mechanical) and recognize that energy is conserved. Show that these transformations involve the release of some thermal energy.
16. Illustrate that chemical reactions are either endothermic or exothermic (e.g., cold packs, hot packs and the burning of fossil fuels).
17. Demonstrate that thermal energy can be transferred by conduction, convection or radiation (e.g., through materials by the collision of particles, moving air masses or across empty space by forms of electromagnetic radiation).

Grade Ten

No indicators present for this benchmark.

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

Grade Nine

Nature of Energy

18. Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays).
19. Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.
20. Describe how waves can superimpose on one another when propagated in the same medium. Analyze conditions in which waves can bend around corners, reflect off surfaces, are absorbed by materials they enter, and change direction and speed when entering a different material.

Grade Ten

No indicators present for this benchmark.

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

Grade Nine

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

Grade Ten

No indicators present for this benchmark.

Grades 9-10

Science and Technology
Students 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.

Benchmark A: Explain the ways in which the processes of technological design respond to the needs of society.

Grade Nine

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

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.

Benchmark B: Explain that science and technology are interdependent; each drives the other.

Grade Nine

Understanding Technology

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

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.

Grades 9-10

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.

Benchmark 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.

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 and 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 and 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.

Grades 9-10

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.

Benchmark A: Explain that scientific knowledge must be based on evidence, be predictive, logical, subject to modification and limited to the natural world.

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.
3. Demonstrate that reliable scientific evidence improves the ability of scientists to offer accurate predictions.

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.

Benchmark B: Explain how scientific inquiry is guided by knowledge, observations, ideas and questions.

Grade Nine

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.

Grade Ten

No indicators present for this benchmark.

Benchmark C: Describe the ethical practices and guidelines in which science operates.

Grade Nine

Nature of Science

2. Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.

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.

Grade Ten

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.

Benchmark D: Recognize that scientific literacy is part of being a knowledgeable citizen.

Grade Nine

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

Science and Society

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

Grades 11-12

Earth and Space Sciences
Students demonstrate an understanding about how Earth systems and processes interact in the geosphere resulting in the habitability of Earth. This includes demonstrating an understanding of the composition of the universe, the solar system and Earth. In addition, it includes understanding the properties and the interconnected nature of Earth's systems, processes that shape Earth and Earth's history. Students also demonstrate an understanding of how the concepts and principles of energy, matter, motion and forces explain Earth systems, the solar system and the universe. Finally, they grasp an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with Earth and space sciences.

Benchmark A: Explain how technology can be used to gather evidence and increase our understanding of the universe.

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.

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.

Benchmark B: Describe how Earth is made up of a series of interconnected systems and how a change in one system affects other systems.

Grade Eleven

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 and 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.
10. Interpret weather maps and their symbols to predict changing weather conditions worldwide (e.g., monsoons, hurricanes and cyclones).

Grade Twelve

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.

Benchmark 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.

Grade Eleven

Earth Systems

9. Explain the effects of biomass and human activity on climate (e.g., climatic change and global warming).
11. Analyze how materials from human societies (e.g., radioactive waste and 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.

Grade Twelve

No indicators present for this benchmark.

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

Grade Eleven

Historical Perspectives 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 and 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 and Plate Tectonics Theory).

Grade Twelve

No indicators present for this benchmark.

Grades 11-12

Life Sciences
Students demonstrate an understanding of how living systems function and how they interact with the physical environment. This includes an understanding of the cycling of matter and flow of energy in living systems. An understanding of the characteristics, structure and function of cells, organisms and living systems will be developed. Students will also develop a deeper understanding of the principles of heredity, biological evolution, and the diversity and interdependence of life. Students demonstrate an understanding of different historical perspectives, scientific approaches and emerging scientific issues associated with the life sciences.

Benchmark A: Explain how processes at the cellular level affect the functions and characteristics of an organism.

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.

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.

Benchmark B: Explain how humans are connected to and impact natural systems.

Grade Eleven

Characteristics and Structure of Life

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.

Grade Twelve

No indicators present for this benchmark.

Benchmark C: Explain how the molecular basis of life and the principles of genetics determine inheritance.

Grade Eleven

No indicators present for this benchmark.

Grade Twelve

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.

Benchmark D: Relate how biotic and abiotic global changes have occurred in the past and will continue to do so in the future.

Grade Eleven

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

Evolutionary Theory

10. Explain additional components of the evolution theory, including genetic drift, immigration, emigration and mutation.

Benchmark E: Explain the interconnectedness of the components of a natural system.

Grade Eleven

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.
10. Explain how environmental factors can influence heredity or development of organisms.

Grade Twelve

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.

Benchmark F: Explain how human choices today will affect the quality and quantity of life on earth.

Grade Eleven

Diversity and Interdependence of Life

9. Give examples of how human activity can accelerate rates of natural change and can have unforeseen consequences.

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 the earth.

Grade Twelve

No indicators present for this benchmark.

Benchmark G: Summarize the historical development of scientific theories and ideas within the study of life sciences.

Grade Eleven

No indicators present for this benchmark.

Grade Twelve

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).

Grades 11-12

Physical Sciences
Students demonstrate an understanding of the composition of physical systems and the concepts and principles that describe and predict physical interactions and events in the natural world. This includes demonstrating an understanding of the structure and properties of matter, the properties of materials and objects, chemical reactions and the conservation of matter. In addition, it includes understanding the nature, transfer and conservation of energy; motion and the forces affecting motion; and the nature of waves and interactions of matter and energy. Students demonstrate an understanding of the historical perspectives, scientific approaches and emerging scientific issues associated with the physical sciences.

Benchmark A: Explain how variations in the arrangement and motion of atoms and molecules form the basis of a variety of biological, chemical and physical phenomena.

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.

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.
4. Recognize that at low temperatures some materials become superconducting and offer little or no resistance to the flow of electrons.

Benchmark B: Recognize that some atomic nuclei are unstable and will spontaneously break down.

Grade Eleven

No indicators present for this benchmark.

Grade Twelve

Nature of Energy

10. Explain the characteristics of isotopes. The nuclei of radioactive isotopes are unstable and spontaneously decay 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.

Benchmark C: Describe how atoms and molecules can gain or lose energy only in discrete amounts.

Grade Eleven

Forces and Motion

3. Describe real world examples showing that all energy transformations tend toward disorganized states (e.g., fossil fuel combustion, food pyramids and electrical use).

Grade Twelve

Nature of Energy

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.

Benchmark D: Apply principles of forces and motion to mathematically analyze, describe and predict the net effects on objects or systems.

Grade Eleven

Forces and Motion

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

3. Explain how all matter tends toward more disorganized states and describe real world examples (e.g., erosion of rocks and expansion of the universe).

Forces and 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 and 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.

Benchmark E: Summarize the historical development of scientific theories and ideas within the study of physical sciences.

Grade Eleven

Nature of Matter

2. Explain that humans have used unique bonding of carbon atoms to make a variety of molecules (e.g., plastics).

Grade Twelve

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 and 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).

Grades 11-12

Science and Technology
Students 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.

Benchmark A: Predict how human choices today will determine the quality and quantity of life on Earth.

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 and 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 and 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.

Grades 11-12

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.

Benchmark 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.

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 and 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.

Grades 11-12

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.

Benchmark A: Explain how scientific evidence is used to develop and revise scientific predictions, ideas or theories.

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.

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.

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 and 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).

Benchmark B: Explain how ethical considerations shape scientific endeavors.

Grade Eleven

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.

Grade Twelve

No indicators present for this benchmark.

Benchmark C: Explain how societal issues and considerations affect the progress of science and technology.

Grade Eleven

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

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

Instructional Commentary

The Foundations of Science Education

A strong foundation in science education results from rich learning experiences.

A strong foundation in science education, which begins in the early years, enables students to increase their knowledge, skills and understanding of the world in which they live - from their home to their community, state, country and world. All students can learn science and all students should have the opportunity to become scientifically literate. "This effort must begin in the early grades when students are naturally curious about the world around them and eager to explore it." (National Science Teachers Association, p. 2) An understanding of science will occur when students have active experiences with the natural and technological world. Learning windows - optimal times for learning at particular developmental stages - should be used to enhance understanding of science, mathematics and technology in young children. Nash, 1997, states that "research findings have strong implications for developing effective early childhood education programs because rich experiences produce rich brains." (American Association for the Advancement of Science, 2002).

The Ohio science academic content standards define what students should know and be able to do. "Scientific knowledge refers to facts, concepts, principles, laws, theories and models. Understanding science requires that an individual integrate a complex structure of many types of knowledge, including the ideas of science, relationships between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to many events. Understanding encompasses the ability to use knowledge, and it entails the ability to distinguish between what is and what is not a scientific idea." (National Research Council, p. 23)

Students can learn and build their understandings through simple investigations.

A foundation of science is formulated within the students' experience and knowledge base from their early years and throughout elementary school. Young children have natural capacities for inquiry which can be seen when they observe, sort and categorize objects. Children learn basic concepts about how things are alike or different. Students in kindergarten through grade two easily understand and remember stories that unfold in a linear way. The science-related stories may relate to seasons, the environment or life cycles. For example, children could grow plants, watch them complete the cycle by planting the seed themselves, and harvest from the plant they grew. Students also learn by building an understanding from simple investigations and by telling stories about what they did, what they found out and how part of their world works.

"Students in the upper elementary grades are able to design simple and comparative tests, analyze results and communicate their findings to others. As they progress, they can learn about cause and effect and how to record data describing those relationships. Their ability to inquire becomes more experimental and is much more advanced than simple comparative tests. Students generate simple hypotheses, conduct tests, and record and analyze data to find evidence for supporting or not supporting the original hypothesis." (National Science Teachers Association, pp. 31-33) An illustration of this could be students provided with the challenge of building a bridge, from a variety of materials. The goal of this project is to determine the maximum number of objects the bridge can accommodate. Students are given several parameters to adhere to while building the bridge. After completion of the bridge, students test the bridge by determining which one will hold the most weight. Students then record data of the performance of each test.

When student learning experiences involve process skills through organizing information, thinking critically and applying knowledge to new situations, they develop a firm content base for effective problem solving. Such problem solving could occur by determining how connections between bulb and battery produce light, and the duration of sustaining light. These learning experiences bring the hands-on world into the classroom.

The value of inquiry-centered science has been measured through longitudinal studies. Arthur Reynolds, Northern Illinois University, found that students who had been taught science in inquiry-centered elementary school classrooms were more successful in middle and high school science classes than were students taught in more traditional ways, such as lecture and reading a textbook. (National Science Resources Center)

The foundation of science education builds science literacy as an integral component of science. "Science literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity; the ability to read science articles for understanding; the ability to evaluate the quality of scientific information on the basis of its source and the methods used to generate it; and using appropriately technical terms or applying scientific concepts and processes." (National Research Council, p. 22)

Students need rich learning experiences in the classroom to enhance their understanding of science and develop skills of scientific inquiry. Learning experiences can also occur outside the classroom through field trips to science centers and museums; local, state and national parks; and business and industrial centers. These experiences can give

"As students move into middle and high school, inquiry becomes a more complete and natural multifaceted activity that involves:

- *Making observations;*
- *Posing questions;*
- *Examining books and other sources of information;*
- *Planning investigations;*
- *Reviewing what is already known in light of experimental evidence;*
- *Using tools to gather, analyze and interpret data;*
- *Proposing answers, explanations, and predictions;*
- *Communicating the results;*
- *Identifying assumptions;*
- *Using critical and logical thinking;*
- *Considering alternative explanations."*

National Research Council, p. 23

"The utilization of subject-matter found in the present life-experience of the learner towards science is perhaps the best illustration that can be found of the basic principle of using existing experience as the means of carrying learners on to a wider, more refined, and better organized world."
John Dewey, p. 7

students the opportunity to explore additional types of abilities: the ability to describe, explain and predict natural phenomena. Students who have foundational knowledge and skills in science enhance their capability to hold meaningful and productive jobs in the future. Employers need both entry and advanced skilled workers who have the ability to learn, reason, think creatively, make decisions and solve problems. A strong focus on science and mathematics education will enable America to remain economically competative in the global market.(National Research Council, p. 12) Science skills develop scientific habits of mind through hands-on exploration, science literacy and applying scientific concepts and relationships to the world.

The enthusiasm of learning science in the early grades can be transferred from teacher to students as the teacher brings the world of science into the classroom. Research on children's motivation to learn, and their achievement reveals that young children are full of curiosity and a passion for learning. This passion for learning can be stimulated by a variety of teaching strategies (American Association for the Advancement of Science).

The Ohio science academic content standards are written to take students to a higher level of understanding about their world. The foundations of science education will help students become responsible citizens, aid in decision-making and problem-solving, and care for the community in which they live. Science has a profound impact on our individual lives and our culture. It plays a role in almost all human endeavors and affects how we relate to one another and the world around us (American Association for the Advancement of Science: Atlas 2001).

American Association for the Advancement of Science: Project 2061, *Atlas of Science Literacy* . Washington, D.C.: American Association For The Advancement of Science and National Science Teachers Association, 2001, pp. 15-18.

American Association for the Advancement of Science: Project 2061, Early Childhood Education in Science, Mathematics and Technology: An NSTA Perspective. Ed. Fred Johnson. 10 Dec. 2002
www.project2061.org/tools/earlychild/perspect/johnson.htm.

Dewey, John. *Experience and Education*. Macmillan Press, 1938, p.7.

National Research Council, *National Science Education Standards.* Washington, D.C.: National Academy Press, 1996, pp. 22-23.

National Science Resources Center, *Science For All Children: A Guide to Improving Elementary Science Education in Your School District*. National Science Resources Center, 1996, pp. 17-18.

National Science Teachers Association, *Pathways: To the Science Standards*, Elementary School Edition. Ed. Lawrence F. Lowery. National Science Teachers Association, 1998, p. 2, 31-33.

Making Science Connections Across Standards and Disciplines

Ohio's science academic content standards provide six domains of clear and rigorous expectations for all students. Through Earth and space sciences, life sciences, physical sciences, science and technology, scientific inquiry, and scientific ways of knowing standards, the expectations for student achievement in science are made explicit. The standards also are intended to be considered appropriate guidelines for teachers of science, as well as for teachers in other content areas where science knowledge and skills are important aspects of the curriculum. The indicators suggest specific content for lessons that will cut across the standards and disciplines to build mastery towards the benchmarks.

"By building on the best of current practice, standards aim to take us beyond the constraints of present structures of schooling toward a shared vision of excellence."
National Research Council, p. 10

The science academic content standards can be interwoven into several disciplines such as mathematics, social studies and English language arts. The purpose of integrating the science curriculum is to help children make realistic connections between what they learn in each content area and the real world. The task of teaching students to inquire, analyze, compare, predict and formulate is the role of teachers at all grades and across all content areas. This is not unique to science education. Teachers in all subject areas lead students to knowledge acquisition through inquiry, the process of asking questions and seeking answers through research. Once students have gained knowledge through research, it is essential that they learn how to effectively communicate this acquired information.

Teachers help students make connections between skills and concepts.

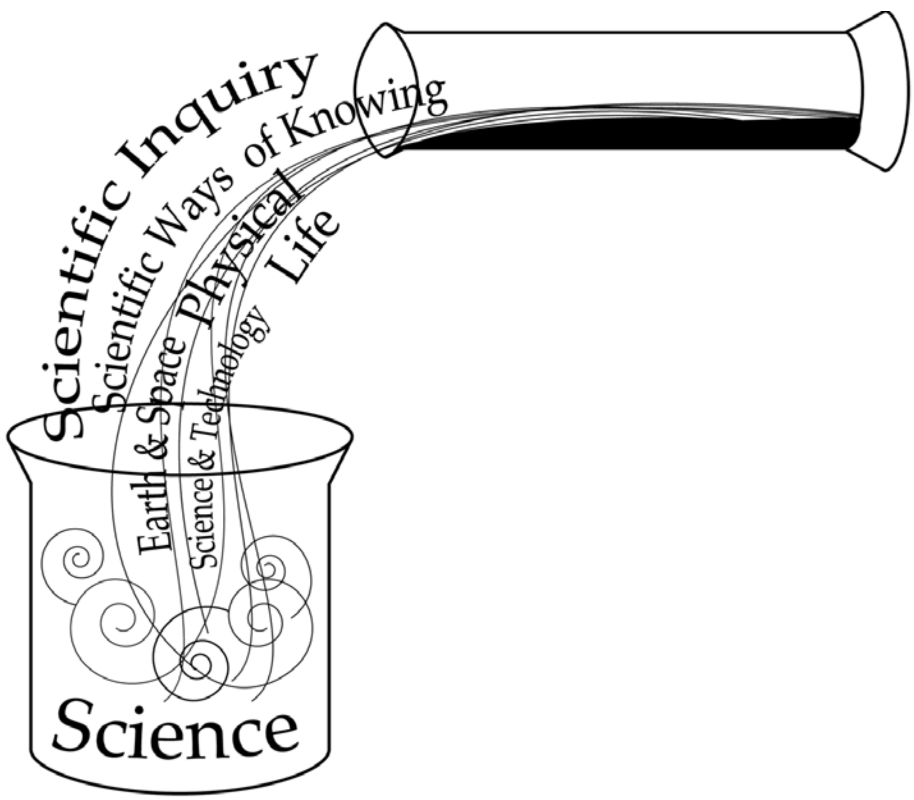
The concept of connections encompasses both the idea of making connections between skills and concepts within science, as well as making connections between science concepts, other disciplines and the outside world. Student experiences designed to focus on these relationships will help them build interconnected knowledge. An interdisciplinary curriculum cuts across subject-matter lines to focus upon comprehensive world issues that bring together the various segments of the curriculum into meaningful association. This provides coherence and allows student experiences to add up to more than just a miscellaneous collection of topics or activities. (American Association of Advancement of Science)

Teachers lead students to knowledge acquisition through inquiry.

There is a body of research related to how children learn that supports an interdisciplinary curriculum. "The brain may resist learning fragmented facts that are presented in isolation. Learning is believed to occur faster and more thoroughly when it is presented in meaningful contexts, with an experiential component. Put to use in the classroom, the brain research points toward interdisciplinary learning, thematic teaching, experiential education, and teaching that is responsive to student learning styles." (Lake, p. 6)

The integration of skills across the standards, and of instruction across the disciplines can result through planning. It is important for science teachers to plan instruction with teachers of other content areas to ensure the effective and efficient integration of the content of the standards into a coherent plan. By doing so, they can best support student achievement and prepare Ohio's learners to become productive citizens in an educated society. Comprehensive, integrated science education promotes critical thinking and supports integration of content and skills from all areas of the curriculum in order for students to extend and apply their knowledge to life outside the classroom.

Connections Across the Standards



Traditionally, science has been divided into content areas and processes, but it is clear that each supports and contributes to the other.

Sample Connections Across Disciplines

Science and Social Studies

- Earth and space science and geography
- Populations, resources and environments
- Science and technology contributions by many people and cultures of different times in history
- Contributions of science and technology to economic growth and productivity among societies
- History of many societies, scientists and engineers of high achievement

Science and Mathematics:

- Measurement, data analysis and probability
- Mathematical processes used in science
- Patterns, functions and algebra

Science and English Language Arts:

- Knowledge acquisition through inquiry
- Research methods and doing science research
- Scientific inquiry and scientific ways of knowing
- Communication of effective research results

American Association For The Advancement of Science: Project 2061, *Benchmarks for Science Literacy*. New York: Oxford University Press, 1993, p. 320.

Lake, Kathy. *Integrated Curriculum*. Portland, Oregon: Northwest Regional Education Laboratory, 1994, p. 6.

National Research Council, *National Science Education Standards*. National Academy Press, 1996, p. 10.

Program Planning

"The alignment of assessment with curriculum and teaching is one of the most critical pieces of science education reform."
National Research Council, p. 208

Ohio's science academic content standards provide clear expectations for all students. They form the foundation of what every student should know and be able to do in science programs throughout the state. While local programs and curriculum may build beyond those expectations, the benchmarks and grade-level indicators provide clarity for instruction. Identified content and skills should be the focus of teaching and learning at each grade band and level. In order to effectively implement a standards-based science program, teachers and curriculum leaders must determine how instructional programs can be organized, implemented and maintained in Ohio's classrooms, schools and districts.

Program planning and implementation is a shared responsibility. Teachers, department chairs, administrators, curriculum leaders, school boards, parents and community members play important roles in making decisions about local science programs. Knowledge of standards, best current practice and sound research should be incorporated into the conversations that go into the development of a coherent science program in which all components - curriculum, instruction and assessment - fit together well.

The first step in implementing a standards-based education program is to become familiar with the standards and to complete an analysis of the current science program. All science academic content standards should be part of the program of study. Content repeated unnecessarily or presented in another grade level, calls for careful decision making. Not all content in the standards will be new to teachers. Teachers and curriculum leaders will find that sections of their current lessons, projects and units fulfill the expectations of the standards. There are a number of models that can be used to compare curriculum to standards and to evaluate the level of alignment of current programs with standards.

The next step in this process is to examine what students need to be able to do and how that knowledge or skill is to be measured or assessed. Planning involves instruction geared to providing students with the knowledge and skills, outlined in the benchmarks and indicators, to achieve the goals for which they will be held accountable. To better understand the expectations of the benchmarks and indicators, educators can examine the nouns that define the content and the verbs that define the levels of thinking and skills expected. Formal and informal assessment with feedback on progress will help discern what students know and are able to do. Where gaps in knowledge exist, teachers need to re-evaluate instructional methods and learning opportunities. Instruction can then be tailored to individual student needs.

Assessment generates the data that educators need to design effective instruction. Whether planning for a particular unit of study, a semester or the entire academic year, assessments guide instruction. Assessments should be multiple measures related to the standards, benchmarks or indicators. By providing a variety of opportunities for students to demonstrate their acquisition of knowledge, multiple intelligences and individual student strengths are recognized. Students should clearly understand the criteria to be measured so that they receive feedback which engages them in the learning process. The data produced makes it possible to check student progress toward standards and to analyze strengths and weaknesses in instruction across groups of students. (Association for Supervision and Curriculum Development p. 45).

Components of Program Planning

Building Awareness and Acquiring Commitment:

- Develop an awareness of the standards and need for program changes;
- Identify issues related to program planning;
- Empower a group of persons representing all stakeholders to work together over an extended period of time to strengthen the program;
- Identify goals and key strategies that include continuous reflection and revision along the way.

Planning and Implementing Improvement Strategies:

- Establish leadership teams to guide and monitor program and implementation plans;
- Identify resources needed and potential barriers;
- Phase in strategies and changes over time and monitor their impact;
- Maintain communication and keep all stakeholders informed of progress;
- Develop and sustain support structures for assisting students and teachers who encounter difficulties.

Monitoring Progress:

- Establish clear and meaningful criteria for measuring the impact of changes and ongoing program effectiveness;
- Align evaluation methods with program goals and key improvement strategies;
- Use results to make decisions about which goals and strategies have been met and which may need to be modified;
- Identify new goals and strategies that may be needed to sustain and accelerate improvement.

"Teachers tend to teach in the manner that they themselves learn best: however, effective teachers stretch beyond their comfort zone to incorporate different learning styles."
Stronge, p. 38

"Assessment should become a routine part of the ongoing classroom activity rather than an interruption."
National Council of Teachers of Mathematics, p. 22

Students learn in different ways. There is no one prescribed instructional approach that will help all students to achieve the knowledge and skills of the content standards. In order for students to be successful, a variety of methodologies should be employed. The emphasis of the science program is on understanding natural phenomena and science-related social issues that students encounter on a regular basis. Just as "real life" does not focus on one issue at a time, neither should instruction. More than one content area and standard can be addressed throughout the learning process. A lesson on Earth and space science could easily weave inquiry skills, mathematic skills, and writing skills together in such a way that it is a meaningful event in the child's life versus a collection of seemingly unrelated facts. "Integrated and thematic approaches to curriculum can be powerful; however they require skill and understanding in their design and implementation." (National Research Council, p. 213)

Strong, effective science programs are created by teams of professionals using a systematic research and development process that involves repeated cycles of design, implementation, evaluation and redesign. It is an ongoing process in which teachers create support networks to evaluate and redesign lessons as they are implemented in the classroom. For teachers to put into practice a quality program, meaningful professional development is necessary to build instructional skills that foster creative instruction. Informed members of the community including universities, professional societies, museums, business, industry and parents can greatly enrich a program and provide relevancy for students.

High quality programs implement key components for success. They should provide students access to appropriate and sufficient resources such as informed teachers, time, materials and equipment, adequate and safe space, and access to the world beyond the classroom. Science needs to be part of children's lives every day, every week, and every year. During this time students act like scientists. Students need to ask questions and discover answers to the questions they develop through investigations that they design, set up and execute. This inquiry process will allow children to learn science in a way that reflects how science actually works. (National Research Council, pp. 42-46)

"Inquiry is a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models and theories. Inquiry is a critical component of a science program at all grade levels in every domain of science, and designers of curricula and programs must be sure that the approach to content, as well as the teaching and assessment strategies, reflect the acquisition of scientific understanding though inquiry." (National Research Council, p. 214)

The final component of program planning for all stakeholders is a set of coordinated procedures for monitoring the quality of the science program and its implementation. Procedures should include ways to provide ongoing review and periodic evaluation to ensure that student achievement goals are being met. Important aspects include monitoring alignment of policy decisions with program goals, impact of professional development strategies, and measures of student performance. Using results to continually improve the quality of the science program is essential for ensuring that all students meet Ohio's science academic content standards.

Association for Supervision and Curriculum Development. *Association for Supervision and Curriculum Development: A Resource for Curriculum Administrators: Planning and Organizing for Curriculum Renewal A Chapter of the Curriculum Handbook*. Alexandria, Virginia, 2001.

National Council of Teachers of Mathematics. *Principles and Standards for School Mathematics*. Reston, Virginia. The National Council of Teachers of Mathematics, Inc., 2000.

National Research Council. *National Science Education Standards*: Washington, D.C: National Academy Press, 1996.

Stronge, James H. *Qualities of Effective Teachers.* Alexandria, Virginia. Association for Supervision and Curriculum Development, 2002.

Planning for Instruction

Ohio's academic content standards provide the foundation for planning integrated instruction and assessment in the classroom. Although the benchmarks and indicators are presented as separate statements of knowledge, the intent is to promote integrated instruction. The indicators suggest specific content for lessons that will integrate content and concepts across the standards and disciplines to build mastery towards the benchmarks.

Inquiry and the National Science Education Standards summarize research findings on how students learn science. They include:

- Students build new knowledge from previous knowledge;
- Students formulate new knowledge by modifying their current concepts;
- Learning is impacted by the social environment in which the learners interact;
- Effective acquisition of knowledge requires students to take control of their own learning;
- The transfer of learning is affected by the degree of student understanding. (National Research Council, pp. 116-128)

Educators need to have a sense of the big picture to see how individual skills can be integrated into a coherent lesson plan, how one lesson fits into a year's program plan, and how one set of grade-level indicators fits into the entire standards.

These findings demonstrate the need to develop scientific thinking skills while learning subject matter.

The researchers of Mid-continent Research for Education and Learning (McREL) identify several instructional strategies that enhance scientific thinking. They include identifying similarities and differences; summarizing and note-taking; nonlinguistic representations; cooperative learning; setting objectives and providing feedback; generating and testing a hypothesis; and questions, cues, and advance organizers.

Effective instruction engages students in scientific investigations in which they may develop the question for study and design the approach for investigation. To allow students the opportunity to do their own investigation they must estimate the costs and benefits of methodologies and determine what instruments to use while conducting trial runs. Students interpret data to create logical explanations and record these results in reports for peer review. Students can then extend and evaluate what they have learned. Using this framework, students will be able to learn science in ways that reflect how science actually works in the real world.

Instruction always begins with identifying the benchmarks and indicators to be addressed and then determining what instruction the student needs to achieve the benchmarks. Lesson planning in standards-based education begins with a pre-assessment and ends with a post-assessment. Pre-assessment directs the instruction that needs to occur. Knowledge and skills are developed through a variety of lessons and activities. Ongoing assessment is a tool that aids in monitoring success and defines areas for improvement. The final assessment is a means to verify that the objectives have been met. The cycle of assessment, revision, teaching and assessment is paramount to successful standards-based education.

The vignette presented in this section provides one example of a lesson designed to highlight some elements of Ohio's science academic content standards and effective instruction. This example can be used to foster dialogue among teachers for planning daily lessons and building units.

Can You Ride the Storm?
Cycles of Nature

Mrs. M begins to plan for her ecology unit by reviewing the standards, indicators, and benchmarks for the 10^{th} grade. She remembers that students completed the introduction to ecology by studying the environment in a nearby park and making observations of biotic and abiotic factors and the interaction between the two. Drawings were made of the area. Various factors were identified, labeled and connections between abiotic and biotic were defined by the students. Mrs. M had also asked students to explain their drawings and the class to contribute suggestions about ways to make the interpretations more accurate.

The abiotic factors such as air, water and soil were identified and their role in the survival of living things discussed in detail. The biotic factors of the area were divided into producers and consumers, and the energy flow between the two types of factors was highlighted. Plants provide food for the world. Animals consume plants and bigger animals consume the smaller ones. Decomposers eliminate the waste, refuse and carrion. Students looked for these connections within the park. As students examined the food choices in the park, they realized that the bird was a high-level consumer/predator because it consumed insects that consumed plants. Other food chains and webs were identified from the organisms that existed in the park. Decomposers such as bacteria and fungi were noted and their role in elimination of wastes and carrion was explored. Trophic levels were defined and discussed.

Next, students were invited to do this same type of evaluation of similarities and differences through research on other biomes such as

Earth and Space Sciences

Grade 10
Benchmark B
Explain that many processes occur in patterns within the Earth's systems.
Indicator 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).

Life Science

Grade 10
Benchmark D
Explain the flow of energy and the cycling of matter through biological and ecological systems (cellular, organismal and ecological).
Indicator 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).

the African savanna or the Gulf of Mexico. They identified three biomes and traced the energy flow within those environments. From this topic, the class moved to the biogeochemical cycles of nature and human influence on these cycles.

After reflecting on student's past learning experiences, Mrs. M was ready to develop a pre-assessment to determine student knowledge levels about biogeochemical cycles. To do this, Mrs. M gave students charts of these cycles and instructed them to draw arrows illustrating the direction and flow of energy and materials. She also asked students to explain their choices. This pre-assessment activity revealed that students had a strong background knowledge of the water cycle but had a weaker knowledge of the carbon and nitrogen cycles. Mrs. M now turned her attention to developing lessons and activities designed to build student knowledge in those areas.

"Techniques and instructional strategies have nearly as much influence on student learning as aptitude."
Stronge, p. 44

Mrs. M selected a cooperative learning approach and divided students into teams of three to research the carbon or nitrogen cycle. The water cycle was omitted since the pre-assessment showed students already had a strong understanding of the cycle. The students became "experts" on the carbon or nitrogen cycle by using the Internet and other resources before sharing their cycle with another group. As students worked in groups, Mrs. M circulated around the room and asked questions to guide their efforts. Mrs. M also used questioning as an informal assessment to determine student comprehension. Her questions were well planned avoiding queries that produced yes/no answers. Instead, she asked higher level questions in which students had to organize and clarify their thoughts.

After time for individual study and preparation, the students presented their discoveries to the entire class. They created a variety of presentations with posters, descriptions, and skits that described each step of their assigned cycle.

Students were paired so that each cycle was represented between the two. Those students who had the other cycle took notes. Each student could tutor the other on the specifics of each cycle. With adequate time to think and review, Mrs. M gave a quiz that required arrows to be drawn to indicate the direction and flow of energy and materials through all three cycles: carbon, nitrogen and water. Then the focus turned to the human influence on the cycles.

The next day the words, "The Human Factor," were written on the board. Students were asked to think about the human factor in relation to the biogeochemical cycles. Mrs. M asked the students to take a few minutes to think individually before pairing up with another student to share and write down their thoughts. After a few moments of sharing and writing, the conversation become a whole-group discussion.

Students talked about pollution being a factor that influenced the environment and its cycles. Pollutants in the air increase the amount of carbon dioxide present leading to the greenhouse effect, which is a possible explanation for the increase of global temperature. They also recognized that humans are a natural part of the system through daily functions needed for survival such as breathing, eating and eliminating waste.

Mrs. M then asked students if there were ways that humans could positively influence the cycles. One student considered the nitrogen cycle and suggested that the addition of fertilizers to the soil influenced the cycle. If plants were provided with more nutrients, then they would increase their growth which would impact their reproductive abilities. This in turn would lead to changes in other cycles with an increase in photosynthesis, oxygen production, and the amount of food available for other organisms. It could also have negative consequences for the biogeochemical cycles because fertilizer runoff into streams and rivers could impact water ecosystems by killing some life forms and increasing others such as algae.

Lawrence Hooper states, "The ultimate source of exceptional performance is exceptional learning. Therefore, the question is how can we best produce exceptional learning in young people? How can we make exceptional learning unexceptional?"
Tileston, p. vii

Connections are starting to be made. Students realized that one factor in the environment had a ripple effect on other aspects of the system. Students concluded that the environment could be divided into two factors which influence each other - biotic and abiotic. Students appreciated the complexity and interactions of the water, carbon and nitrogen cycles. Students also realized that humans influenced the environment in both positive and negative ways. The time had come to pull all these factors together in an assessment.

Working individually or in groups of two, Mrs. M asked students to write a creative story about the complex nature of the water, carbon and nitrogen cycles. The story was to begin on a stormy spring night with lightning flashing through the sky. The main character could be either a molecule of water, carbon or nitrogen moving through the Earth's system or an animal consumed by a predator. During the story, the main character should travel through or be influenced by every step of each cycle.

Additional expectations about the story included that it consisted of a minimum of three detailed paragraphs; be written in complete sentences; and be shared during peer review. Each story would be rated on a class rubric generated from the following questions:
- Does the story accurately describe the cycles?
- Does the story consist of appropriate scientific terms?
- Does the story include any inaccurate scientific information? If so, cite an example from the story.
- What do you think was the most creative use of accurate information in the story? Cite the example.
- Rate the story with a one to four star rating, with four stars being the best. Provide an explanation of the score.

Throughout this vignette, Mrs. M incorporated standards, benchmarks and indicators in a way that addressed various learning styles, multiple intelligences, cooperative and interdisciplinary learning. She developed a series of integrated standards-based lessons designed to enable her students to meet the 10th grade academic content standards. By using a variety of instructional methods, Mrs. M increased the opportunity for all students to learn and fully understand the standards.

Teachers and curriculum leaders need to consider how each lesson fits into the progression of the year. They need to look at the skills being developed and how each lesson influences what can be explored in the future. Additionally, they need to plan and develop formal and informal assessments that provide valuable information about student understandings and drive lesson design. These components of standards-based education will provide Ohio teachers with a clear instructional plan to help all students meet the demands of the 21st century.

National Research Council. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, D.C.: National Academy Press, 2000.

Mid-continent Research for Education and Learning. *EDThoughts: What We Know About Science Teaching and Learning*. Aurora, CO: Mid-continent Research for Education and Learning, 2001.

Stronge, James H. *Qualities of Effective Teachers*. Alexandria, Virginia: Association for Supervision and Curriculum Development, 2002.

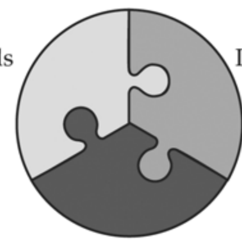
Tileston, Donna Walker. *Ten Best Teaching Practices: How Brain Research, Learning Styles, and Standards Define Teaching Competencies*. Thousand Oaks, California. Corwin Press, 2000.

The Role of Assessment

Ohioans are currently engaged in the important process of aligning critical parts of the state's educational system to enhance the effectiveness of that system in promoting learning. Those critical parts include academic content standards, instruction and assessment.

"Teachers of science engage in ongoing assessment of their teaching and of student learning." ***National Research Council, pp. 37-43***

The Three Parts of an Aligned Educational System



Ohio has developed and adopted clear and rigorous academic content standards for its students. As part of an ongoing process of aligning the educational system, educators and members of the public have a need to know if students meet these standards. The process of assessment provides students with opportunities to demonstrate their understandings related to content standards. Assessment is a means of collecting evidence of what students know and are able to do. A comprehensive and thoughtful assessment system provides teachers with needed information about student performance, which can be used for planning instruction, reporting progress and reflecting on teaching practices. It also provides students with a way to determine what they are learning and what they need to do in order to improve achievement.

"If students are to participate effectively in the [assessment] process, they need to ***be clear about the target and the criteria*** *for good work, to assess their own efforts in light of the criteria, and to* ***share responsibility in taking action*** *in light of the feedback."* ***National Research Council, p. 9***

Ohio's comprehensive assessment system includes several approaches to assessment:

- Classroom assessment;
- Diagnostic assessments;
- Achievement tests;
- National and international assessments.

Each type of assessment provides invaluable information to Ohio's educators, parents, students and communities. While each approach to assessment supports the others, each also serves its own unique purpose.

Ohio's Comprehensive Assessment System

Assessment Types	Basis for Content	Purpose
Classroom Assessments	Local Courses of Study and Standards	• Measure process as well as product of student understanding and knowledge. • Inform teachers and students about progress. • Provide information for instructional planning.
Diagnostic Assessments	Ohio's Academic Content Standards	• Monitoring student progress. • Make instructional decisions (e.g., intervention, enrichment). • Provide information to students, parents and teachers.
Achievement Tests	Ohio's Academic Content Standards	• Measure student achievement. • Demonstrate evidence of continuous improvement at the state and local level. • Provide data for Ohio's accountability system.
National and International Assessments	National and International Standards	• Compare Ohio achievement against that of other states and nations.

Classroom Assessment

One of the most important components in implementing an aligned standards-based system is ongoing classroom assessment. Good teaching practice embraces assessing student performance and providing constructive feedback to students. Classroom assessment uses both informal and formal methods. Observing student actions and listening to student responses to reflective questions are ways classroom assessment may be conducted, as are examining student concept maps, reading student science portfolio entries, and monitoring inquiry thinking and skills. *Inquiry and the National Science Education Standards* provides a focused discussion relevant to the relationship of classroom assessment and scientific inquiry.

"When they assess for learning, teachers use the classroom assessment process and the continuous flow of information about student achievement that it provides in order to advance, not merely check on, student learning."
Richard J. Stiggins, p. 761

Classroom assessment can be used not only to evaluate student performance and progress, but also to inform instructional planning so that it better meets the needs of students. The use of a variety of assessment opportunities, such as participating in class, writing answers for test questions and presenting a demonstration can provide a multi-faceted picture of student performance. An important benefit of classroom assessment is that the feedback can be frequent and immediate. The information gleaned from assessments can then be used to determine if further instruction is needed. It can also shape the form that instruction will take, such as remediation activities, conceptual reinforcement with the use of different techniques, extension projects for enrichment, and other appropriate strategies based upon the results of the assessments.

Classroom assessments can be used to determine student readiness for new content and skills, monitor student progress in achieving new expectations and summarize student accomplishments. Teachers can then plan where to begin the instructional activities, decide how to pace the instruction and determine the degree of success brought about by the instructional strategies used with the students.

Ohio's assessment system includes diagnostic and achievement assessments. These are being created with substantial input from Ohio's classroom teachers, parents, administrators, higher education faculty and business/community representatives.

Diagnostic Assessments

Ohio's assessment system enhances the work teachers do in classrooms by providing for annually administered diagnostic assessments. These assessments are drawn from the expectations found in Ohio's academic content standards grade-level indicators.

Depending on the content area involved, diagnostic assessments are administered at various grade levels from kindergarten through the eighth grade. They are designed to provide common instruments that districts may use to obtain a second perspective on the strengths and weaknesses of individual students. They can provide teachers with important information for instructional planning. These assessments will also identify students needing additional help meeting the content standards and preparing for the achievement tests.

Sample Classroom Assessment Tasks/Tools:

- *Projects, investigations and demonstrations*
- *Research reports and position papers*
- *Tests and quizzes*
- *Group K-W-L charts and graphic organizers*
- *Oral presentations and portfolios*
- *Student self-assessments and reflections*
- *Observations and checklists*

Achievement Tests

Achievement tests, including the Ohio Graduation Tests, are a third component of Ohio's comprehensive assessment system. They provide periodic checkpoints on the progress of students in meeting the benchmarks established by the state's content standards.

The results obtained from the achievement tests will provide a broad measure of student achievement. The results will provide guidance for districts in making program decisions. They will also be used to make decisions related to the allocation of resources at the state and local levels.

National and International Assessments

Ohio's assessment system is complemented through the state's participation in national and international assessment processes, such as the National Assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS). Participation in these assessments enables Ohio to compare the achievement of its students with that of students in other states and nations. In this way, Ohio ensures that its standards are sufficiently rigorous and world-class.

The Best Preparation for All Types of Assessment

In Ohio's aligned educational system, educators will collaborate to design, refine and enact instructional plans and classroom assessment strategies based upon the benchmarks and grade-level indicators that are contained as part of the academic content standards. These educators will know:

- That they will not have to set aside good classroom instruction to prepare students for assessment experiences;
- That they are evaluating students against common reference points shared by all Ohio educators;
- That they are preparing students for the statewide diagnostic and achievement tests.

In this way, Ohio's aligned system will help ensure that all students are prepared to meet the rigorous demands of the new century.

National Research Council, *Classroom Assessment and the National Science Education Standards.* Washington, D.C.: National Research Council, 2001.

National Research Council, *Inquiry and the National Science Education Standards.* Washington, D.C.: National Research Council, 2000.

National Research Council, *National Science Education Standards*. Washington, D.C.: National Research Council, 1996.

Stiggins, Richard J. "Assessment Crisis: The Absence of Assessment FOR Learning." *Phi Delta Kappan* 83:10 (2002): p. 761.

The Role of Technology

As Ohio educators and education stakeholders develop and implement kindergarten through 12th grade science content standards for all students, educators must consider the time in which students live, the type of skills that are useful and the variety of connections science makes with everyday lives. One area of great importance is technology and its use - in the classroom and elsewhere.

A clear understanding of technology is needed. *Standards for Technological Literacy* defines technology as the "human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities; and as the innovation, change or modification of the natural environment to satisfy perceived human needs and wants." (International Technology Education Association, p. 22) Webster defines technology as "the scientific method and material used to achieve a commercial or industrial objective; the body of knowledge available to a civilization that is of use in fashioning implements, practicing manual arts and skills, and extracting of an art of craft." (Webster's II New College Dictionary, 2001)

"The goal of science is to understand the natural world, and the goal of technology is to make modifications in the world to meet human needs." **National Research Council, p.24**

In general, there are three areas of particular importance in kindergarten through 12th grade science and related technology:

- Technology design and improvement. (e.g., processes for meeting changing human needs, improving on development and uses of resources, improving systems, creating new materials);
- Technology in our lives. (e.g., communication, transportation, medical uses, personal care, household uses, entertainment);
- Technology for learning. (e.g., information retrieval, asking questions/finding answers, computing, experimenting, data gathering/analysis/storage, networking, assessment, problem-solving, communicating).

Technology has, for decades, referred to the tools of science, such as microscopes, X-ray devices, balances and even meter sticks. In our everyday lives, commonly used technology tools have included automobiles, telephones, eyeglasses and washing machines. It is likely there has been movement toward the computer definition of technology because of the tremendous breakthroughs in recent years in computer design, adaptability and widespread applications - moving from the Industrial Age into the Information Age. In science classrooms and in our world, technology is more than computers.

Technology also includes processes and systems (recycling of materials, Doppler-radar weather forecasting, global positioning systems), methods (producing electricity from various energy sources, managing natural resources such as of water and soil), and other inventions that are meant to improve lives in some way (automation and robots, hybrid-fuel engines).

Throughout human history, there has been technology of many different forms. Rocks used as hammers, animal hide slingshots, and bone sewing needles, for example, provide evidence of the beginning of human culture. Only later did science develop as humans attempted to understand, in some rational way, their world. Today, science and technology are intricately intertwined as knowledge of science increases, thus expanding the ability to develop technologies - which then enables scientific knowledge to be further extended.

Technological literacy incorporates problem-based learning by utilizing mathematics, science and technology principles. It encompasses unique knowledge, capabilities, devices and ways of thinking. For example, technology education addresses the relationship between technology and society, including medical, agricultural, communication, energy, manufacturing and construction technologies.
International Technology Education Association

Technology and engineering function with science to help extend the ability to understand the world and the universe. Advances in technology, or the development of new technologies, result from the recognition of a need or problem and the creation of a technological solution. In the broadest sense, science explains the world, and technology extends the ability to understand and change the world. Together they allow us to move things, develop new materials, manage processes, market products, design, store and distribute information - even as we acknowledge and assess risks and benefits.

Children are experienced in using technology before they start kindergarten. Most have observed very young children as they attempt to construct the perfect castle or fort, from building sets and various materials. They experimentally perfect the scale, the stability and shape of the structure and the product serves their imagined purpose. Children experiment with a variety of materials (plastic, wood, cloth, paper) in constructing or improving playthings. They invent or use existing tools or simple machines (such as hammers and wheels) to accomplish playtime activities.

As children get older, they develop an understanding of how things work and how an object can be modified for many different purposes. Elementary and middle school students become adept at converting wagons into skateboards, using video cameras for creating a science project, and devising new methods for preparing their favorite sandwich. By the time students reach high school, they are likely to be building or modifying their own sound systems, designing computer programs, or creating their own system and tools for making a special piece of clothing.

Most students, at all age levels, have some expertise in the use of technology. How, then, can learning activities in science classes be planned so that all students have the opportunity to expand their knowledge and skills in using, modifying, or designing available and emerging technologies? Beginning in kindergarten and extending through grade 12, various technologies can be made a part of everyday teaching and learning, where, for example, the use of meter sticks, hand lenses, temperature probes and computers becomes a seamless part of what teachers and students are learning and doing. As students move through grade levels, they can engage in increasingly sophisticated hands-on, inquiry-based, personally relevant activities where they investigate, research, measure, compile and analyze information to reach conclusions, solve problems, make predictions and/or seek alternatives.

Benchmarks for Science Literacy suggests these activities or materials as appropriate technology-based learning tools or experiences for the kindergarten through 12th grade bands:

Grades kindergarten through two: Students measure, observe, communicate and design things, using simple technology tools such as paper, pencils, computers with simple programs cameras and magnifiers.

Grades three through five: Students design, construct, gain knowledge, measure, calculate, communicate and transport, using technology devices such as microscopes, telescopes, cameras, audio and video tapes, CD-ROMs and DVDs, tapes, rulers and simple balances.

Grades six through eight: Students experiment, find something out, collect and store data, investigate and consider human values and limitations, as well as trade-offs risks and benefits. They begin to select technological tools for appropriate uses in designing experiments and investigations. Students at these ages begin to consider possible occupations. They can be introduced to technology- and science-related careers, such as engineering, architecture, and industrial design via field trips, readings and interviews.

Grades nine through 12: Students participate in major design projects, deepen their understanding of technology, and develop a rich sense of the relationships linking science and technology. Students realize that technology, more than science itself, presents risks, as well as benefits, to society.

American Association for the Advancement of Science: Project 2061, pp. 41-57.

"Students and teachers must be willing to adopt familiar and unfamiliar technologies, function in a variety of instructional settings, and utilize tools, methods and processes that reflect the scientific and social culture of the time."
ENC Focus: New Horizons in Mathematics and Science Education

What, then, is the role of technology in educating Ohio's kindergarten through 12th grade science students to meet their needs for career preparation, informed citizenship and enjoyment of life? Students need grade-level appropriate classroom experiences, enabling them to learn and to be able to do science in an active, inquiry-based fashion where technological tools, resources, methods and processes are readily available and extensively used. As students integrate technology into learning about and doing science, emphasis should be placed on how to think through problems and projects, not just what to think.

According to the student's grade and level of learning, technological tools and resources may range from hand lenses and pendulums, to electronic balances and up-to-date online computers (with software), to methods and processes for planning and doing a project. Students can learn by observing, designing, communicating, calculating, researching, building, testing, assessing risks and benefits, and modifying structures, devices and processes - while applying their developing knowledge of science and technology.

American Association for the Advancement of Science: Project 2061, *Benchmarks for Science Literacy.* New York: Oxford University Press, 1993, pp. 41-57.

American Association for the Advancement of Science: Project 2061, *Designs for Science Literacy.* New York: Oxford University Press, 2000.

ENC Focus: New Horizons in Mathematics and Science Education. Columbus, Ohio: Eisenhower National Clearinghouse, Vol. 8 # 4, 2001.

International Technology Education Association, *Standards for Technological Literacy: Content for the Study of Technology*. Reston, Virginia: International Technology Education Association, 2002, p. 22.

National Research Council, *National Science Education Standards*. Washington, D.C.: National Academy Press, 1996, p. 24.

National Science Teachers Association Pathways: *To Science Standards: Guidelines for Moving the Vision into Practice, (Elementary)*. Ed. L. Lowery, 1997.

Webster's II New College Dictionary. Boston: Houghton Mifflin Company, 2001.

Making Real-World Connections

Science education in the 21st century provides opportunities for teachers to connect the knowledge and skills of the science academic content standards to their students' real world. Students' worlds can be as close as the inside of their home to as far away as the other side of the world through use of the Internet. Real-world connections are as diverse as understanding what generates the energy of a sports car, discovering the depths of the sea, to exploring the vastness of space.

The world of science is changing. All learners - children and adults - are flooded with data that must be absorbed, filtered and organized and then used to make informed decisions. Showing learners how to navigate their way through data, discern valid and reliable information, and render the data useful requires a deliberate and concerted effort. In the past, learners with rich agricultural backgrounds came to school with firsthand knowledge of life cycles, cycles of the moon, topography and simple machines. Today, the challenge lies in providing enriching experiences for those students lacking opportunities related to science and connecting each student's background to a meaningful classroom experience. Teachers who know how to motivate students, who know how to connect the content to the student's world, can succeed in raising students' science academic achievement.

"The world we live in has been shaped in many important ways by human action. We have created technological options to prevent, eliminate, or lessen threats to life and the environment and to fulfill social needs. . Many parts of our world are designed - shaped and controlled, largely through the use of technology - in light of what we take our interest to be."
American Association for the Advancement of Science, p.181

Connections made through application of science knowledge, skills and effective classroom instruction can contribute to the goal of narrowing the achievement gap and improving students' academic success. It may be an educator's challenge, at any level, to provide learning opportunities that ignite students' enthusiasm for science. Students can play an active role in learning when science inquiry and investigation occurs both in and outside the classroom. Links to the student's own experiences will strengthen the connections between the classroom and life outside the classroom. Such active learning opportunities and instructional methods can be aligned with the Ohio science academic content standards.

Real-world connections through science literacy is important to the understanding of science which can offer personal fulfillment and excitement for all. Americans are confronted increasingly with questions in their lives that require scientific information and scientific ways of thinking for informed decision-making. The collective judgment of our people will determine how we manage shared resources - air, water, and land such as national forests (National Research Council, p. 11).

Science helps in solving problems and understanding the world.

Making Real-World Connections

- Provide opportunities for students to collect water samples from a nearby stream for monitoring purposes.
- Discuss current events, topics that relate to and link with the science standards through newspapers, journals and other valid and reliable resources.
- Invite professionals from a local business or industry to discuss and describe what they make, what they do and the science involved in the process.
- Investigate the physics behind sports, such as the way the ball is shaped, its composition and how these factors effect speed and direction.
- Explore the science demonstrated in the entertainment industry: the science behind special effects, discovering science for designing and building robots, and making machines that move from junkyard finds.
- Discover the science behind the clothing industry.
- Investigate the science of food production, from the material of the lunch tray to the content of the food on the tray.
- Discover the benefits and costs of space travel and research.
- Compare the energy sources used in Ohio and different parts of the world.
- Study technology used such as the Global Positioning System (GPS) when teaching about earth and space sciences, and science and technology. Describe how navigators, military personnel, car manufacturers, hikers and farmers use the GPS.

Create links between each learner's needs and his or her interests.

Making connections within science and between sciences and other disciplines is critical for student success in using science effectively. Science is more than inventing things and doing scientific experiments; it also helps in solving problems and understanding the world. Science knowledge and skills are important to prepare students in a global economy for high-skill, high-knowledge jobs in engineering, computer programming, quality control, supervision and maintenance. The real-world emphasis of the Ohio science academic content standards will help create links between each learner's needs, his or her interests and strengths, and between the classroom and the world or work. However, the instructional strategies used by teachers are what will bring the science standards to life and create real-world connections.

American Association for the Advancement of Science: Project 2061. *Science For All Americans.* Washington, D.C.: American Association for the Advancement of Science, 1990, p. 181.

National Research Council, *National Science Education Standards.* Washington, D.C.: National Academy Press, 1996, p. 11.

National Science Teachers Association. Teacher Resources. Dec. 2002. www.nsta.org./resources

K-12 Science

Glossary

A

abiotic	Non-living.
acceleration	The rate of change of velocity with respect to time.
acid	A substance that dissolves in water with the formation of hydrogen ions and reacts with a base to form a salt and water. It neutralizes alkalis, dissolves some metals, and turns litmus red; typically, a corrosive and sour-tasting liquid.
adaptation	Adjustment to environmental conditions, modification of an organism or its parts that makes it more fit for existence under the conditions of its environment.
alleles	Any of the alternative forms of a gene that may occur at a given locus on a chromosome.
anemometer	An instrument for measuring and indicating the force or speed of the wind.
asexual reproduction	Involving or reproducing by reproductive processes (as cell division, spore formation, fission or budding) that do not involve the union of germ cells or egg and sperm.
asteroid	A small rocky body orbiting the sun.
atmosphere	The gaseous envelope surrounding the earth; consists of oxygen, nitrogen and other gases, extends to a height of about 40,744 km (22,000 miles), and rotates with Earth.
atmospheric pressure	The pressure exerted by the atmosphere at the surface of the Earth due to the weight of the air.
atom	The smallest particle of an element that can exist either alone or in combination.
atomic number	The number of protons in the nucleus of an atom.

B

bacteria	Unicellular, prokaryotic microorganisms that lack chlorophyll, multiply by fission, and can be seen only with a microscope; they occur in three main forms: spherical, rod-shaped and spiral. Some bacteria cause diseases such as pneumonia, tuberculosis and anthrax, and others are necessary for fermentation and nitrogen fixation.
balance	An instrument for measuring mass.
barometer	An instrument for determining the pressure of the atmosphere.
base	A substance that dissolves in water with the formation of hydroxyl ions and reacts with an acid to form a salt and water; turns litmus paper blue.
biogeochemical cycles	Relating to the partitioning and cycling of chemical elements and compounds between the living and nonliving parts of an ecosystem.
biological evolution	Changes in the genetic composition of a population through successive generations.

biomass	The amount of living matter.
biome	Major ecological community (tropical rain forest, grassland or desert).
biotechnology	Biological science when applied especially in genetic engineering and recombinant DNA technology.
biotic	Relating to life.
body covering	Feature that covers the body, such as fur or feathers.
body system	A system of the body (i.e. digestive system, circulatory system).
boiling point	The temperature at which a liquid boils.

C

capacity	The maximum amount or number that can be contained or accommodated.
carnivore	A flesh-eating animal.
cell	The smallest structural and functional unit of an organism.
cell division	The formation of two daughter cells from one parent cell, mitosis.
cell membrane	The bounding membrane of cells which controls the entry of molecules and the interaction of cells with their environment, plasma membrane.
cell respiration	Metabolic processes which break down nutrients into usable energy.
cell wall	A structure external to the plasma membrane of a plant cell. It provides structure and support.
characteristic	A distinguishing trait, feature, quality or property.
chemical change	A change in a substance resulting in an entirely different substance with different properties from the first.
chemical property	Chemical characteristics of a substance that distinguish it from other substances.
chemical reaction	A process that involves rearrangement of the molecular or ionic structure of a substance, as opposed to a change in physical form or a nuclear reaction.
chemosynthesis	Synthesis of organic compounds (as in living cells) by energy derived from chemical reactions.
chloroplast	A plastid that contains chlorophyll and is the site of photosynthesis.
chromosome	A threadlike structure of nucleic acids and protein found in the nucleus of most living cells, carrying genetic information in the form of genes.
chrysalis	The pupa of a butterfly and some insects.
cilia	Fine hair-like protrusions of the cell surface, which beat in unison to create currents of liquid over cell surface or propel the cell through the medium.

circuit	The complete path of an electric current usually including the source of electric energy.
circular motion	Motion of an object that follows the circumference of a circle.
classification	Systematic arrangement in groups or categories according to established criteria.
climate	The average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity and precipitation.
comet	A celestial body that consists of a fuzzy head usually surrounding a bright nucleus, that has a usually highly eccentric orbit, and that often, when in the part of its orbit near the sun, develops a long tail which points away from the sun.
community	Interacting populations that live in a defined habitat.
composition	The qualitative and quantitative makeup of a chemical compound.
compound	A substance formed from two or more elements chemically united in fixed proportions.
condensation	The conversion of a substance (such as water) from the vapor state to a denser liquid or solid state usually initiated by a reduction in the temperature of the vapor.
conduction	Process by which heat or electricity is transmitted through a material or body without movement of the medium itself.
conservation	A careful preservation and protection of something; especially planned management of a natural resource to prevent exploitation, destruction or neglect.
consumer	An organism requiring complex organic compounds for food, which it obtains by preying on other organisms or by eating particles of organic matter.
control	A group used as a standard of comparison for checking the results of an experiment.
covalent	Chemical bonds formed by the sharing of electrons between atoms.
convection	The circulatory motion that occurs in a fluid at a non-uniform temperature owing to the variation of its density and the action of gravity.
convergent	To come together or tend to come together at a point.
core	The central part of a celestial body (as Earth or sun) usually having different physical properties from the surrounding parts.
crust	The outer part of a planet, moon or asteroid composed essentially of crystalline rocks.
crustal deformation	A change in the crust of a planet, moon or asteroid.
crystal	A piece of a homogeneous solid substance having a natural, geometrically regular form with symmetrically arranged plane faces.
current	Continuous flow as of air, water or electric charge.

cycle An interval of time during which a sequence of a recurring succession of events or phenomena is completed.

D

decay rate The rate at which a radioactive isotope disintegrates until a final non-radioactive isotope is formed.

decomposers Organisms such as bacteria and fungi that feed and breakdown dead organisms returning constituents of organic substances to the environment.

dependent variable A variable whose values are determined by one or more (independent) variables.

design To create, fashion, execute or construct according to plan.

differentiation The sum of the processes whereby apparently indifferent cells, tissues and structures attain their adult form and function.

diversity A great deal of variety.

DNA Deoxyribonucleic acid, a double strand of nucleotides, that is a self-replicating material present in living organisms as the main constituent of chromosomes. It contains the genetic code and transmits the heredity pattern.

dominant A gene, that when present, is expressed in the phenotype.

E

eclipse The total or partial obscuring of one celestial body by another.

ecological The interactions and relationships between organisms and their environment.

ecosystem The complex of a community of organisms and its environment functioning as an ecological unit.

egg Female gamete; ovum.

electric field A region associated with a distribution of electric charge or a varying magnetic field, in which forces due to that charge or field, act upon other electric charges.

electric force A force that exists between two charged objects.

electricity A form of energy resulting from the existence of charged particles, either statically as an accumulation of charge or dynamically as a current.

electromagnetic radiation A kind of radiation including visible light, radio waves, gamma rays and x-rays in which electric and magnetic fields vary simultaneously.

electromagnetic spectrum The entire range of wavelengths or frequencies of electromagnetic radiation extending from gamma rays to the longest radio waves and including visible light.

electron A stable subatomic particle with negative electrical charge, found in all atoms and acting as the primary carrier of electricity in solids.

element	Any of more than 100 fundamental substances that consist of atoms of only one kind and that singly or in combination constitute all matter.
emigration	A category of population dispersal covering one-way movement out of the population area.
endothermic	Characterized by or formed with absorption of heat.
energy	The capacity for doing work, can be in various forms such as nuclear, sound, thermal and light.
entropy	A thermodynamic quantity representing the unavailability of a system's thermal energy for conversion into mechanical work, often interpreted as the degree of disorder or randomness in the system.
environment	The complex of physical, chemical and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival.
epicenter	The part of the Earth's surface directly above the focus of an earthquake.
equilibrium	A state in which opposing forces or influences are balanced.
eukaryotic	An organism composed of one or more cells containing visibly evident nuclei and organelles.
evaporation	To convert into vapor.
evidence	Facts or observations on which a conclusion can be based.
evolution (biological)	Changes in the genetic composition of a population through successive generations.
exothermic	Characterized by or formed with liberation of heat.
extinct	A species of organisms that no longer exists.

F

faulting	To fracture so as to produce a geologic fault.
fermentation	An enzymatically controlled anaerobic breakdown of an energy-rich compound.
fission	The splitting of an atomic nucleus resulting in the release of large amounts of energy.
flagella	Long hair-like extensions from the cell surface whose movement is used for locomotion.
focus	The place of origin of an earthquake or moonquake (as related to earthquakes).
folding	Causing rock strata to undergo bending or curvature.
food chain	An arrangement of the organisms of an ecological community according to the order of predation in which each uses the next usually lower member as a food source.
food web	The totality of interacting food chains in an ecological community; interacting food chains in an ecological community.

force	An influence, that if applied to a free body, results chiefly in an acceleration of that body in the direction of its application.
fossil	Remnant, impression or trace of an organism of past geologic ages that has been preserved in the Earth's crust.
fossil fuel	A fuel (such as coal, oil or natural gas) that is formed in Earth from plant or animal remains.
frame of reference	An arbitrary set of axes with reference to which the position or motion of something is described or physical laws are formulated.
friction	The force that resists relative motion between two bodies in contact.
fungi	Any of a major group of saprophytic and parasitic spore-producing organisms including molds, rusts, mildews, smuts, mushrooms and yeasts.
fusion	The union of atomic nuclei to form heavier nuclei resulting in the release of enormous quantities of energy.

G

galaxy	Any of the very large groups of stars and associated matter that are found throughout the universe.
gas	A fluid (such as air) that has neither independent shape nor volume but tends to expand indefinitely.
gene	A functional hereditary unit located at a particular point on a chromosome that controls or acts in the transmission of hereditary characteristics.
genetic drift	The process by which gene frequencies are changed.
germination	The beginning of growth in a spore, seed, zygote etc., especially following a dormant period.
glaciation	To subject to glacial action in which a large body of ice moves slowly down a slope or valley, or spreads outward on a land surface.
gravitation	A force manifested by acceleration toward each other of two free material particles or bodies, or of radiant-energy quanta.
gravity	The gravitational attraction of the mass of the Earth, the moon or a planet for bodies at or near its surface.

H

habitability	Suitable for a dwelling place.
habitat	The place or environment where a plant or animal naturally or normally lives and grows.
herbivore	A plant-eating animal.

heredity The sum of the qualities and potentialities genetically derived from one's ancestors; the relation between successive generations, by which characteristics persist.

heritable Capable of being inherited or of passing by inheritance.

homeostasis A state of equilibrium between different but interrelated functions or elements, as in an organism or group.

humidity The amount of moisture in the atmosphere.

hydrosphere The aqueous envelope of the Earth including bodies of water and aqueous vapor in the atmosphere.

hypothesis A formula derived by inference from scientific data that explains a principle operating in nature.

I

igneous Relating to, resulting from, or suggestive of the intrusion or extrusion of magma or volcanic activity.

immigration Coming into the population.

independent assortment Each chromosome in a pair that is independent of other chromosomes.

independent variable A variable whose value is specified first and determines the value of one or more other values.

infrared radiation Invisible rays just beyond the red end of the visible spectrum. Their waves are longer than those of the spectrum colors but shorter than radio waves, and have a penetrating heating effect; used in cooking and photography.

interstellar Located, taking place or traveling among the stars, especially of the Milky Way galaxy.

ion An atom or group of atoms that carries a positive or negative electric charge as a result of having lost or gained one or more electrons.

isotope Any of two or more species of atoms of a chemical element with the same atomic number and nearly identical chemical behavior, but with differing atomic mass or mass number and different physical properties.

J

jumping genes Genes that move from one position on the chromosome to another.

K

kinetic energy Energy associated with motion.

L

landform	A natural feature of a land surface.
life	An organism that has the capacity for metabolism, growth, reaction to stimuli and reproduction.
life cycle	The series of stages in form and functional activity through which an organism passes from fertilized ovum to the fertilized ovum of the next generation.
liquid	A fluid (such as water) that has no independent shape but has a definite volume, does not expand indefinitely and that is only slightly compressible.
lithosphere	The solid part of a celestial body (such as Earth), specifically, the outer part of the solid Earth composed of rock essentially like that exposed at the surface and usually considered to be about 80 kilometers (50 miles) in thickness.

M

magma	Molten rock material within the Earth from which igneous rock results by cooling.
magnetic reversal	Periods of time in which there was a reversal in direction of the Earth's magnetic field.
mantle	The part of the interior of a terrestrial planet, especially the Earth, that lies beneath the lithosphere and above the central core.
mass	The property of a body that is a measure of its inertia and that is commonly taken as a measure of the amount of material it contains causing it to have weight in a gravitational field.
matter	Material substance that occupies space, has mass and is composed of atoms consisting of protons, neutrons and electrons that constitutes the observable universe, and that is interchangeable with energy.
mean	The sum of a set of numbers divided by the number of elements in the set.
median	The middle number or item in a set of numbers or objects arranged from least to greatest, or the mean of the two middle numbers when the set has two middle numbers.
metamorphism	A change in the constitution of rock; specifically, a pronounced change affected by pressure, heat and water that results in a more compact and more highly crystalline condition.
meteor	Any of the small particles of matter in the solar system that are directly observable only by their incandescence from frictional heating on entry into the atmosphere.
meteoroid	One of a large number of celestial bodies of various size that appear as meteors when they enter Earth's atmosphere.

method	A systematic procedure, technique or mode of inquiry employed by or proper to a particular discipline or art.
microorganisms	An organism of microscopic or ultramicroscopic size.
metric system	A decimal system of weights and measures based on the meter and on the kilogram.
Milky Way	A broad luminous irregular band of light that stretches completely around the celestial sphere and is caused by the light of myriads of faint stars.
mineral	A solid homogeneous crystalline chemical element or compound that results from the inorganic processes of nature.
mitochondria	Cell structure responsible for cellular respiration.
mixture	A portion of matter consisting of two or more components in varying proportions that retain their own properties.
mode	The number or object that appears most frequently in a set of numbers of objects.
model	A description or analogy used to help visualize something (such as an atom) that cannot be directly observed.
molecule	The smallest particle of a substance that retains all the properties of the substance and is composed of one or more atoms.
moon cycle	The cycle of the moon's phases, from new to full and back.
motion	An act, process or instance of changing position through time.
multicellular	Having or consisting of many cells.
mutation	A relatively permanent change in hereditary material involving either a physical change in chromosome relations or a biochemical change in the codon(s) that make up genes.

N

natural	Existing in, or produced by nature.
natural selection	The principle that in a given environment individuals having characteristics that aid survival will produce more offspring, and the proportion of individuals having such characteristics will increase with each succeeding generation.
nesting	To build or occupy a nest; settle in.
neutral	Neither acidic nor basic (as in pH).
neutrons	An uncharged elementary particle that has a mass nearly equal to that of the proton and is present in atomic nuclei.
nuclear	Used in or produced by a nuclear reaction; referring to particles or properties of an atomic nucleus.
nuclear reaction	A change in the identity or characteristics of an atomic nucleus that results when it is bombarded with an energetic particle.

nucleus	1. The positively charged central portion of an atom that comprises nearly all of the atomic mass and that consists of protons and neutrons. 2. The portion of a eukoryotic cell that is surrounded by a nuclear membrane and contains DNA.
nutrient	A nutritive substance or ingredient.

O

observe	To watch carefully, especially with attention to details or behavior for the purpose of arriving at a judgment.
ocean trench	A long, narrow, deep depression in the ocean bed.
omnivore	An animal that feeds on both animal and vegetable substances.
orbit	A path described by one body in its revolution about another (as by the Earth about the sun or by an electron about an atomic nucleus).
organ	A differentiated structure (such as a heart, kidney, leaf or stem) consisting of cells and tissues, and performing some specific function in an organism.
organ systems	Organs working together for a specific function.
organic	Compounds containing carbon and chiefly or ultimately of biological origin.
organism	An individual constituted to carry on the activities of life by means of organs separate in function but mutually dependent; a living being.
oxidation	Combination of a substance with oxygen.
oxidize	To combine with oxygen.

P

parasite	An organism living in, with or on another organism in which a parasite obtains benefits from a host that it usually injures.
particle	Any of the basic units of matter and energy (such as a molecule, atom, proton, electron or photon).
pattern	A reliable sample of traits, acts, tendencies or other observable characteristics.
periodic table	An arrangement of chemical elements based on the periodic law.
pH scale	A numerical measure of the acidity or alkalinity of a chemical solution.
phenomenon	A fact or event of scientific interest susceptible to scientific description and explanation.
photosynthesis	The chemical process by which chlorophyll-containing plants use light to convert carbon dioxide and water into carbohydrates, releasing oxygen as a byproduct.
physical change	A change in a substance that does not alter its chemical makeup.
physical properties	A property of a material that can be observed without changing the chemical makeup of the material.

physiology The biological science of essential and characteristic life processes, activities and functions.

pitch The property of a sound, especially a musical tone, that is determined by the frequency of the waves producing it; highness or lowness of sound.

planet Any of the large bodies that revolve around the sun in the solar system.

pollution A substance that, when added to the environment causes the environment to be harmful or unfit for living things.

population All the plants or animals of the same kind found in a given area.

potential energy The energy that matter has because of its position or because of the arrangement of atoms or parts.

precipitation A deposit on Earth of hail, mist, rain, sleet or snow.

predator An animal that lives by capturing prey as a means of maintaining life.

prey An animal taken by a predator as food.

producer Any of various organisms (such as a green plant) which produce their own organic compounds from simple precursors (such as carbon dioxide and inorganic nitrogen) and many of which are food sources for other organisms.

prokaryotic A cellular organism (such as a bacterium or a blue-green alga) that does not have a distinct nucleus.

property A quality or trait belonging to an individual or thing.

proton A stable subatomic particle occurring in all atomic nuclei with a positive electric charge equal in magnitude to that of an electron.

Q

qualitative Involving quality or kind.

quantitative Involving the measurement of quantity or amount.

R

radiation The transfer of heat by radiation (such as energy transfer). The process of emitting radiant energy in the form of waves or particles (such as particle emission).

react To undergo chemical reaction (chemically).

reactant A substance that enters into and is altered in the course of a chemical reaction.

recycle To process (as liquid body waste, glass or cans) in order to regain material for human use.

reference point A basis or standard for evaluation, assessment or comparison; a criterion.

reflection The throwing back by a body or surface of light, heat or sound without absorbing it.

refraction	Deflection from a straight path undergone by a light ray or energy wave in passing obliquely from one medium (such as air) into another (such as glass) in which its velocity is different.
repel	To force away or apart, or tend to do so by mutual action at a distance.
replicate	To duplicate experiments, procedures or samples.
reproduction	The process by which organisms give rise to offspring and which fundamentally consists of the segregation of a portion of the parental body by a sexual or an asexual process, and its subsequent growth and differentiation into a new individual.
resource	Industrial materials and capacities (as mineral deposits and waterpower) supplied by nature (earth science) and substances used by an organism for survival (biology).
respiration	The physical and chemical processes by which an organism supplies its cells and tissues with the oxygen needed for metabolism and relieves them of the carbon dioxide formed in energy-producing reactions.
rotation	The turning of a body part about its long axis as if on a pivot.

S

scavenger	An organism that feeds habitually on refuse or carrion.
scientific law	A statement of an order or relation of phenomena that, so far as is known, is invariable under the given conditions.
scientific method	Principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses.
scientific theory	A plausible or scientifically acceptable general principle or body of principles offered to explain phenomena.
sediment	Material deposited by water, wind or glaciers.
segregation	The separation of two alleles in a heterozygote when gametes are formed.
significant figure	Each of the digits of a number that are used to express it to the required degree of accuracy.
solid	A substance that does not flow perceptibly under moderate stress, has a definite capacity for resisting forces (such as compression or tension) that tend to deform it, and under ordinary conditions retains a definite size and shape.
solubility	The amount of a substance that will dissolve in a given amount of another substance.
solution	An act, or the process by which a solid, liquid or gaseous substance is homogeneously mixed with a liquid or sometimes a gas or solid.
sound waves	Mechanical radiant energy that is transmitted by longitudinal pressure waves in a material medium (such as air) and is the objective cause of hearing.

species	A group of organisms consisting of similar individuals capable of exchanging genes or interbreeding.
sperm	A male gamete.
star	A natural luminous body visible in the sky, especially at night.
structure	The arrangement of particles or parts in a substance or body.
survival	The continuation of life or existence.
system	1. A group of body organs that together perform one or more vital functions. 2. An organized group of devices, parts or factors that together perform a function or drive a process (weather systems, mechanical systems).

T

technology	Human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.
theory	A supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained.
tides	The alternate rising and falling of the surface of the ocean and water bodies (such as gulfs and bays) connected with the ocean that occurs usually twice a day, and is caused by the gravitational attraction of the sun and moon occurring unequally on different parts of the Earth.
tissue	An aggregate of cells usually of a particular kind together with their intercellular substance that form one of the structural materials of organisms.
tool	A device that aids in accomplishing a task, a form of technology.
trait	An inherited characteristic.
transform	To change in composition or structure.

U

unit	A determinate quantity (such as of length, time, heat or value) adopted as a standard of measurement.
unity	The state of being united into a whole.
uplift	To cause (a portion of Earth's surface) to rise above adjacent areas.

V

variable	A quantity that may assume any one of a set of values.
velocity	The rate of change of position and direction with respect to time.

virus	Any of various submicroscopic pathogens consisting essentially of a particle of nucleic acid enclosed in protein and able to replicate only within a living cell.
volcano	A vent in the crust of the Earth or another planet from which usually molten rock, ash and steam are ejected.

W

water cycle	The sequence of conditions through which water passes from vapor in the atmosphere through precipitation upon land or water surfaces and ultimately back into the atmosphere as a result of evaporation and transpiration.
wave	A disturbance or variation that transfers energy progressively from point to point in a medium, and that may take the form of an elastic deformation or of a variation of pressure, electric or magnetic intensity, electric potential, or temperature.
wavelength	The distance between successive crests of a wave.
weather	The state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness.
weathering	To subject to the action of the elements.

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Webster's New World Dictionary of the American Language, New York: Simon and Schuster, 1984.

Webster's II New Riverside Dictionary Revised Edition. Boston: Houghton Mifflin Co., 1996.

K-12 Science

Resources

These sample resources can be used to aid in the understanding of academic content standards. In addition, these resources can be used to begin the process of implementing standards-based instruction and assessment. The model curriculum will provide a greater opportunity to explore best practices, research-based instruction and effective lessons and strategies for all children.

Instructional Resources

Resources listed in this section provide information for educators seeking practical and creative ways to implement standards-based instruction.

Instructional Resources on the Internet

- **Eisenhower National Clearinghouse for Mathematics and Science Education (ENC) -** ENC's mission is to identify effective curriculum resources, create high-quality professional development materials, and disseminate useful information and products to improve kindergarten through grade 12 science and mathematics teaching and learning.
  www.enc.org
- **ERIC Clearinghouse for Science, Mathematics and Environmental Education -** The Educational Resources Information Center (ERIC) is a national information system designed to provide users with ready access to an extensive body of education-related literature. ERIC's goal is to provide access to the best information about teaching and learning in the areas of science, mathematics, and the environment for educators, students, and others.
  www.ericse.org
- **Ohio Resource Center for Mathematics, Science, & Reading -** ORC is a unique service that provides peer-reviewed, best practice Web sites for educators. Its purpose is to help educators enhance learning opportunities for the young people of Ohio and to provide ideas for teaching the high expectations found in the Ohio academic content standards.
  www.ohiorc.org

Instructional Publications

- American Association for the Advancement of Science: Project 2061, *Resources for Science Literacy.* Oxford University Press, 1997.
- Mid-continent Research for Education and Learning, Council of State Supervisors of Science, and The National Network of Eisenhower Regional Consortia and Clearinghouse. *EDThoughts: What We Know About Science Teaching and Learning.* Aurora, CO: Mid-continent Research for Education and Learning, 2001.
- National Science Teachers Association, *Pathways to Science Standards: High School.* Editors Texley and Wild, National Science Teachers Association, 1996.
- National Science Teachers Association, *Pathways to Science Standards: Middle School.* Editor Rakow, National Science Teachers Association, 2000.
- National Science Teachers Association, *Pathways to Science Standards: Elementary School.* Editors Texley, Marshall and Wild, National Science Teachers Association, 2000.

Professional Resources

Resources listed in this section provide access to professional organizations and public institutions to afford educators opportunities to stay informed within their field.

Professional Organizations

- **National Science Education Leadership Association** - the mission of NSELA is to communicate the principles and practices of effective science education leadership, build a community of science education leaders and to influence science education policies and practices.
  www.nsela.org
- **National Science Teachers Association** - NSTA promotes excellence and innovation in science teaching and learning for all. NSTA's membership includes science teachers, science supervisors, administrators, scientists, business and industry representatives, and others involved in and committed to science education.
  www.nsta.org
- **Ohio Academy of Science** - the mission of the Ohio Academy of Science is to foster curiosity, discovery and innovation for the benefit of society. It strives to unite all who value education, science, engineering, technology, or their applications.
  www.ohiosci.org
- **Ohio Council of Elementary Science Teachers** - OCESS is an educational organization serving teachers of early and middle childhood science. It promotes professional development through workshops, a teacher grant program, and the Web site. It is an associated group of the National Science Teachers Association (NSTA) and the Science Education Council of Ohio (SECO).
  http://members.aol.com/OCESS
- **Ohio Mathematics and Science Coalition** - OMSC's mission is to facilitate collaboration for continuous, systemic and sustainable improvement in mathematics, science and technology education for Ohio students.
  www.oai.org/OMSC
- **Science Education Council of Ohio** - SECO promotes and supports excellence in science teaching and learning for all. It is the state chapter of the National Science Teachers Association (NSTA).
  www.secoonline.org

Departments of Education

- **Ohio Department of Education**
  www.ode.state.oh.us

  Office of Curriculum and Instruction
  www.ode.state.oh.us/curriculum-assessment/ci

  Office of Assessment
  www.ode.state.oh.us/curriculum-assessment/Assessment
- **Other state Departments of Education (via CCSSO)**
  www.ccsso.org/seamenu.html
- **United States Department of Education**
  www.ed.gov

Research Resources

Resources listed in this section provide information about educational theories, skills and strategies to build knowledge and understanding of standards as well as other related topics.

Research Resources on the Internet

- **International Association for the Evaluation of Educational Achievement (IEA)** - is an independent, international cooperative of national research institutions and governmental research agencies. Its primary purpose is to conduct large-scale comparative studies of educational achievement, with the aim of gaining a more in-depth understanding of the effects of policies and practices within and across systems in education. To find information about Trends in Mathematics and Science Study (TIMSS) go to this site.
  www.iea.nl/Home/home.html
- **International Study Center** - is the principle site for IEA's Trends in Mathematics and Science Study (TIMSS) which is an ongoing study scheduled to end in 2003. This site gives status of the current TIMSS study, elaborates on its framework, provides information for the previous TIMSS study, and details the specifics for other educational studies past and current.
  http://timss.bc.edu
- **National Assessment of Educational Progress (NAEP)**- also known as "the Nation's Report Card," is the only nationally representative and continuing assessment of what America's students know and can do in various subject areas. NAEP offers results regarding subject-matter achievement, instructional experiences, and school environment for populations of students (e.g., fourth-graders) and subgroups of those populations (e.g., female students, Hispanic students). From this site you can look at the data and use the data analysis tool to analyze the data.
  www.nces.ed.gov/nationsreportcard
- **North Central Regional Educational Laboratory** - is a nonprofit, organization providing research-based expertise, resources, assistance, and professional development opportunities to educators and policymakers. NCREL also supports advancing systemic change in mathematics and science education.
  www.ncrel.org
- **Project 2061**- is the long-term initiative of the American Association for the Advancement of Science (AAAS) working to reform kindergarten through grade 12 science, mathematics and technology education nationwide. This Internet site offers Standards for All Americans, professional development opportunities, methodology and an analysis of middle school textbooks for mathematics and science, based on the Project 2061 Standards.
  www.project2061.org
- **US National Research Center**- is a site funded by the National Science Foundation and the National Center for Education Statistics. There are several items of interest from this site related to TIMSS: Internet links and related resources; presentation materials; research and publications; and assessment items used for the study.
  http://timss.msu.edu

Research Publications

- American Association for the Advancement of Science: Project 2061, *Atlas of Science Literacy.* Washington, D.C.: Association For The Advancement of Science and National Science Teachers Association, 2001.
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