RULES AND REGULATIONS

Title 22—EDUCATION

STATE BOARD OF EDUCATION

[22 PA. CODE CH. 4]

Academic Standards and Assessment for Science and Technology and Environment and Ecology

The State Board of Education (Board) amends Chapter 4 (relating to academic standards and assessment) to add academic standards in science and technology and environment and ecology, to read as set forth in Annex A, under authority of the Public School Code of 1949 (24 P. S. §§ 1-101—27-2702).

Notice of proposed rulemaking was published at 31 Pa.B. 2136 (April 21, 2001) with an invitation to submit written comments.

Purpose

These final-form regulations add academic standards in science and technology and environment and ecology. The purpose of adding these requirements is to specify academic standards to be achieved by students enrolled in the public schools (including public charter schools) of this Commonwealth.

Comments and Responses

More than 120 individuals and organizations offered comments on the proposed rulemaking. Fourteen letters were received from members of the House and Senate Education Committees. In addition, the Independent Regulatory Review Commission (IRRC) offered detailed comments on the proposed rulemaking.

Evolution and the Theory of Evolution

In the proposed rulemaking, Standards 3.3.10.D and 3.3.12.D require what must be taught about evolution and the theory of evolution. A wide range of opinions and suggestions for change regarding evolution were expressed by public commentators and members of the House and Senate Education Committees. The majority of public commentators objected to the wording of these standards in the proposed rulemaking and stated that the theory of evolution was inappropriately singled out for critical analyses. They suggested that these standards would permit or even encourage schools to teach creationism or intelligent design. Others supported the wording in the proposed rulemaking because they believed that it would encourage healthy skepticism regarding evolution. Some suggested that schools be required to teach other theories of evolution, including intelligent design. Several suggested that it may be impossible to separate religious beliefs from the teaching of evolution and recommended that all mention of evolution regarding the origin of life be removed from the document. IRRC questioned the intent of these two standards and suggested that they duplicate standards in Section 3.2 Inquiry and Design that sets forth requirements for the examination of new data and critical evaluation of existing scientific theories.

Despite the reading that many had of these standards in the proposed rulemaking, the Board did not intend to encourage the teaching of creationism or intelligent design; standards were written to encourage critical thinking by students. To clarify this intent, a number of revisions have been made in these final-form regulations. The descriptor calling for students to analyze records and studies "that support or do not support the theory of evolution" in Standard 3.3.10.D has been substantially changed to call for students to analyze studies "relevant to the theory of evolution." The descriptor "Analyze the impact of new scientific facts on the theory of evolution" in Standard 3.3.12.D has been eliminated in these final-form regulations.

To reinforce the importance the Board places on critical thinking in the teaching of scientific theories, changes were made in Standard 3.2.12.A by specifying a number of theories (including the theory of evolution) which might be critically evaluated to meet the standard "Evaluate the nature of scientific and technological knowledge." In addition, the theory of evolution has been added as an example in Standards 3.1.10.E and 3.1.12.E in Section 3.1 Unifying Themes.

Because of the detailed attention to evolution in comments received by the Board, there were many suggestions to clarify and improve the wording of the individual standards in Section 3.2 Biology that deal with evolutionary concepts. As a result, specific changes have been made in these final-form regulations to Standards 3.3.4.C, 3.3.7.C and 3.3.12.C regarding inherited characteristics, gene mutation and natural selection. Specific changes were also made to Standards 3.3.7.D, 3.3.10.D and 3.3.12.D regarding individual differences, population growth, gene frequency and natural selection.

Clarifying the Meaning of Individual Standards

Several changes were recommended by commentators, members of the House Education Committee and IRRC to make individual standards more precise and clear. Standard 3.1.4.D in the proposed rulemaking states, "Describe scale as a ratio (such as, pipe fittings)." Members of the House Education Committee and IRRC commented that the use of "pipe fittings" as an example is confusing and recommended the use of model scales or map scales. The final-form regulations refer to "map scales" in Standard 3.1.4.D.

Standard 3.2.10.A in the proposed rulemaking stated, "Know that science is limited to the study of observable aspects of the world and universe." Commentators and IRRC noted that the term "observable" could be interpreted to mean "directly visible." IRRC recommended that since not all scientific phenomena can be "seen" directly, the term observable should be defined in Section IX Glossary. In response to these comments, the statement has been changed in the final-form regulations to state, "Know that science uses both direct and indirect observation means to study the world and the universe."

Standard 3.4.4.D required fourth graders to "Recognize the earth's place in the solar system" and to "explain (such as, days, seasons), major lunar phases and eclipses." Commentators and IRRC commented that this requirements are too abstract for fourth grade students to understand. IRRC noted that the proposal did not specify the depth of understanding of these concepts in the fourth grade and recommended that this be specified in the final-form rulemaking. After considering the comments, the Board did not elect to make changes to the Standard 3.4.4.D. Information and examples of the level of understanding required by this standard and others will be contained in the "Classrooms Connections" kits, other training and instructional materials and parent information.

Standard 3.5.4.D. in the proposed rulemaking required fourth grade students to "describe locations of fresh and salt water" in or near Pennsylvania. Also, 10th and 12th grade standards (Standards 3.5.10.D and 3.5.12.D) required students to compare sources of water and development of water use in Pennsylvania. Commentators and IRRC commented that these standards should not be limited to bodies of water in Pennsylvania. These final-form regulations revise Standards 3.5.4.D, 3.5.10.D and 3.5.12.D to more generally refer to sources of water and development of water use, thus not restricting study to Pennsylvania alone.

Standard 3.5.7.C in the proposed rulemaking, relating to meteorology for seventh graders, required students to "Identify cloud types, wind directions and barometric pressure changes are associated with weather patterns. . . ." Commentators and IRRC suggested that the comparable fourth grade standard should expect students to identify cloud types as a precursor for the seventh grade standard. The final-form regulations add an expectation for students to identify cloud types in Standard 3.5.4.C.

Agricultural Science

Commentators, members of the House Education Committee and IRRC stated the proposed standards did not adequately address the agricultural sciences as required by Chapter 4 or reflect the importance of agriculture and agricultural sciences in Pennsylvania. As a result, the Board has made a number of changes in these final-form regulations.

In the Science and Technology standards, language has been added to Section 3.6 Technology Education, specifically under the descriptors for Standards 3.6.7.A, 3.6.10.A and 3.6.12.A. Taken together these descriptors call for students to understand, describe and apply agricultural sciences and their impact and relationship to biotechnology. In Section 3.8 Science, Technology and Human Endeavors, additional descriptors have been added to Standards 3.8.7.B, 3.8.10.B and 3.8.12.B that call for students to identify, explain, assess and apply knowledge of agricultural sciences in meeting human needs.

In the Environment and Ecology standards, new standards in the final-form regulations have been added to Section 4.4 Agriculture and Society specific to agriculture and agricultural sciences. New Standards 4.4.4.B, 4.4.7.B, 4.4.10.B and 4.4.12.B require students to identify the role of the sciences in Pennsylvania agriculture, investigate how agricultural science has recognized the various soil types, assess the influence of agricultural science on farming practices and describe how agricultural science has influenced biotechnology. Each of these new standards also includes detailed descriptors.

IRRC suggested that Standard 4.8.12.B in the proposed rulemaking that required students to "analyze how technology has improved agricultural productivity" was more consistent with the standards under Section 4.4.12 relating to Agriculture and Society. In these final-form regulations, the standard has been eliminated in favor of more detailed standards in Section 4.4 that encompass concepts of agricultural productivity.

Implementation Concerns

Commentators and members of the House Education Committee raised concerns about the implementation of these science standards. First, there is a concern that these standards will change the current organization and sequencing of science courses and curricula at the high school level because there are standards for biology, chemistry, earth sciences and the like at both the 10th and 12th grade levels. It is anticipated that each district will be reviewing its current curriculum and will modify it where necessary to ensure that it is organized to enable students to meet these standards. Based on discussions with teachers and curriculum directors around the State, these standards will not require courses in each of the science disciplines each year; they will, however, encourage more integration in the science curriculum across the disciplines.

Second, a concern was expressed about when State assessments in science would be administered. Currently, state assessments in reading and mathematics are administered in grades 5, 8 and 11 while assessments in writing are administered in grades 6, 9 and 11. Science assessments will be administered based on the 4th, 7th and 10th grade standards. It is anticipated that science assessments will begin in the 2002-03 school year.

Changes for Clarity

IRRC recommended that the table of contents for both sets of standards list subject areas and categories with the same capital letters that label them in the text of the standards. That change was made in these final-form regulations to Section VII Table of Contents and Section X Table of Contents. IRRC recommended that the Section 3.2 Inquiry and Design, be changed to "Inquiry and Experimental Design" to accurately reflect its attention to experimental design. After considering the comment, the Board elected to retain the title as "Inquiry and Design" because the section relates not solely to experimental design, but also to technological processes, applications and design.

Misspellings, Punctuation Errors and Typographical Errors

The following corrections to the final-form as recommended by IRRC are made in these final-form regulations. "Ecology" was misspelled in the title of Section X Table of Contents in the *Pennsylvania Bulletin* version of the proposed rulemaking and is corrected in these final-form regulations. A typographical error occurred in the second sentence of the descriptor for Section 3.2 Inquiry and Design as published in the *Pennsylvania Bulletin*. These final-form regulations change the period to a comma after the word "estimating." An additional typographical error is corrected in the first sentence of Standard 3.2.10.C where "to" is changed to "of."

Additional Definitions

Commentators and the IRRC suggested that additional terms used in the text of the standards be defined in the glossaries of the standards found in Sections IX and XII. Terms used in the science and technology standards that are now defined in these final-form regulations are "evolution," "fact," "hypothesis," "law," "theory" and "theory of evolution." Terms used in the environment and ecology standards that are now defined in these final-form regulations are "commodities," "consumer," "decomposer," "endangered species," "environment," "extinction," "hazardous waste," "regulation" and "shredder." In addition, a more detailed definition of "risk management" has been added.

Affected Parties

These final-form regulations affect the students and professional employees of the public schools of this Commonwealth (including intermediate units, area vocational-technical schools, public charter and alternative schools).

Cost and Paperwork Estimates

Costs to implement these final-form regulations may include curriculum development and the professional development of teachers. These costs vary by school district. Curriculum development is an ongoing activity for schools and is typically part of their normal budgeting. Costs associated with aligning curricula with these standards at the local level will be minimized by the following efforts: technical assistance in curriculum development provided by Department staff; detailed implementation kits provided to school districts by the Department; and the Standards Implementation Project which funds Intermediate Unit services throughout this Commonwealth supporting the implementation of these and other standards. The majority of the cost to develop implementation kits was incurred in the previous fiscal year. Current year funds available to the Department to support curriculum alignment is $225,000.

Professional development of teachers is an ongoing activity for schools and is addressed in the normal budgeting of school districts. Specific programs designed to support the implementation of these standards will minimize any financial impact on school districts. These programs include professional development provided through the Standards Implementation Project and Governor's Academies for Teachers (currently provided in the Life Sciences, Technology, Physical Sciences and Environment and Ecology). In addition, the act of November 23, 1999 (P. L. 529, No. 48) (Act 48) establishing a requirement for all educators to engage in continuing professional education, further requires the Department to provide 40 hours of professional development annually at no cost to teachers. Online professional development courses are being developed for use in the current year for science and technology and environment and ecology. Current year funds available to the Department to support professional development is $730,000.

Effective Date

These final-form regulations will become effective upon final publication in the *Pennsylvania Bulletin*.

Sunset Date

The effectiveness of Chapter 4 will be reviewed by the Board every 4 years, in accordance with the Board's policy and practice respecting all regulations promulgated by the Board. Thus, no sunset date is necessary.

Regulatory Review

Under Section 5(a) of the Regulatory Review Act (71 P. S. § 745.5(a)), on April 11, 2001, the Board submitted a copy of the proposed rulemaking published at 31 Pa.B. 2136 to IRRC and to the Chairpersons of the House and Senate Committees on Education for review and comment.

In compliance with section 5(c) of the Regulatory Review Act, the Board also provided IRRC and the Committees with copies of the comments received as well as other documentation. In preparing the final-form regulations, the Board considered the comments received from IRRC, the Committees and the public.

Under section 5.1(d) of the Regulatory Review Act (71 P. S. § 745.5a(d)), the final-form regulations were approved by the Senate Education Committee on October 16, 2001, and approved by the House Education Committee on October 17, 2001. IRRC met on November 15, 2001, and approved the final-form regulations in accordance with section 5.1(e) of the Regulatory Review Act.

Contact Person

The official responsible for information on these final-form regulations is Peter H. Garland, Executive Director of the State Board of Education, 333 Market Street, Harrisburg, PA 17126-0333, (717) 787-3787 or TDD (717) 787-7367.

Findings

The Department finds that:

(1) Public notice of the intention to adopt these final-form regulations was given under sections 201 and 202 of the act of July 31, 1968 (P. L. 769, No. 240) (45 P. S. §§ 1201 and 1202) and the regulations promulgated thereunder in 1 Pa. Code §§ 7.1 and 7.2.

(2) A public comment period was provided as required by law and all comments were considered.

(3) The final-form regulations are necessary and appropriate for the administration of the act.

Order

The Board, acting under the authorizing statute, orders that:

(a) The regulations of the Board, 22 Pa. Code Chapter 4, are amended by adding Appendix B to read as set forth at Annex A.

(b) The Executive Director will submit this order and Annex A to the Office of General Counsel and the Office of Attorney General for review and approval as to legality and form as required by law.

(c) The Executive Director of the Board shall certify this order and Annex A and deposit them with the Legislative Reference Bureau as required by law.

(d) This order is effective upon final publication in the *Pennsylvania Bulletin*.

PETER H. GARLAND,
Executive Director

(*Editor's Note*: For the text of the order of the Independent Regulatory Review Commission relating to this document, see 31 Pa.B. 6587 (December 1, 2001).)

Fiscal Note: Fiscal Note 6-273 remains valid for the final adoption of the subject regulations.

Annex A

TITLE 22. EDUCATION

PART I. STATE BOARD OF EDUCATION

CHAPTER 4. ACADEMIC STANDARDS AND ASSESSEMENT

APPENDIX B

ACADEMIC STANDARDS FOR SCIENCE AND TECHNOLOGY AND ENVIRONMENT AND ECOLOGY

Academic Standards for Science and Technology

VII. TABLE OF CONTENTS

VIII. INTRODUCTION

This document describes what students should know and be able to do in the following eight areas:

- 3.1. Unifying Themes of Science
- 3.2. Inquiry and Design
- 3.3. Biological Sciences
- 3.4. Physical Science, Chemistry and Physics
- 3.5. Earth Sciences
- 3.6. Technology Education
- 3.7. Technological Devices
- 3.8. Science, Technology and Human Endeavors

These standards describe what students should know and be able to do by the end of fourth, seventh, tenth and twelfth grade. In addition, these standards reflect the increasing complexity and sophistication that students are expected to achieve as they progress through school.

This document avoids repetition, making an obvious progression across grade levels less explicit. Teachers shall expect that students know and can apply the concepts and skills expressed at the preceding level. Consequently, previous learning is reinforced but not retaught.

Standards are arranged by categories, for example, 3.5 Earth Science. Under each category are standard statements that are preceded by a capital letter; for example, in 3.1 Unifying Themes, grade 10.B, "Describe concepts of models as a way to predict and understand science and technology." Following the standard statements are bulleted standard descriptors, which explain the nature and scope of the standard. Descriptors specify the nature of the standard and the level of complexity needed in meeting that standard in a proficient manner. Descriptors serve to benchmark the standard statement. Curriculum, instruction and assessment should focus on meeting the standard statement. Technology education, computer applications and science are separate curricular areas. Meeting standards should be approached as a collaborative effort among all curricular areas.

The following descriptors explain the intent of each standard category:

3.1. Unifying Themes Unifying themes of science and technology provide big ideas that integrate with significant concepts. There are only a few fundamental concepts and processes that form the framework upon which science and technology knowledges are organized—motion and forces, energy, structure of matter, change over time and machines. These themes create the context through which the content of the disciplines can be taught and are emphasized in each standard.

3.2. Inquiry and Design The nature of science and technology is characterized by applying process knowledge that enables students to become independent learners. These skills include observing, classifying, inferring, predicting, measuring, computing, estimating, communicating, using space/time relationships, defining operationally, raising questions, formulating hypotheses, testing and experimenting, designing controlled experiments, recognizing variables, manipulating variables, interpreting data, formulating models, designing models, and producing solutions. Everyone can use them to solve real-life problems. These process skills are developed across the grade levels and differ in the degree of sophistication, quantitative nature and application to the content.

3.3. Biological Sciences	Biology concerns living things, their appearance, different types of life, the scope of their similarities and differences, where they live and how they live. Living things are made of the same components as all other matter, involve the same kinds of transformations of energy and move using the same basic kinds of forces as described in chemistry and physics standards. Through the study of the diversity of life, students learn to understand how life has changed over a long period of time. This great variety of life forms continues to change even today as genetic instructions within cells are passed from generation to generation, yet the amazing integrity of most species remain.
3.4. Physical Science Chemistry and Physics	Physics and chemistry involve the study of objects and their properties. Students examine changes to materials during mixing, freezing, heating and dissolving and then learn how to observe and measure results. In chemistry students study the relationship between matter, atomic structure and its activity. Laboratory investigations of the properties of substances and their changes through a range of chemical interactions provide a basis for students to understand atomic theory and a variety of reaction types and their applications in business, agriculture and medicine. Physics deepens the understanding of the structure and properties of materials and includes atoms, waves, light, electricity, magnetism and the role of energy, forces and motion.
3.5. Earth Sciences	The dynamics of earth science include the studies of forces of nature that build the earth and wear down the earth. The understanding of these concepts uses principles from physical sciences, geography and mathematics.
3.6. Technology Education	Technology education is the use of accumulated knowledge to process resources to meet human needs and improve the quality of life. Students develop the ability to select and correctly use materials, tools, techniques and processes to answer questions, understand explanations and solve problems encountered in real life situations. These overriding themes require students to design, create, use, evaluate and modify systems of Biotechnologies, Information Technologies, and Physical Technologies.
3.7. Technological Devices	Students use tools to observe, measure, move and make things. New technological tools and techniques make it possible to enact far-reaching changes in our world. Technology enhances the students' abilities to identify problems and determine solutions. Computers play an integral role in every day life by extending our abilities to collect, analyze and communicate information and ideas.
3.8. Science, Technology and Human Endeavors	Scientific knowledge and societal needs often create a demand for new technology. Conversely, new technology advances scientific knowledge. Both influence society through the impact of their products and processes.

What Is Science? Any study of science includes the search for understanding the natural world and facts, principles, theories and laws that have been verified by the scientific community and are used to explain and predict natural phenomena and events.

Acquiring scientific knowledge involves constructing hypotheses using observation and knowledge in the content area in order to formulate useful questions that provoke scientific inquiry. As a result of repeated, rigorous testing over time and applying multiple perspectives to a problem, consistent information emerges. A theory describes this verifiable event or phenomena. Theories are powerful elements in science and are used to predict other events. As theories lose their ability to predict, they are modified, expanded or generalized or incorporated into a broader theory.

Knowledge of what science is incorporates carefully developed and integrated components:

- **Nature of science**—the ways in which scientists search for answers to questions and explanations of observations about the natural world; includes process knowledge of observing, classifying, inferring, predicting, measuring, hypothesizing, experimenting and interpreting data
- **Unifying themes of science**—concepts, generalizations and principles that result from and lead to inquiry
- **Knowledge**—facts, principles, theories and laws verifiable through scientific inquiry by the world community of scientists; includes physics, chemistry, earth science and biological sciences
- **Inquiry**—an intellectual process of logic that includes verification of answers to questions about and explanations for natural objects, events and phenomena
- **Process skills**—Recognition by students how knowledge is acquired and applied in science by observing, classifying, inferring, predicting, measuring, computing, estimating, communicating, using space/time relationships, defining operationally, formulating hypotheses, testing and experimenting, designing controlled experiments, recognizing variables, manipulating variables, interpreting data, formulating models, designing models and producing solutions.
- **Problem solving**—application of concepts to problems of human adaptation to the environment that often leads to recognition of new problems; has social implications and leads to personal decision-making and action; a process which forms the link for interactions between scientific and technological results or findings; involves operational definitions, recognizing variables, formulating models and asking questions
- **Scientific thinking**—the disposition to suspend judgment, not make decisions and not take action until results, explanations or answers have been tested and verified with information.

What Is Technology Education? It is the means by which we teach technology. Technology is a body of knowledge separate from but related to the sciences, with specific content, curriculum and specific certification requirements. Technology is the application of tools, materials, processes and systems by humans to solve problems

and provide benefits to humankind. We use technology in an attempt to improve our environment. These improvements may relate to survival needs (e.g., food, shelter, defense) or they may relate to human aspirations (e.g., knowledge, art, control). They can include unexpected benefits, unexpected costs and unexpected risks.

Technology education involves a broad spectrum of knowledge and activities. Effective technology education combines knowledge of content, process and skills to provide students with a holistic approach to learning. Technology education offers unique opportunities to apply numerous academic concepts through practical, hands-on applications. Instructional technology, on the other hand, deals specifically with use of computers and different software to solve problems and communicate effectively. Knowledge of content, process and skills should be used together to effectively engage students and promote a complete understanding of the sciences, related technologies and their interrelationship. The relationship between science and technology is one where science builds principles or theories and technology provides the practical application of those principles or theories.

Knowledge of content, process and skills in technology involves learning processes that include these components:

- Methods of designing and developing solutions
- Standards for selecting and using appropriate materials, tools and processes
- Experimental and design specifications for testing and evaluating solutions
- Criteria for judging the performance and impact of the solutions
- Evaluating the impact of modifying a system to improve performance.

Technology education can be divided into three main systems that include biotechnological, informational, and physical technologies:

Biotechnological Systems	***Informational Systems***	***Physical Systems***
Bioconversion	Computer-Aided Drafting/Design (CADD)	Automation/Robotics
Bioprocessing	Drafting & Design	Computer-Aided and Integrated Manufacturing (CAM/CIM)
Environment	Desktop Publishing	Construction
Ergonomics	Electronic Communications	Electronic Circuits/Control Systems
Engineering/Design Systems	Engineering/Design Systems	Energy Systems
Research and Development	Graphic Communications	Architecture and Community Planning
	Communications Systems	Engineering/Design Systems
	Multimedia Technology	Enterprise Organization & Operation
	Networking Systems	Manufacturing
	Research and Development	Material Processes
	Video and Television Production	Research and Development
	World Wide Web Design & Publishing	Transportation

3.1. Unifying Themes			
3.1.4. GRADE 4	**3.1.7. GRADE 7**	**3.1.10. GRADE 10**	**3.1.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .			
A. Know that natural and human-made objects are made up of parts. • Identify and describe what parts make up a system. • Identify system parts that are natural and human-made (e.g., ball point pen, simple electrical circuits, plant anatomy). • Describe the purpose of analyzing systems. • Know that technologies include physical technology systems (e.g., construction, manufacturing, transportation), informational systems and biochemical-related systems.	A. Explain the parts of a simple system and their relationship to each other. • Describe a system as a group of related parts that work together to achieve a desired result (e.g., digestive system). • Explain the importance of order in a system. • Distinguish between system inputs, system processes and system outputs. • Distinguish between open loop and closed loop systems. • Apply systems analysis to solve problems.	A. Discriminate among the concepts of systems, subsystems, feedback and control in solving technological problems. • Identify the function of subsystems within a larger system (e.g., role of thermostat in an engine, pressure switch). • Describe the interrelationships among inputs, processes, outputs, feedback and control in specific systems. • Explain the concept of system redesign and apply it to improve technological systems. • Apply the universal systems model to illustrate specific solutions and troubleshoot specific problems. • Analyze and describe the effectiveness of systems to solve specific problems.	A. Apply concepts of systems, subsystems, feedback and control to solve complex technological problems. • Apply knowledge of control systems concept by designing and modeling control systems that solve specific problems. • Apply systems analysis to predict results. • Analyze and describe the function, interaction and relationship among subsystems and the system itself. • Compare and contrast several systems that could be applied to solve a single problem. • Evaluate the causes of a system's inefficiency.
B. Know models as useful simplifications of objects or processes. • Identify different types of models. • Identify and apply models as tools for prediction and insight. • Apply appropriate simple modeling tools and techniques. • Identify theories that serve as models (e.g., molecules).	B. Describe the use of models as an application of scientific or technological concepts. • Identify and describe different types of models and their functions. • Apply models to predict specific results and observations (e.g., population growth, effects of infectious organisms). • Explain systems by outlining a system's relevant parts and its purpose and/or designing a model that illustrates its function.	B. Describe concepts of models as a way to predict and understand science and technology. • Distinguish between different types of models and modeling techniques and apply their appropriate use in specific applications (e.g., kinetic gas theory, DNA). • Examine the advantages of using models to demonstrate processes and outcomes (e.g., blue print analysis, structural stability). • Apply mathematical models to science and technology.	B. Apply concepts of models as a method to predict and understand science and technology. • Evaluate technological processes by collecting data and applying mathematical models (e.g., process control). • Apply knowledge of complex physical models to interpret data and apply mathematical models. • Appraise the importance of computer models in interpreting science and technological systems.

3.1. Unifying Themes			
3.1.4. GRADE 4	**3.1.7. GRADE 7**	**3.1.10. GRADE 10**	**3.1.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .			
C. Illustrate patterns that regularly occur and reoccur in nature. • Identify observable patterns (e.g., growth patterns in plants, crystal shapes in minerals, climate, structural patterns in bird feathers). • Use knowledge of natural patterns to predict next occurrences (e.g., seasons, leaf patterns, lunar phases).	C. Identify patterns as repeated processes or recurring elements in science and technology. • Identify different forms of patterns and use them to group and classify specific objects. • Identify repeating structure patterns. • Identify and describe patterns that occur in physical systems (e.g., construction, manufacturing, transportation), informational systems and biochemical-related systems.	C. Apply patterns as repeated processes or recurring elements in science and technology. • Examine and describe recurring patterns that form the basis of biological classification, chemical periodicity, geological order and astronomical order. • Examine and describe stationary physical patterns. • Examine and describe physical patterns in motion.	C. Assess and apply patterns in science and technology. • Assess and apply recurring patterns in natural and technological systems. • Compare and contrast structure and function relationships as they relate to patterns. • Assess patterns in nature using mathematical formulas.
D. Know that scale is an important attribute of natural and human made objects, events and phenomena. • Identify the use of scale as it relates to the measurement of distance, volume and mass. • Describe scale as a ratio (e.g., map scales). • Explain the importance of scale in producing models and apply it to a model.	D. Explain scale as a way of relating concepts and ideas to one another by some measure. • Apply various applications of size and dimensions of scale to scientific, mathematical, and technological applications. • Describe scale as a form of ratio and apply to a life situation.	D. Apply scale as a way of relating concepts and ideas to one another by some measure. • Apply dimensional analysis and scale as a ratio. • Convert one scale to another.	D. Analyze scale as a way of relating concepts and ideas to one another by some measure. • Compare and contrast various forms of dimensional analysis. • Assess the use of several units of measurement to the same problem. • Analyze and apply appropriate measurement scales when collecting data.

3.1. Unifying Themes			
3.1.4. GRADE 4	**3.1.7. GRADE 7**	**3.1.10. GRADE 10**	**3.1.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to . . .			
E. Recognize change in natural and physical systems. • Recognize change as fundamental to science and technology concepts. • Examine and explain change by using time and measurement. • Describe relative motion. • Describe the change to objects caused by heat, cold, light or chemicals.	E. Identify change as a variable in describing natural and physical systems. • Describe fundamental science and technology concepts that could solve practical problems. • Explain how ratio is used to describe change. • Describe the effect of making a change in one part of a system on the system as a whole.	E. Describe patterns of change in nature, physical and man made systems. • Describe how fundamental science and technology concepts are used to solve practical problems (e.g., momentum, Newton's laws of universal gravitation, tectonics, conservation of mass and energy, cell theory, theory of evolution, atomic theory, theory of relativity, Pasteur's germ theory, relativity, heliocentric theory, gas laws, feedback systems). • Recognize that stable systems often involve underlying dynamic changes (e.g., a chemical reaction at equilibrium has molecules reforming continuously). • Describe the effects of error in measurements. • Describe changes to matter caused by heat, cold, light or chemicals using a rate function.	E. Evaluate change in nature, physical systems and man made systems. • Evaluate fundamental science and technology concepts and their development over time (e.g., DNA, cellular respiration, unified field theory, energy measurement, automation, miniaturization, Copernican and Ptolemaic universe theories). • Analyze how models, systems and technologies have changed over time (e.g., germ theory, theory of evolution, solar system, cause of fire). • Explain how correlation of variables does not necessarily imply causation. • Evaluate the patterns of change within a technology (e.g., changes in engineering in the automotive industry).

3.2. Inquiry and Design			
3.2.4. GRADE 4	**3.2.7. GRADE 7**	**3.2.10. GRADE 10**	**3.2.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Identify and use the nature of scientific and technological knowledge. • Distinguish between a scientific fact and a belief. • Provide clear explanations that account for observations and results. • Relate how new information can change existing perceptions.	A. Explain and apply scientific and technological knowledge. • Distinguish between a scientific theory and a belief. • Answer "What if" questions based on observation, inference or prior knowledge or experience. • Explain how skepticism about an accepted scientific explanation led to a new understanding. • Explain how new information may change existing theories and practice.	A. Apply knowledge and understanding about the nature of scientific and technological knowledge. • Compare and contrast scientific theories and beliefs. • Know that science uses both direct and indirect observation means to study the world and the universe. • Integrate new information into existing theories and explain implied results.	A. Evaluate the nature of scientific and technological knowledge. • Know and use the ongoing scientific processes to continually improve and better understand how things work. • Critically evaluate the status of existing theories (e.g., germ theory of disease, wave theory of light, classification of subatomic particles, theory of evolution, epidemiology of AIDS).
B. Describe objects in the world using the five senses. • Recognize observational descriptors from each of the five senses (e.g., see-blue, feel-rough). • Use observations to develop a descriptive vocabulary.	B. Apply process knowledge to make and interpret observations. • Measure materials using a variety of scales. • Describe relationships by making inferences and predictions. • Communicate, use space/time relationships, define operationally, raise questions, formulate hypotheses, test and experiment. • Design controlled experiments, recognize variables, and manipulate variables. • Interpret data, formulate models, design models, and produce solutions.	B. Apply process knowledge and organize scientific and technological phenomena in varied ways. • Describe materials using precise quantitative and qualitative skills based on observations. • Develop appropriate scientific experiments: raising questions, formulating hypotheses, testing, controlled experiments, recognizing variables, manipulating variables, interpreting data, and producing solutions. • Use process skills to make inferences and predictions using collected information and to communicate, using space/time relationships, defining operationally.	B. Evaluate experimental information for appropriateness and adherence to relevant science processes. • Evaluate experimental data correctly within experimental limits. • Judge that conclusions are consistent and logical with experimental conditions. • Interpret results of experimental research to predict new information or improve a solution.

3.2. Inquiry and Design			
3.2.4. GRADE 4	**3.2.7. GRADE 7**	**3.2.10. GRADE 10**	**3.2.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
C. Recognize and use the elements of scientific inquiry to solve problems. • Generate questions about objects, organisms and/or events that can be answered through scientific investigations. • Design an investigation. • Conduct an experiment. • State a conclusion that is consistent with the information.	C. Identify and use the elements of scientific inquiry to solve problems. • Generate questions about objects, organisms and/or events that can be answered through scientific investigations. • Evaluate the appropriateness of questions. • Design an investigation with limited variables to investigate a question. • Conduct a two-part experiment. • Judge the significance of experimental information in answering the question. • Communicate appropriate conclusions from the experiment.	C. Apply the elements of scientific inquiry to solve problems. • Generate questions about objects, organisms and/or events that can be answered through scientific investigations. • Evaluate the appropriateness of questions. • Design an investigation with adequate control and limited variables to investigate a question. • Conduct a multiple step experiment. • Organize experimental information using a variety of analytic methods. • Judge the significance of experimental information in answering the question. • Suggest additional steps that might be done experimentally.	C. Apply the elements of scientific inquiry to solve multi-step problems. • Generate questions about objects, organisms and/or events that can be answered through scientific investigations. • Evaluate the appropriateness of questions. • Design an investigation with adequate control and limited variables to investigate a question. • Organize experimental information using analytic and descriptive techniques. • Evaluate the significance of experimental information in answering the question. • Project additional questions from a research study that could be studied.
D. Recognize and use the technological design process to solve problems. • Recognize and explain basic problems. • Identify possible solutions and their course of action. • Try a solution. • Describe the solution, identify its impacts and modify if necessary. • Show the steps taken and the results.	D. Know and use the technological design process to solve problems. • Define different types of problems. • Define all aspects of the problem, necessary information and questions that must be answered. • Propose the best solution. • Design and propose alternative methods to achieve solutions. • Apply a solution. • Explain the results, present improvements, identify and infer the impacts of the solution.	D. Identify and apply the technological design process to solve problems. • Examine the problem, rank all necessary information and all questions that must be answered. • Propose and analyze a solution. • Implement the solution. • Evaluate the solution, test, redesign and improve as necessary. • Communicate the process and evaluate and present the impacts of the solution.	D. Analyze and use the technological design process to solve problems. • Assess all aspects of the problem, prioritize the necessary information and formulate questions that must be answered. • Propose, develop and appraise the best solution and develop alternative solutions. • Implement and assess the solution. • Evaluate and assess the solution, redesign and improve as necessary. • Communicate and assess the process and evaluate and present the impacts of the solution.

3.3. Biological Sciences			
3.3.4. GRADE 4	**3.3.7. GRADE 7**	**3.3.10. GRADE 10**	**3.3.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Know the similarities and differences of living things. • Identify life processes of living things (e.g., growth, digestion, react to environment). • Know that some organisms have similar external characteristics (e.g., anatomical characteristics; appendages, type of covering, body segments) and that similarities and differences are related to environmental habitat. • Describe basic needs of plants and animals.	A. Describe the similarities and differences that characterize diverse living things. • Describe how the structures of living things help them function in unique ways. • Explain how to use a dichotomous key to identify plants and animals. • Account for adaptations among organisms that live in a particular environment.	A. Explain the structural and functional similarities and differences found among living things. • Identify and characterize major life forms according to their placement in existing classification groups. • Explain the relationship between structure and function at the molecular and cellular levels. • Describe organizing schemes of classification keys. • Identify and characterize major life forms by kingdom, phyla, class and order.	A. Explain the relationship between structure and function at all levels of organization. • Identify and explain interactions among organisms (e.g., mutually beneficial, harmful relationships). • Explain and analyze the relationship between structure and function at the molecular, cellular and organ-system level. • Describe and explain structural and functional relationships in each of the five (or six) kingdoms. • Explain significant biological diversity found in each of the biomes.
B. Know that living things are made up of parts that have specific functions. • Identify examples of unicellular and multicellular organisms. • Determine how different parts of a living thing work together to make the organism function.	B. Describe the cell as the basic structural and functional unit of living things. • Identify the levels of organization from cell to organism. • Compare life processes at the organism level with life processes at the cell level. • Explain that cells and organisms have particular structures that underlie their functions. • Describe and distinguish among cell cycles, reproductive cycles and life cycles. • Explain disease effects on structures or functions of an organism.	B. Describe and explain the chemical and structural basis of living organisms. • Describe the relationship between the structure of organic molecules and the function they serve in living organisms. • Identify the specialized structures and regions of the cell and the functions of each. • Explain how cells store and use information to guide their functions. • Explain cell functions and processes in terms of chemical reactions and energy changes.	B. Analyze the chemical and structural basis of living organisms. • Identify and describe factors affecting metabolic function (e.g., temperature, acidity, hormones). • Evaluate metabolic activities using experimental knowledge of enzymes. • Evaluate relationships between structure and functions of different anatomical parts given their structure. • Describe potential impact of genome research on the biochemistry and physiology of life.

3.3. Biological Sciences			
3.3.4. GRADE 4	**3.3.7. GRADE 7**	**3.3.10. GRADE 10**	**3.3.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
C. Know that characteristics are inherited and, thus, offspring closely resemble their parents. • Identify characteristics for animal and plant survival in different climates. • Identify physical characteristics that appear in both parents and offspring and differ between families, strains or species.	C. Know that every organism has a set of genetic instructions that determines its inherited traits. • Identify and explain inheritable characteristics. • Identify that the gene is the basic unit of inheritance. • Identify basic patterns of inheritance (e.g., dominance, recessive, codominance). • Describe how traits are inherited. • Distinguish how different living things reproduce (e.g., vegetative budding, sexual). • Recognize that mutations can alter a gene. • Describe how selective breeding, natural selection and genetic technologies can change genetic makeup of organisms.	C. Describe how genetic information is inherited and expressed. • Compare and contrast the function of mitosis and meiosis. • Describe mutations' effects on a trait's expression. • Distinguish different reproductive patterns in living things (e.g., budding, spores, fission). • Compare random and selective breeding practices and their results (e.g., antibiotic resistant bacteria). • Explain the relationship among DNA, genes and chromosomes. • Explain different types of inheritance (e.g., multiple allele, sex-influenced traits). • Describe the role of DNA in protein synthesis as it relates to gene expression.	C. Explain gene inheritance and expression at the molecular level. • Analyze gene expression at the molecular level. • Describe the roles of nucleic acids in cellular reproduction and protein synthesis. • Describe genetic engineering techniques, applications and impacts. • Explain birth defects from the standpoint of embryological development and/or changes in genetic makeup.

3.3. Biological Sciences			
3.3.4. GRADE 4	**3.3.7. GRADE 7**	**3.3.10. GRADE 10**	**3.3.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
D. Identify changes in living things over time. • Compare extinct life forms with living organisms.	D. Explain basic concepts of natural selection. • Identify adaptations that allow organisms to survive in their environment. • Describe how an environmental change can affect the survival of organisms and entire species. • Know that differences in individuals of the same species may give some advantage in surviving and reproducing. • Recognize that populations of organisms can increase rapidly. • Describe the role that fossils play in studying the past. • Explain how biologic extinction is a natural process.	D. Explain the mechanisms of the theory of evolution. • Analyze data from fossil records, similarities in anatomy and physiology, embryological studies and DNA studies that are relevent to the theory of evolution. • Explain the role of mutations and gene recombination in changing a population of organisms. • Compare modern day descendents of extinct species and propose possible scientific accounts for their present appearance. • Describe the factors (e.g., isolation, differential reproduction) affecting gene frequency in a population over time and their consequences. • Describe and differentiate between the roles of natural selection and genetic drift. • Describe changes that illustrate major events in the earth's development based on a time line. • Explain why natural selection can act only on inherited traits. • Apply the concept of natural selection to illustrate and account for a species' survival, extinction or change over time.	D. Analyze the theory of evolution. • Examine human history by describing the progression from early hominids to modern humans. • Apply the concept of natural selection as a central concept in illustrating evolution theory.
Ecosystem Standards are in the Environment and Ecology Standard Category (4.6).			

3.4. Physical Science, Chemistry and Physics			
3.4.4. GRADE 4	**3.4.7. GRADE 7**	**3.4.10. GRADE 10**	**3.4.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Recognize basic concepts about the structure and properties of matter. • Describe properties of matter (e.g., hardness, reactions to simple chemical tests). • Know that combining two or more substances can make new materials with different properties. • Know different material characteristics (e.g., texture, state of matter, solubility).	A. Describe concepts about the structure and properties of matter. • Identify elements as basic building blocks of matter that cannot be broken down chemically. • Distinguish compounds from mixtures. • Describe and conduct experiments that identify chemical and physical properties. • Describe reactants and products of simple chemical reactions.	A. Explain concepts about the structure and properties of matter. • Know that atoms are composed of even smaller sub-atomic structures whose properties are measurable. • Explain the repeating pattern of chemical properties by using the repeating patterns of atomic structure within the periodic table. • Predict the behavior of gases through the use of Boyle's, Charles' or the ideal gas law, in everyday situations. • Describe phases of matter according to the Kinetic Molecular Theory. • Explain the formation of compounds and their resulting properties using bonding theories (ionic and covalent). • Recognize formulas for simple inorganic compounds. • Describe various types of chemical reactions by applying the laws of conservation of mass and energy. • Apply knowledge of mixtures to appropriate separation techniques. • Understand that carbon can form several types of compounds.	A. Apply concepts about the structure and properties of matter. • Apply rules of systematic nomenclature and formula writing to chemical substances. • Classify and describe, in equation form, types of chemical and nuclear reactions. • Explain how radioactive isotopes that are subject to decay can be used to estimate the age of materials. • Explain how the forces that bind solids, liquids and gases affect their properties. • Characterize and identify important classes of compounds (e.g., acids, bases, salts). • Apply the conservation of energy concept to fields as diverse as mechanics, nuclear particles and studies of the origin of the universe. • Apply the predictability of nuclear decay to estimate the age of materials that contain radioactive isotopes. • Quantify the properties of matter (e.g., density, solubility coefficients) by applying mathematical formulas.

3.4. Physical Science, Chemistry and Physics			
3.4.4. GRADE 4	**3.4.7. GRADE 7**	**3.4.10. GRADE 10**	**3.4.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
B. Know basic energy types, sources and conversions. • Identify energy forms and examples (e.g., sunlight, heat, stored, motion). • Know the concept of the flow of energy by measuring flow through an object or system. • Describe static electricity in terms of attraction, repulsion and sparks. • Apply knowledge of the basic electrical circuits to design and construction simple direct current circuits. • Classify materials as conductors and nonconductors. • Know and demonstrate the basic properties of heat by producing it in a variety of ways. • Know the characteristics of light (e.g., reflection, refraction, absorption) and use them to produce heat, color or a virtual image.	B. Relate energy sources and transfers to heat and temperature. • Identify and describe sound changes in moving objects. • Know that the sun is a major source of energy that emits wavelengths of visible light, infrared and ultraviolet radiation. • Explain the conversion of one form of energy to another by applying knowledge of each form of energy. • Explain the parts and functions in an electrical circuit.	B. Analyze energy sources and transfers of heat. • Determine the efficiency of chemical systems by applying mathematical formulas. • Use knowledge of chemical reactions to generate an electrical current. • Evaluate energy changes in chemical reactions. • Use knowledge of conservation of energy and momentum to explain common phenomena (e.g., refrigeration system, rocket propulsion). • Explain resistance, current and electromotive force (Ohm's Law).	B. Apply and analyze energy sources and conversions and their relationship to heat and temperature. • Determine the heat involved in illustrative chemical reactions. • Evaluate mathematical formulas that calculate the efficiency of specific chemical and mechanical systems. • Use knowledge of oxidation and reduction to balance complex reactions. • Apply appropriate thermodynamic concepts (e.g., conservation, entropy) to solve problems relating to energy and heat.

3.4. Physical Science, Chemistry and Physics			
3.4.4. GRADE 4	**3.4.7. GRADE 7**	**3.4.10. GRADE 10**	**3.4.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
C. Observe and describe different types of force and motion. • Identify characteristics of sound (pitch, loudness and echoes). • Recognize forces that attract or repel other objects and demonstrate them. • Describe various types of motions. • Compare the relative movement of objects and describe types of motion that are evident. • Describe the position of an object by locating it relative to another object or the background (e.g., geographic direction, left, up).	C. Identify and explain the principles of force and motion. • Describe the motion of an object based on its position, direction and speed. • Classify fluid power systems according to fluid used or mode of power transmission (e.g., air, oil). • Explain various motions using models. • Explain how convex and concave mirrors and lens change light images. • Explain how sound and light travel in waves of differing speeds, sizes and frequencies.	C. Distinguish among the principles of force and motion. • Identify the relationship of electricity and magnetism as two aspects of a single electromagnetic force. • Identify elements of simple machines in compound machines. • Explain fluid power systems through the design and construction of appropriate models. • Describe sound effects (e.g., Doppler effect, amplitude, frequency, reflection, refraction, absorption, sonar, seismic). • Describe light effects (e.g., Doppler effect, dispersion, absorption, emission spectra, polarization, interference). • Describe and measure the motion of sound, light and other objects. • Know Newton's laws of motion (including inertia, action and reaction) and gravity and apply them to solve problems related to forces and mass. • Determine the efficiency of mechanical systems by applying mathematical formulas.	C. Apply the principles of motion and force. • Evaluate wave properties of frequency, wavelength and speed as applied to sound and light through different media. • Propose and produce modifications to specific mechanical power systems that will improve their efficiency. • Analyze the principles of translational motion, velocity and acceleration as they relate to free fall and projectile motion. • Analyze the principles of rotational motion to solve problems relating to angular momentum, and torque. • Interpret a model that illustrates circular motion and acceleration. • Describe inertia, motion, equilibrium, and action/reaction concepts through words, models and mathematical symbols.

3.4. Physical Science, Chemistry and Physics			
3.4.4. GRADE 4	**3.4.7. GRADE 7**	**3.4.10. GRADE 10**	**3.4.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
D. Describe the composition and structure of the universe and the earth's place in it. • Recognize earth's place in the solar system. • Explain and illustrate the causes of seasonal changes. • Identify planets in our solar system and their general characteristics. • Describe the solar system motions and use them to explain time (e.g., days, seasons), major lunar phases and eclipses.	D. Describe essential ideas about the composition and structure of the universe and the earth's place in it. • Compare various planets' characteristics. • Describe basic star types and identify the sun as a star type. • Describe and differentiate comets, asteroids and meteors. • Identify gravity as the force that keeps planets in orbit around the sun and governs the rest of the movement of the solar system and the universe. • Illustrate how the position of stars and constellations change in relation to the Earth during an evening and from month to month. • Identify equipment and instruments that explore the universe. • Identify the accomplishments and contributions provided by selected past and present scientists in the field of astronomy. • Identify and articulate space program efforts to investigate possibilities of living in space and on other planets.	D. Explain essential ideas about the composition and structure of the universe. • Compare the basic structures of the universe (e.g., galaxy types, nova, black holes, neutron stars). • Describe the structure and life cycle of star, using the Hertzsprung-Russell diagram. • Describe the nuclear processes involved in energy production in a star. • Explain the "red-shift" and Hubble's use of it to determine stellar distance and movement. • Compare absolute versus apparent star magnitude and their relation to stellar distance. • Explain the impact of the Copernican and Newtonian thinking on man's view of the universe. • Identify and analyze the findings of several space instruments in regard to the extent and composition of the solar system and universe.	D. Analyze the essential ideas about the composition and structure of the universe. • Analyze the Big Bang Theory's use of gravitation and nuclear reaction to explain a possible origin of the universe. • Compare the use of visual, radio and x-ray telescopes to collect data regarding the structure and evolution of the universe. • Correlate the use of the special theory of relativity and the life of a star.
Refer to Technology Standard Category 3.6 for applied uses of these concepts and principles.			

3.5. Earth Sciences			
3.5.4. GRADE 4	**3.5.7. GRADE 7**	**3.5.10. GRADE 10**	**3.5.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Know basic landforms and earth history. • Describe earth processes (e.g., rusting, weathering, erosion) that have affected selected physical features in students' neighborhoods. • Identify various earth structures (e.g., mountains, faults, drainage basins) through the use of models. • Identify the composition of soil as weathered rock and decomposed organic remains. • Describe fossils and the type of environment they lived in (e.g., tropical, aquatic, desert).	A. Describe earth features and processes. • Describe major layers of the earth. • Describe the processes involved in the creation of geologic features (e.g., folding, faulting, volcanism, sedimentation) and that these processes seen today (e.g., erosion, weathering crustal plate movement) are similar to those in the past. • Describe the processes that formed Pennsylvania geologic structures and resources including mountains, glacial formations, water gaps and ridges. • Explain how the rock cycle affected rock formations in the state of Pennsylvania. • Distinguish between examples of rapid surface changes (e.g., landslides, earthquakes) and slow surface changes (e.g., weathering). • Identify living plants and animals that are similar to fossil forms.	A. Relate earth features and processes that change the earth. • Illustrate and explain plate tectonics as the mechanism of continental movement and sea floor changes. • Compare examples of change to the earth's surface over time as they related to continental movement and ocean basin formation (e.g., Delaware, Susquehanna, Ohio Rivers system formations, dynamics). • Interpret topographic maps to identify and describe significant geologic history/ structures in Pennsylvania. • Evaluate and interpret geologic history using geologic maps. • Explain several methods of dating earth materials and structures. • Correlate rock units with general geologic time periods in the history of the earth. • Describe and identify major types of rocks and minerals.	A. Analyze and evaluate earth features and processes that change the earth. • Apply knowledge of geophysical processes to explain the formation and degradation of earth structures (e.g., mineral deposition, cave formations, soil composition). • Interpret geological evidence supporting evolution. • Apply knowledge of radioactive decay to assess the age of various earth features and objects.

3.5. Earth Sciences			
3.5.4. GRADE 4	**3.5.7. GRADE 7**	**3.5.10. GRADE 10**	**3.5.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
B. Know types and uses of earth materials. • Identify uses of various earth materials (e.g., buildings, highways, fuels, growing plants). • Identify and sort earth materials according to a classification key (e.g., soil/rock type).	B. Recognize earth resources and how they affect everyday life. • Identify and locate significant earth resources (e.g., rock types, oil, gas, coal deposits) in Pennsylvania. • Explain the processes involved in the formation of oil and coal in Pennsylvania. • Explain the value and uses of different earth resources (e.g., selected minerals, ores, fuel sources, agricultural uses). • Compare the locations of human settlements as related to available resources.	B. Explain sources and uses of earth resources. • Compare the locations of strategic minerals and earth resources in the world with their geologic history using maps and global information systems. • Demonstrate the effects of sedimentation and erosion before and after a conservation plan is implemented. • Evaluate the impact of geologic activities/ hazards (e.g., earthquakes, sinkholes, landslides). • Evaluate land use (e.g., agricultural, recreational, residential, commercial) in Pennsylvania based upon soil characteristics.	B. Analyze the availability, location and extraction of earth resources. • Describe how the location of earth's major resources has affected a country's strategic decisions. • Compare locations of earth features and country boundaries. • Analyze the impact of resources (e.g., coal deposits, rivers) on the life of Pennsylvania's settlements and cities.
C. Know basic weather elements. • Identify cloud types. • Identify weather patterns from data charts (including temperature, wind direction and speed, precipitation) and graphs of the data. • Explain how the different seasons effect plants, animals, food availability and daily human life.	C. Describe basic elements of meteorology. • Explain weather forecasts by interpreting weather data and symbols. • Explain the oceans' impact on local weather and the climate of a region. • Identify how cloud types, wind directions and barometric pressure changes are associated with weather patterns in different regions of the country. • Explain and illustrate the processes of cloud formation and precipitation. • Describe and illustrate the major layers of the earth's atmosphere. • Identify different air masses and global wind patterns and how they relate to the weather patterns in different regions of the U.S.	C. Interpret meteorological data. • Analyze information from meteorological instruments and online sources to predict weather patterns. • Describe weather and climate patterns on global levels. • Evaluate specific adaptations plants and animals have made that enable them to survive in different climates.	C. Analyze atmospheric energy transfers. • Describe how weather and climate involve the transfer of energy in and out of the atmosphere. • Explain how unequal heating of the air, ocean and land produces wind and ocean currents. • Analyze the energy transformations that occur during the greenhouse effect and predict the long-term effects of increased pollutant levels in the atmosphere. • Analyze the mechanisms that drive a weather phenomena (e.g., El Nino, hurricane, tornado) using the correlation of three methods of heat energy transfer.

3.5. Earth Sciences			
3.5.4. GRADE 4	**3.5.7. GRADE 7**	**3.5.10. GRADE 10**	**3.5.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
D. Recognize the earth's different water resources. • Know that approximately three-fourths of the earth is covered by water. • Identify and describe types of fresh and saltwater bodies. • Identify examples of water in the form of solid, liquid and gas on or near the surface of the earth. • Explain and illustrate evaporation and condensation. • Recognize other resources available from water (e.g., energy, transportation, minerals, food).	D. Explain the behavior and impact of the earth's water systems. • Explain the water cycle using the processes of evaporation and condensation. • Describe factors that affect evaporation and condensation. • Distinguish salt from fresh water (e.g., density, electrical conduction). • Compare the effect of water type (e.g., polluted, fresh, salt water) and the life contained in them. • Identify ocean and shoreline features (e.g., bays, inlets, spit, tidal marshes).	D. Assess the value of water as a resource. • Compare specific sources of potable water (e.g., wells, public systems, rivers) used by people in Pennsylvania. • Identify the components of a municipal/agricultural water supply system and a wastewater treatment system. • Relate aquatic life to water conditions (e.g., turbidity, temperature, salinity, dissolved oxygen, nitrogen levels, pressure). • Compare commercially important aquatic species in or near Pennsylvania. • Identify economic resources found in marine areas. • Assess the natural and man-made factors that affect the availability of clean water (e.g., rock and mineral deposits, man-made pollution).	D. Analyze the principles and history of hydrology. • Analyze the operation and effectiveness of a water purification and desalination system. • Evaluate the pros and cons of surface water appropriation for commercial and electrical use. • Analyze the historical development of water use in Pennsylvania (e.g., recovery of Lake Erie). • Compare the marine life and type of water found in the intertidal, neritic and bathyal zones.
Refer to Environment and Ecology Standards Categories 4.1, 4.3, 4.8 for standards that deal with environmental impact of Earth structures and forces.			

3.6. Technology Education			
3.6.4. GRADE 4	**3.6.7. GRADE 7**	**3.6.10. GRADE 10**	**3.6.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Know that biotechnologies relate to propagating, growing, maintaining, adapting, treating and converting. • Identify agricultural and industrial production processes that involve plants and animals. • Identify waste management treatment processes. • Describe how knowledge of the human body influences or impacts ergonomic design. • Describe how biotechnology has impacted various aspects of daily life (e.g., health care, agriculture, waste treatment).	A. Explain biotechnologies that relate to related technologies of propagating, growing, maintaining, adapting, treating and converting. • Identify the environmental, societal and economic impacts that waste has in the environment. • Identify and explain the impact that a specific medical advancement has had on society. • Explain the factors that were taken into consideration when a specific object was designed. • Define and describe how fuels and energy can be generated through the process of biomass conversion. • Identify and group basic plant and animal production processes. • Explain the impact that agricultural science has had on biotechnology.	A. Apply biotechnologies that relate to propagating, growing, maintaining, adapting, treating and converting. • Apply knowledge of plant and animal production processes in designing an improvement to existing processes. • Apply knowledge of biomedical technology applications in designing a solution to a simple medical problem (e.g., wheel chair design, artificial arteries). • Apply knowledge of how biomedical technology affects waste products in designing a solution that will result in reduced waste. • Apply ergonomic engineering factors when devising a solution to a specific problem. • Describe various methods of biochemical conversion. • Describe specific examples that reflect the impact that agricultural science has had on biotechnology.	A. Analyze biotechnologies that relate to propagating, growing, maintaining, adapting, treating and converting. • Analyze and solve a complex production process problem using biotechnologies (e.g., hydroponics, fish farming, crop propagation). • Analyze specific examples where engineering has impacted society in protection, personal health application or physical enhancement. • Appraise and evaluate the cause and effect and subsequent environmental, economic and societal impacts that result from biomass and biochemical conversion. • Evaluate and apply biotechnical processes to complex plant and animal production methods. • Apply knowledge of biochemical-related technologies to propose alternatives to hazardous waste treatment. • Apply knowledge of agricultural science to solve or improve a biochemical related problem.

3.6. Technology Education			
3.6.4. GRADE 4	**3.6.7. GRADE 7**	**3.6.10. GRADE 10**	**3.6.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
B. Know that information technologies involve encoding, transmitting, receiving, storing, retrieving and decoding. • Identify electronic communication methods that exist in the community (e.g., digital cameras, telephone, internet, television, fiber optics). • Identify graphic reproduction methods. • Describe appropriate image generating techniques (e.g., photography, video). • Demonstrate the ability to communicate an idea by applying basic sketching and drawing techniques.	B. Explain information technologies of encoding, transmitting, receiving, storing, retrieving and decoding. • Demonstrate the effectiveness of image generating technique to communicate a story (e.g., photography, video). • Analyze and evaluate the effectiveness of a graphic object designed and produced to communicate a thought or concept. • Apply basic technical drawing techniques to communicate an idea or solution to a problem. • Apply the appropriate method of communications technology to communicate a thought.	B. Apply knowledge of information technologies of encoding, transmitting, receiving, storing, retrieving and decoding. • Describe the proper use of graphic and electronic communication systems. • Apply a variety of advanced mechanical and electronic drafting methods to communicate a solution to a specific problem. • Apply and analyze advanced communication techniques to produce an image that effectively conveys a message (e.g., desktop publishing, audio and/or video production). • Illustrate an understanding of a computer network system by modeling, constructing or assembling its components.	B. Analyze knowledge of information technologies of processes encoding, transmitting, receiving, storing, retrieving and decoding. • Apply and analyze advanced information techniques to produce a complex image that effectively conveys a message (e.g., desktop publishing, audio and/or video production). • Analyze and evaluate a message designed and produced using still, motion and animated communication techniques. • Describe the operation of fiber optic, microwave and satellite informational systems. • Apply various graphic and electronic information techniques to solve real world problems (e.g., data organization and analysis, forecasting, interpolation).

3.6. Technology Education			
3.6.4. GRADE 4	**3.6.7. GRADE 7**	**3.6.10. GRADE 10**	**3.6.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
C. Know physical technologies of structural design, analysis and engineering, finance, production, marketing, research and design. • Identify and group a variety of construction tasks. • Identify the major construction systems present in a specific local building. • Identify specific construction systems that depend on each other in order to complete a project. • Know skills used in construction. • Identify examples of manufactured goods present in the home and school. • Identify basic resources needed to produce a manufactured item. • Identify basic component operations in a specific manufacturing enterprise (e.g., cutting, shaping, attaching). • Identify waste and pollution resulting from a manufacturing enterprise. • Explain and demonstrate the concept of manufacturing (e.g., assemble a set of papers or ball point pens sequentially, mass produce an object). • Identify transportation technologies of propelling, structuring, suspending, guiding, controlling and supporting. • Identify and experiment with simple machines used in transportation systems. • Explain how improved transportation systems have changed society.	C. Explain physical technologies of structural design, analysis and engineering, personnel relations, financial affairs, structural production, marketing, research and design. • Use knowledge of material effectiveness to solve specific construction problems (e.g., steel vs. wood bridges). • Differentiate among the different types of construction applications (e.g., microwave tower, power plants, aircrafts). • Explain basic material processes that manufactured objects undergo during production (e.g., separating, forming, combining). • Evaluate a construction activity by specifying task analyses and necessary resources. • Explain the relationships among the basic resources needed in the production process for a specific manufactured object. • Explain the difference between design engineering and production engineering processes. • Analyze manufacturing steps that affect waste and pollutants. • Explain transportation technologies of propelling, structuring, suspending, guiding, controlling and supporting. • Identify and explain the workings of several mechanical power systems. • Model and explain examples of vehicular propulsion, control, guidance, structure and suspension systems. • Explain the limitations of land, marine, air and space transportation systems.	C. Apply physical technologies to structural design, analysis and engineering, personnel relations, financial affairs, structural production, marketing, research and design to real world problems. • Describe and classify common construction by their characteristics and composition. • Compare and contrast specific construction systems that depend on each other in order to complete a project. • Evaluate material failure common to specific applications. • Demonstrate knowledge of various construction systems by building or interpreting models. • Select and apply the necessary resources to successfully conduct a manufacturing enterprise. • Apply concepts of design engineering and production engineering in the organization and application of a manufacturing activity. • Apply the concepts of manufacturing by redesigning an enterprise to improve productivity or reduce or eliminate waste and/or pollution. • Evaluate the interrelationship of various transportation systems in the community. • Analyze the impacts that transportation systems have on a community.	C. Analyze physical technologies of structural design, analysis and engineering, personnel relations, financial affairs, structural production, marketing, research and design to real world problems. • Apply knowledge of construction technology by designing, planning and applying all the necessary resources to successfully solve a construction problem. • Compare resource options in solving a specific manufacturing problem. • Analyze and apply complex skills needed to process materials in complex manufacturing enterprises. • Apply advanced information collection and communication techniques to successfully convey solutions to specific construction problems. • Assess the importance of capital on specific construction applications. • Analyze the positive and negative qualities of several different types of materials as they would relate to specific construction applications. • Analyze transportation technologies of propelling, structuring, suspending, guiding, controlling and supporting. • Analyze the concepts of vehicular propulsion, guidance, control, suspension and structural systems while designing and producing specific complex transportation systems.

3.7. Technological Devices			
3.7.4. GRADE 4	**3.7.7. GRADE 7**	**3.7.10. GRADE 10**	**3.7.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Explore the use of basic tools, simple materials and techniques to safely solve problems. • Describe the scientific principles on which various tools are based. • Group tools and machines by their function. • Select and safely apply appropriate tools and materials to solve simple problems.	A. Describe the safe and appropriate use of tools, materials and techniques to answer questions and solve problems. • Identify uses of tools, machines, materials, information, people, money, energy and time that meet specific design criteria. • Describe safe procedures for using tools and materials. • Assess materials for appropriateness of use.	A. Identify and safely use a variety of tools, basic machines, materials and techniques to solve problems and answer questions. • Select and safely apply appropriate tools, materials and processes necessary to solve complex problems. • Apply advanced tool and equipment manipulation techniques to solve problems.	A. Apply advanced tools, materials and techniques to answer complex questions. • Demonstrate the safe use of complex tools and machines within their specifications. • Select and safely apply appropriate tools, materials and processes necessary to solve complex problems that could result in more than one solution. • Evaluate and use technological resources to solve complex multi-step problems.
B. Select appropriate instruments to study materials. • Develop simple skills to measure, record, cut and fasten. • Explain appropriate instrument selection for specific tasks.	B. Use appropriate instruments and apparatus to study materials. • Select appropriate instruments to measure the size, weight, shape and temperature of living and non-living objects. • Apply knowledge of different measurement systems to measure and record objects' properties.	B. Apply appropriate instruments and apparatus to examine a variety of objects and processes. • Describe and use appropriate instruments to gather and analyze data. • Compare and contrast different scientific measurement systems; select the best measurement system for a specific situation. • Explain the need to estimate measurements within error of various instruments. • Apply accurate measurement knowledge to solve everyday problems. • Describe and demonstrate the operation and use of advanced instrumentation in evaluating material and chemical properties (e.g., scanning electron microscope, nuclear magnetic resonance machines).	B. Evaluate appropriate instruments and apparatus to accurately measure materials and processes. • Apply and evaluate the use of appropriate instruments to accurately measure scientific and technologic phenomena within the error limits of the equipment. • Evaluate the appropriate use of different measurement scales (macro and micro). • Evaluate the utility and advantages of a variety of absolute and relative measurement scales for their appropriate application.
Computer literacy, including the use of hardware and software in standard statements C, D, and E, should be integrated across all content areas.			

3.7. Technological Devices			
3.7.4. GRADE 4	**3.7.7. GRADE 7**	**3.7.10. GRADE 10**	**3.7.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
C. Identify basic computer operations and concepts. • Identify the major parts necessary for a computer to input and output data. • Explain and demonstrate the basic use of input and output devices (e.g., keyboard, monitor, printer, mouse). • Explain and demonstrate the use of external and internal storage devices (e.g., disk drive, CD drive).	C. Explain and demonstrate basic computer operations and concepts. • Know specialized computer applications used in the community. • Describe the function of advanced input and output devices (e.g., scanners, video images, plotters, projectors) and demonstrate their use. • Demonstrate age appropriate keyboarding skills and techniques.	C. Apply basic computer operations and concepts. • Identify solutions to basic hardware and software problems. • Apply knowledge of advanced input devices. • Apply knowledge of hardware setup. • Describe the process for basic software installation and demonstrate it. • Analyze and solve basic operating systems problems. • Apply touch keyboarding skills and techniques at expectable speed and accuracy. • Demonstrate the ability to perform basic software installation.	C. Evaluate computer operations and concepts as to their effectiveness to solve specific problems. • Describe and demonstrate atypical software installation. • Analyze and solve hardware and advanced software problems. • Assess and apply multiple input and output devices to solve specific problems.
D. Use basic computer software. • Apply operating system skills to perform basic computer tasks. • Apply basic word processing skills. • Identify and use simple graphic and presentation graphic materials generated by the computer. • Apply specific instructional software.	D. Apply computer software to solve specific problems. • Identify software designed to meet specific needs (e.g., Computer Aided Drafting, design software, tutorial, financial, presentation software). • Identify and solve basic software problems relevant to specific software applications. • Identify basic multimedia applications. • Demonstrate a basic knowledge of desktop publishing applications. • Apply intermediate skills in utilizing word processing, database and spreadsheet software. • Apply basic graphic manipulation techniques.	D. Utilize computer software to solve specific problems. • Identify legal restrictions in the use of software and the output of data. • Apply advanced graphic manipulation and desktop publishing techniques. • Apply basic multimedia applications. • Apply advanced word processing, database and spreadsheet skills. • Describe and demonstrate how two or more software applications can be used to produce an output. • Select and apply software designed to meet specific needs.	D. Evaluate the effectiveness of computer software to solve specific problems. • Evaluate the effectiveness of software to produce an output and demonstrate the process. • Design and apply advanced multimedia techniques. • Analyze, select and apply the appropriate software to solve complex problems. • Evaluate the effectiveness of the computer as a presentation tool. • Analyze the legal responsibilities of computer users.

3.7. Technological Devices			
3.7.4. GRADE 4	**3.7.7. GRADE 7**	**3.7.10. GRADE 10**	**3.7.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
E. Identify basic computer communications systems. • Apply a web browser. • Apply basic electronic mail functions. • Use on-line searches to answer age appropriate questions.	E. Explain basic computer communications systems. • Describe the organization and functions of the basic parts that make up the World Wide Web. • Apply advanced electronic mail functions. • Apply basic on-line research techniques to solve a specific problem.	E. Apply basic computer communications systems. • Identify and explain various types of on-line services. • Identify and explain the function of the parts of a basic network. • Describe and apply the components of a web page and their function. • Explain and demonstrate file transfer within and out side of a computer network. • Identify, describe and complete advanced on-line research.	E. Assess the effectiveness of computer communications systems. • Assess the effectiveness of a computer based communications system. • Transfer files among different computer platforms. • Analyze the effectiveness of on-line information resources to meet the needs for collaboration, research, publications, communications and productivity. • Apply knowledge of protocol standards to solve connectivity problems.

3.8. Science, Technology and Human Endeavors			
3.8.4. GRADE 4	**3.8.7. GRADE 7**	**3.8.10. GRADE 10**	**3.8.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
A. Know that people select, create and use science and technology and that they are limited by social and physical restraints. • Identify and describe positive and negative impacts that influence or result from new tools and techniques. • Identify how physical technology (e.g., construction, manufacturing, transportation), informational technology and biotechnology are used to meet human needs. • Describe how scientific discoveries and technological advancements are related. • Identify interrelationships among technology, people and their world. • Apply the technological design process to solve a simple problem.	A. Explain how sciences and technologies are limited in their effects and influences on society. • Identify and describe the unavoidable constraints of technological design. • Identify changes in society as a result of a technological development. • Identify and explain improvements in transportation, health, sanitation and communications as a result of advancements in science and technology and how they effect our lives.	A. Analyze the relationship between societal demands and scientific and technological enterprises. • Identify past and current tradeoffs between increased production, environmental harm and social values (e.g., increased energy needs, power plants, automobiles). • Compare technologies that are applied and accepted differently in various cultures (e.g., factory farming, nuclear power). • Describe and evaluate social change as a result of technological developments. • Assess the social impacts of a specific international environmental problem by designing a solution that applies the appropriate technologies and resources.	A. Synthesize and evaluate the interactions and constraints of science and technology on society. • Compare and contrast how scientific and technological knowledge is both shared and protected. • Evaluate technological developments that have changed the way humans do work and discuss their impacts (e.g., genetically engineered crops). • Evaluate socially proposed limitations of scientific research and technological application.

3.8. Science, Technology and Human Endeavors			
3.8.4. GRADE 4	**3.8.7. GRADE 7**	**3.8.10. GRADE 10**	**3.8.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
B. Know how human ingenuity and technological resources satisfy specific human needs and improve the quality of life. • Identify and distinguish between human needs and improving the quality of life. • Identify and distinguish between natural and human-made resources. • Describe a technological invention and the resources that were used to develop it.	B. Explain how human ingenuity and technological resources satisfy specific human needs and improve the quality of life. • Identify interrelationships between systems and resources. • Identify and describe the resources necessary to solve a selected problem in a community and improve the quality of life. • Identify and explain specific examples of how agricultural science has met human needs and has improved the quality of life.	B. Analyze how human ingenuity and technological resources satisfy specific human needs and improve the quality of life. • Identify several problems and opportunities that exist in your community, apply various problem-solving methods to design and evaluate possible solutions. • Analyze a recently invented item, describing the human need that prompted its invention and the current and potential social impacts of the specific invention. • Apply knowledge of oceanography, meteorology, geology and human anatomy to explain important considerations that need to be made for construction of homes, buildings and businesses in the United States. • Assess the impacts that agricultural science has had on meeting human needs and improving the qualify of life.	B. Apply the use of ingenuity and technological resources to solve specific societal needs and improve the quality of life. • Apply appropriate tools, materials and processes to solve complex problems. • Use knowledge of human abilities to design or modify technologies that extend and enhance human abilities. • Apply appropriate tools, materials and processes to physical, informational or biotechnological systems to identify and recommend solutions to international problems. • Apply knowledge of agricultural science to develop a solution that will improve on a human need or want.

3.8. Science, Technology and Human Endeavors			
3.8.4. GRADE 4	**3.8.7. GRADE 7**	**3.8.10. GRADE 10**	**3.8.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to. . .			
C. Know the pros and cons of possible solutions to scientific and technological problems in society. • Compare the positive and negative expected and unexpected impacts of technological change. • Identify and discuss examples of technological change in the community that have both positive and negative impacts.	C. Identify the pros and cons of applying technological and scientific solutions to address problems and the effect upon society. • Describe the positive and negative expected and unexpected effects of specific technological developments. • Describe ways technology extends and enhances human abilities.	C. Evaluate possibilities, consequences and impacts of scientific and technological solutions. • Relate scientific and technological advancements in terms of cause and effect. • Describe and evaluate the impacts that financial considerations have had on specific scientific and technological applications. • Compare and contrast potential solutions to technological, social, economic and environmental problems. • Analyze the impacts on society of accepting or rejecting scientific and technological advances.	C. Evaluate the consequences and impacts of scientific and technological solutions. • Propose solutions to specific scientific and technological applications, identifying possible financial considerations. • Analyze scientific and technological solutions through the use of risk/benefit analysis. • Analyze and communicate the positive or negative impacts that a recent technological invention had on society. • Evaluate and describe potential impacts from emerging technologies and the consequences of not keeping abreast of technological advancements (e.g., assessment alternatives, risks, benefits, costs, economic impacts, constraints).

IX. GLOSSARY

Allele: Any of a set of possible forms of a gene.

Biochemical conversion: The changing of organic matter into other chemical forms.

Biomass conversion: The changing of organic matter that has been produced by photosynthesis into useful liquid, gas or fuel.

Biomedical technology: The application of health care theories to develop methods, products and tools to maintain or improve homeostasis.

Biomes: A community of living organisms of a single major ecological region.

Biotechnology: The ways that humans apply biological concepts to produce products and provide services.

Carbon chemistry: The science of the composition, structure, properties and reactions of carbon based matter, especially of atomic and molecular systems; sometimes referred to as organic chemistry.

Construction technology: The ways that humans build structures on sites.

Desalinization: To remove salts and other chemicals from sea or saline water.

Dichotomous: Divided or dividing into two parts or classifications.

Electronic communication: System for the transmission of information using electronic technology (e.g., digital cameras, cellular telephones, Internet, television, fiber optics).

Embryology: The branch of biology dealing with the development of living things from fertilized egg to its developed state.

Engineering: The application of scientific, physical, mechanical and mathematical principles to design processes, products and structures that improve the quality of life.

Enzyme: A protein that increases the rate of a chemical reaction without being changed by the reaction; an organic catalyst.

Ergonomical:	Of or relating to the design of equipment or devices to fit the human body's control, position, movement and environment.
Evolution:	A process of change that explains why what we see today is different from what existed in the past; it includes changes in the galaxies, stars, solar system, earth and life on earth. Biological evolution is a change in hereditary characteristics of groups of organisms over the course of generations.
Fact:	Information that has been objectively verified.
Geologic hazard:	A naturally occurring or man-made condition or phenomenon that presents a risk or is a potential danger to life and property (e.g., landslides, floods, earthquakes, ground subsidence, coastal and beach erosion, faulting, dam leakage and failure, mining disasters, pollution and waste disposal, sinkholes).
Geologic map:	A representation of a region on which is recorded earth information (e.g., the distribution, nature and age relationships of rock units and the occurrences of structural features, mineral deposits and fossil localities).
Hydrology:	The scientific study of the properties, distribution and effects of water on the earth's surface, in the soil and underlying rocks and in the atmosphere.
Hypothesis:	An assertion subject to verification or proof as a premise from which a conclusion is drawn.
Information technology:	The technical means that humans create to store and transmit information.
Inquiry:	A systematic process for using knowledge and skills to acquire and apply new knowledge.
Instructional technology:	Any mechanical aid (including computer technology) used to assist in or enhance the process of teaching and learning.
Law:	Summarizing statement of observed experimental facts that has been tested many times and is generally accepted as true.
Manufacturing technology:	The ways that humans produce goods and products.
Mitosis:	The sequential differentiation and segregation of replicated chromosomes in a cell's nucleus that precedes complete cell division.
Model:	A description, analogy or a representation of something that helps us understand it better (e.g., a physical model, a conceptual model, a mathematical model).
Nova:	A variable star that suddenly increases in brightness to several times its normal magnitude and returns to its original appearance in a few weeks to several months or years.
Patterns:	Repeated processes that are exhibited in a wide variety of ways; identifiable recurrences of the element and/or the form.
Physical technology:	The ways that humans construct, manufacture and transport products.
Radioactive isotope:	An atom that gives off nuclear radiation and has the same number of protons (atomic number) as another atom but a different number of neutrons.
Relationship between science and technology:	Science builds principles or theories while technology is the practical application of those principles or theories.
Scale:	Relates concepts and ideas to one another by some measurement (e.g., quantitative, numeral, abstract, ideological); provides a measure of size and/or incremental change.
Science:	Search for understanding the natural world using inquiry and experimentation.
System:	A group of related objects that work together to achieve a desired result.
Open Loop system:	A group of related objects that do not have feedback and cannot modify themselves.
Closed Loop system:	A group of related objects that have feedback and can modify themselves.
Subsystem:	A group of related objects that make up a larger system (e.g., automobiles have electrical systems, fuel systems).
Technology education:	The application of tools, materials, processes and systems to solve problems and extend human capabilities.
Technological design process:	Recognizing the problem, proposing a solution, implementing the solution, evaluating the solution and communicating the problem, design and solution.
Theory:	Systematically organized knowledge applicable in a relatively wide variety of circumstances; especially, a system of assumptions, accepted principles and rules of procedure devised to analyze, predict or otherwise explain the nature or behavior of a specified set of phenomena.
Theory of evolution:	A theory that the various types of animals and plants have their origin in other preexisting types and that the distinguishable differences are due to modification in successive generations.

Topographic map: A representation of a region on a sufficient scale to show detail, selected man-made and natural features of a portion of the land surface including its relief and certain physical and cultural features; the portrayal of the position, relation, size, shape and elevation of the area.

Transportation systems: A group of related parts that function together to perform a major task in any form of transportation.

Transportation technology: The physical ways humans move materials, goods and people.

Tool: Any device used to extend human capability including computer-based tools.

Academic Standards for Environment and Ecology

X. TABLE OF CONTENTS

XI. INTRODUCTION

This document includes Environment and Ecology standards that describe what students should know and be able to do in these areas:

- 4.1. Watersheds and Wetlands
- 4.2. Renewable and Nonrenewable Resources
- 4.3. Environmental Health
- 4.4. Agriculture and Society
- 4.5. Integrated Pest Management
- 4.6. Ecosystems and their Interactions
- 4.7. Threatened, Endangered and Extinct Species
- 4.8. Humans and the Environment
- 4.9. Environmental Laws and Regulations

The Declaration of Rights, Article l of the Pennsylvania Constitution states in Section 27: "The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and aesthetic values of the environment. Pennsylvania's public natural resources are the common property of all people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people." To this end it is our responsibility to develop a citizenry that is aware of and concerned about the total environment and has the knowledge and skills to work toward solutions to current problems and the prevention of new ones.

Environment and Ecology is grounded in the complexity of the world we live in and our impact on its sustainability. The human interactions with the ecosystem and the results of human decisions are the main components of this academic area. Environment and Ecology examines the world with respect to the economic, cultural, political and social structure as well as natural processes and systems. This integration across systems is what sets this academic area apart from all others.

Environment and Ecology places its main emphasis in the real world. It allows students to understand, through a sound academic content base, how their everyday lives evolve around their use of the natural world and the resources it provides. As we move into a more technologically driven society, it is crucial for every student to be aware of his/her dependence on a healthy environment. The 2lst century will demand a more sophisticated citizen capable of making sound decisions that will impact our natural systems forever.

These standards establish the essential elements of what students should know and be able to do at the end of grades four, seven, ten and twelve. The sequential nature of this document reflects the need for rigorous academic content that students will be expected to achieve. The standards will help students understand decision-making processes, the art of compromise and problem solving skills. The document reinforces all areas across the grade levels with increasing degrees of difficulty as the students mature intellectually.

Environment and Ecology is a very engaging academic area that captivates students' innate interests in their surroundings of the natural and built environment. The skills and knowledge that are addressed in this area of study will serve as tools for student participation in a democratic world of constantly evolving issues and concerns. As they achieve these standards, students will become aware of the role they play in the community in reaching decisions related to the environment.

The study of Environment and Ecology will allow students to be active participants and problem solvers in real issues that affect them, their homes, schools and communities.

A glossary is included to assist the reader in understanding terminology contained in the standards.

4.1. Watersheds and Wetlands			
4.1.4. GRADE 4	**4.1.7. GRADE 7**	**4.1.10. GRADE 10**	**4.1.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Identify various types of water environments. • Identify the lotic system (e.g., creeks, rivers, streams). • Identify the lentic system (e.g., ponds, lakes, swamps).	A. Explain the role of the water cycle within a watershed. • Explain the water cycle. • Explain the water cycle as it relates to a watershed.	A. Describe changes that occur from a stream's origin to its final outflow. • Identify Pennsylvania's major watersheds and their related river systems. • Describe changes by tracing a specific river's origin back to its headwaters including its major tributaries.	A. Categorize stream order in a watershed. • Explain the concept of stream order. • Identify the order of watercourses within a major river's watershed. • Compare and contrast the physical differences found in the stream continuum from headwater to mouth.
B. Explain the differences between moving and still water. • Explain why water moves or does not move. • Identify types of precipitation.	B. Understand the role of the watershed. • Identify and explain what determines the boundaries of a watershed. • Explain how water enters a watershed. • Explain factors that affect water quality and flow through a watershed.	B. Explain the relationship among landforms, vegetation and the amount and speed of water. • Analyze a stream's physical characteristics. • Describe how topography influences streams. • Explain the influence of mountains on precipitation. • Explain how vegetation affects storm water runoff. • Delineate the boundaries of a watershed. • Describe factors that affect the quality of groundwater. • Explain how the speed of water and vegetation cover relates to erosion.	B. Explain the relationships that exist within watersheds in the United States. • Understand that various ecosystems may be contained in a watershed. • Examine and describe the ecosystems contained within a specific watershed. • Identify and describe the major watersheds in the United States.

4.1. Watersheds and Wetlands			
4.1.4. GRADE 4	**4.1.7. GRADE 7**	**4.1.10. GRADE 10**	**4.1.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
C. Identify living things found in water environments. • Identify fish, insects and amphibians that are found in fresh water. • Identify plants found in fresh water.	C. Explain the effects of water on the life of organisms in a watershed. • Explain how water is necessary for all life. • Explain how the physical components of aquatic systems influence the organisms that live there in terms of size, shape and physical adaptations. • Describe the life cycle of organisms that depend on water. • Identify organisms that have aquatic stages of life and describe those stages.	C. Describe the physical characteristics of a stream and determine the types of organisms found in aquatic environments. • Describe and explain the physical factors that affect a stream and the organisms living there. • Identify terrestrial and aquatic organisms that live in a watershed. • Categorize aquatic organisms found in a watershed continuum from headwater to mouth (e.g., shredder, predator, decomposer). • Identify the types of organisms that would live in a stream based on the stream's physical characteristics. • Explain the habitat needs of specific aquatic organisms.	C. Analyze the parameters of a watershed. • Interpret physical, chemical and biological data as a means of assessing the environmental quality of a watershed. • Apply appropriate techniques in the analysis of a watershed (e.g., water quality, biological diversity, erosion, sedimentation).
D. Identify a wetland and the plants and animals found there. • Identify different kinds of wetlands. • Identify plants and animals found in wetlands. • Explain wetlands as habitats for plants and animals.	D. Explain and describe characteristics of a wetland. • Identify specific characteristics of wetland plants and soils. • Recognize the common types of plants and animals. • Describe different types of wetlands. • Describe the different functions of a wetland.	D. Describe the multiple functions of wetlands. • Describe wetlands in terms of their effects (e.g., habitat, flood, buffer zones, prevention areas, nurseries, food production areas). • Explain how a wetland influences water quality, wildlife and water retention. • Analyze wetlands through their indicators (e.g., soils, plants, hydrology).	D. Analyze the complex and diverse ecosystems of wetlands. • Explain the functions of habitat, nutrient production, migration stopover and groundwater recharge as it relates to wetlands. • Explain the dynamics of a wetland ecosystem. • Describe and analyze different types of wetlands.
E. Recognize the impact of watersheds and wetlands on animals and plants. • Explain the role of watersheds in everyday life. • Identify the role of watersheds and wetlands for plants and animals.	E. Describe the impact of watersheds and wetlands on people. • Explain the impact of watersheds and wetlands in flood control, wildlife habitats and pollution abatement. • Explain the influence of flooding on wetlands.	E. Identify and describe natural and human events on watersheds and wetlands. • Describe how natural events affect a watershed (e.g., drought, floods). • Identify the effects of humans and human events on watersheds.	E. Evaluate the trade-offs, costs and benefits of conserving watersheds and wetlands. • Evaluate the effects of natural events on watersheds and wetlands. • Evaluate the effects of human activities on watersheds and wetlands.

4.2. Renewable and Nonrenewable Resources			
4.2.4. GRADE 4	**4.2.7. GRADE 7**	**4.2.10. GRADE 10**	**4.2.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Identify needs of people. • Identify plants, animals, water, air, minerals and fossil fuels as natural resources. • Explain air, water and nutrient cycles. • Identify how the environment provides for the needs of people.	A. Know that raw materials come from natural resources. • Identify resources used to provide humans with energy, food, housing and water. • Explain how plants and animals may be classified as natural resources. • Compare means of growing or acquiring food. • Identify fiber and other raw materials used in clothing and shelter production. • Identify types of minerals and fossil fuels used by humans.	A. Explain that renewable and nonrenewable resources supply energy and materials. • Identify alternative sources of energy. • Identify and compare fuels used in industrial and agricultural societies. • Compare and contrast the cycles of various natural resources. • Explain food and fiber as renewable resources.	A. Analyze the use of renewable and nonrenewable resources. • Explain the effects on the environment and sustainability through the use of nonrenewable resources. • Evaluate the advantages and disadvantages of reusing our natural resources.
B. Identify products derived from natural resources. • Identify products made from trees. • Identify by-products of plants and animals. • Identify the sources of manmade products (e.g., plastics, metal, aluminum, fabrics, paper, cardboard).	B. Examine the renewability of the resources. • Identify renewable resources and describe their uses. • Identify nonrenewable resources and describe their uses. • Compare finished products to their original raw material. • Identify the waste derived from the use of renewable and nonrenewable resources. • Determine how consumption may impact the availability of resources. • Compare the time spans of renewability for fossil fuels and alternative fuels.	B. Evaluate factors affecting availability of natural resources. • Describe natural occurrences that may affect the natural resources. • Analyze technologies that affect the use of our natural resources. • Evaluate the effect of consumer desires on various natural resources.	B. Analyze factors affecting the availability of renewable and nonrenewable resources. • Evaluate the use of natural resources and offer approaches for using them while diminishing waste. • Compare the economics of different areas based on the availability and accessibility of the natural resources.

4.2. Renewable and Nonrenewable Resources			
4.2.4. GRADE 4	**4.2.7. GRADE 7**	**4.2.10. GRADE 10**	**4.2.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
C. Know that some natural resources have limited life spans. • Identify renewable and nonrenewable resources used in the local community. • Identify various means of conserving natural resources. • Know that natural resources have varying life spans.	C. Explain natural resource distribution. • Distinguish between readily available and less accessible resources. • Identify the locations of different concentrations of fossil fuels and mineral resources. • Analyze the effects of management practices on air, land and water in forestry, agriculture, fisheries, wildlife, mining and food and fiber production that is unique to different climates.	C. Analyze how man-made systems have impacted the management and distribution of natural resources. • Explain the complete cycle of a natural resource, from extraction to disposal, detailing its uses and effects on the environment. • Analyze energy uses and energy conservation in different regions. • Examine conservation practices in different countries. • Analyze the costs and benefits of different man-made systems and how they use renewable and nonrenewable natural resources. • Analyze the impact of information systems on management and distribution of natural resources.	C. Analyze factors that influence the availability of natural resources. • Compare the use of natural resources in different countries. • Determine how delivery systems influence the availability of resources at the local, regional and national level.
D. Identify by-products and their use of natural resources. • Understand the waste stream. • Identify those items that can be recycled and those that can not. • Identify use of reusable products. • Identify the use of compost, landfills and incinerators.	D. Describe the role of recycling and waste management. • Identify materials that can be recycled in the community. • Explain the process of closing the loop in recycling. • Compare the decomposition rates of different organic materials. • Describe methods that could be used to reuse materials for new products. • Evaluate the costs and benefits of disposable products.	D. Explain different management alternatives involved in recycling and solid waste management. • Analyze the manufacturing process (before, during and after) with consideration for resource recovery. • Compare various methods dealing with solid waste (e.g., incineration, compost, land application). • Differentiate between pre/post-consumer and raw materials. • Illustrate how one natural resource can be managed through reduction, recycling, reuse or use.	D. Evaluate solid waste management practices. • Examine and explain the path of a recyclable material from collection to waste, reuse or recycling identifying the market forces. • Understand current regulations concerning recycling and solid waste. • Research new technologies in the use, reuse or recycling of materials.

4.3. Environmental Health			
4.3.4. GRADE 4	**4.3.7. GRADE 7**	**4.3.10. GRADE 10**	**4.3.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Know that plants, animals and humans are dependent on air and water. • Know that all living things need air and water to survive. • Describe potentially dangerous pest controls used in the home. • Identify things that cause sickness when put into the air, water or soil. • Identify different areas where health can be affected by air, water or land pollution. • Identify actions that can prevent or reduce waste pollution.	A. Identify environmental health issues. • Identify various examples of long-term pollution and explain their effects on environmental health. • Identify diseases that have been associated with poor environmental quality. • Describe different types of pest controls and their effects on the environment. • Identify alternative products that can be used in life to reduce pollution.	A. Describe environmental health issues. • Identify the effects on human health of air, water and soil pollution and the possible economic costs to society. • Describe how indoor pollution may affect human health (e.g., dust mites, fumes, cat dandruff). • Explain the costs and benefits of cleaning up contaminants. • Explain how common household cleaning products are manufactured and how to dispose of their by-products after use.	A. Analyze the complexity of environmental health issues. • Identify environmental health issues and explain how they have been addressed on a worldwide level. • Analyze efforts to prevent, control and/or reduce pollution through cost and benefit analysis and risk management. • Describe the impact of occupational exposures as they relate to environmental health issues. • Identify invisible pollutants and explain their effects on human health. • Explain the relationship between wind direction and velocity as it relates to dispersal and occurrence of pollutants. • Explain the different disposal methods used for toxic and hazardous waste.

4.3. Environmental Health			
4.3.4. GRADE 4	**4.3.7. GRADE 7**	**4.3.10. GRADE 10**	**4.3.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
B. Identify how human actions affect environmental health. • Identify pollutants. • Identify sources of pollution. • Identify litter and its effect on the environment. • Describe how people can reduce pollution.	B. Describe how human actions affect the health of the environment. • Identify land use practices and their relation to environmental health. • Explain how natural disasters affect environmental health. • Identify residential and industrial sources of pollution and their effects on environmental health. • Explain the difference between point and nonpoint source pollution. • Explain how nonpoint source pollution can affect the water supply and air quality. • Explain how acid deposition can affect water, soil and air quality. • Explain the relationship between resource use, reuse, recycling and environmental health.	B. Explain how multiple variables determine the effects of pollution on environmental health, natural processes and human practices. • Explain how human practices affect the quality of the water and soil. • Identify evidence of natural events around the world and their effects on environmental health (e.g., Yellowstone National Park fires). • Identify local and state environmental regulations and their impact on environmental health. • Analyze data and explain how point source pollution can be detected and eliminated. • Identify and explain ways of detecting pollution by using state-of-the-art technologies.	B. Analyze the local, regional and national impacts of environmental health. • Analyze the cost of natural disasters in both dollars and loss of natural habitat. • Research and analyze the local, state and national laws that deal with point and nonpoint source pollution; evaluate the costs and benefits of these laws. • Explain mitigation and its role in environmental health. • Explain industry's initiatives to meet state and federal mandates on clean air and water. • Describe the impacts of point and nonpoint source pollution on the Chesapeake Bay. • Identify and evaluate the costs and benefits of laws regulating air and water quality and waste disposal.
C. Understand that the elements of natural systems are interdependent. • Identify some of the organisms that live together in an ecosystem. • Understand that the components of a system all play a part in a healthy natural system. • Identify the effects of a healthy environment on the ecosystem.	C. Explain biological diversity. • Explain the complex, interactive relationships among members of an ecosystem. • Explain how diversity affects ecological integrity of the natural resources.	C. Explain biological diversity as an indicator of a healthy environment. • Explain species diversity. • Analyze the effects of species extinction on the health of an ecosystem.	C. Analyze the need for a healthy environment. • Research the relationship of some chronic diseases to an environmental pollutant. • Explain how man-made systems may affect the environment.

4.4. Agriculture and Society			
4.4.4. GRADE 4	**4.4.7. GRADE 7**	**4.4.10. GRADE 10**	**4.4.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Know the importance of agriculture to humans. • Identify people's basic needs. • Explain the influence of agriculture on food, clothing, shelter and culture from one area to another. • Know how people depend on agriculture.	A. Explain society's standard of living in relation to agriculture. • Compare and contrast agricultural changes that have been made to meet society's needs. • Compare and contrast how animals and plants affect agricultural systems. • Compare several technological advancements and their effect(s) on the historical growth of agriculture. • Compare different environmental conditions related to agricultural production, cost and quality of the product.	A. Describe the importance of agriculture to society. • Identify the major cash crops of Pennsylvania. • Identify what percentage of the United States' population is involved in the food and fiber industry. • Compare and contrast the influence of agriculture on a nation's culture, standard of living and foreign trade. • Identify laws that affect conservation and management of food and fiber production in the local area and analyze their impact. • Compare a contemporary economic issue in agriculture to its historical origin.	A. Analyze the management practices in the agriculture business. • Define the components of an agriculture system that would result in a minimal waste of resources. • Identify the diversity in crop production and analyze the advantages and disadvantages of such diversity. • Research and analyze environmental practices related to agricultural systems. • Analyze the effects of agricultural practices on the economy. • Analyze the impact of nutrient management laws on Pennsylvania agriculture. • Assess the role of agriculture cooperatives.
B. Identify the role of the sciences in Pennsylvania agriculture. • Identify common animals found on Pennsylvania farms. • Identify common plants found on Pennsylvania farms. • Identify the parts of important agricultural related plants (i.e., corn, soybeans, barley). • Identify a fiber product from Pennsylvania farms.	B. Investigate how agricultural science has recognized the various soil types found in Pennsylvania. • Explain the importance of particle sizes in different soil types. • Determine how water has influenced the development of Pennsylvania soil types. • Investigate how soil types have influenced the plant types used on Pennsylvania farms • Analyze how soil types and geographic regions have impacted the profitability of Pennsylvania farms.	B. Assess the influence of agricultural science on farming practices. • Compare the practices of no-till farming to traditional soil preparation (e.g., plow, disc). • Analyze and explain the various practices of nutrient management on the farm. • Analyze and explain how farm efficiencies have changed human nutrition.	B. Describe how agricultural science has influenced biotechnology. • Investigate how bioengineered crops may influence the food supply. • Analyze the use of specific bacteria for the control of agricultural pests. • Evaluate the use of feed additives in shifting metabolism to increase muscle mass and reduce fat in farm animals.

4.4. Agriculture and Society			
4.4.4. GRADE 4	**4.4.7. GRADE 7**	**4.4.10. GRADE 10**	**4.4.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
C. Know that food and fiber originate from plants and animals. • Define and identify food and fiber. • Identify what plants and animals need to grow. • Identify agricultural products that are local and regional. • Identify an agricultural product based on its origin. • Describe several products and tell their origins. • Describe the journey of a local agricultural product from production to the consumer.	C. Explain agricultural systems' use of natural and human resources. • Analyze the needs of plants and animals as they relate to climate and soil conditions. • Identify the plants and animals that can be raised in the area and explain why. • Identify natural resources necessary for agricultural systems. • Compare the need for crop production to the need for animal production. • Define issues associated with food and fiber production.	C. Explain the functions of the components of the food and fiber system. • Compare and analyze growing conditions in the United States to determine which plants and animals are most suitable to each region. • Compare the management practices needed for a commodity (i.e., production, processing, research and development, marketing, distribution and regulations). • Identify a commodity, its origin and its steps of production. • Compare and analyze the cost of a commodity to its production cost. • Identify and describe how food safety issues have impacted production in agriculture.	C. Analyze and research the social, political and economic factors that affect agricultural systems. • Analyze the costs and benefits associated with agriculture practices and how they affect economic and human needs. • Analyze the costs and benefits of agriculture research practices in society. • Research the use of by-products that are the results of agriculture production (e.g., manure handling, bird feathers).
D. Identify technology and energy use associated with agriculture. • Identify the various tools and machinery necessary for farming. • Identify the types of energy used in producing food and fiber. • Identify tools and machinery used in the production of agricultural products.	D. Explain the improvement of agricultural production through technology. • Compare the technologies that have advanced agricultural production. • Explain how energy sources have changed to meet agricultural technology.	D. Analyze the efforts of increased efficiency in agriculture through technology. • Compare various technological advancements and analyze each for its contribution toward labor and cost efficiency. • Compare the current market value of both natural and alternative energy sources involved in the production of food and fiber.	D. Analyze research and development activities as they relate to agriculture. • Analyze the role of research, development and technology as it relates to the food and fiber system. • Research and analyze energy sources used and/or generated by producing, processing and marketing agricultural products.

4.5. Integrated Pest Management			
4.5.4. GRADE 4	**4.5.7. GRADE 7**	**4.5.10. GRADE 10**	**4.5.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Know types of pests. • Identify classifications of pests. • Identify and categorize pests. • Know how pests fit into a food chain.	A. Explain benefits and harmful effects of pests. • Identify different examples of pests and explain the beneficial or harmful effects of each. • Identify several locations where pests can be found and compare the effects the pests have on each location.	A. Identify similar classifications of pests that may or may not have similar effects on different regions. • Identify environmental effect(s) of pests on different regions of the world. • Identify introduced species that are classified as pests in their new environments.	A. Research integrated pest management systems. • Analyze the threshold limits of pests and the need for intervention in a managed environment. • Research the types of germicides and analyze their effects on homes, industry, hospitals and institutions. • Design and explain an integrated pest management plan that uses a range of pest controls.
B. Explain pest control. • Know reasons why people control pests. • Identify different methods for controlling specific pests in the home, school and community. • Identify chemical labels (e.g., caution, poison, warning).	B. Explain how pest management affects the environment. • Explain issues related to integrated pest management including biological technology, resistant varieties, chemical practices, medical technology and monitoring techniques. • Describe how integrated pest management and related technology impact human activities. • Identify issues related to integrated pest management that affect the environment.	B. Analyze health benefits and risks associated with integrated pest management. • Identify the health risks associated with chemicals used in common pesticides. • Assess various levels of control within different integrated pest management practices including increased immunity to pesticides, food safety, sterilization, nutrient management and weed control.	B. Research and analyze integrated pest management practices globally. • Research worldwide integrated pest management systems and evaluate the level of impact. • Research and analyze the international regulations that exist related to integrated pest management. • Explain the complexities associated with moving from one level of control to the next with different integrated pest management practices and compare the related costs of each system.

4.5. Integrated Pest Management			
4.5.4. GRADE 4	**4.5.7. GRADE 7**	**4.5.10. GRADE 10**	**4.5.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
C. Understand society's need for integrated pest management. • Identify integrated pest management practices in the home. • Identify integrated pest management practices outside the home.	C. Explain various integrated pest management practices used in society. • Compare and contrast integrated pest management monitoring methods utilized in different community settings. • Compare integrated pest management to past practices. • Compare and analyze the long-term effects of using integrated pest management products.	C. Determine the effects of integrated pest management practices on society over time. • Analyze the risks to the environment and society associated with alternative practices used in integrated pest management. • Analyze the benefits to the environment and society associated with alternative practices used in integrated pest management.	C. Analyze the historical significance of integrated pest management on society. • Explain the dynamics of integrated pest management practices and their relative effects upon society. • Identify historic events affecting integrated pest management and cite the practices used (e.g., avian flu, bubonic plague, potato blight). • Research and analyze the long-term effects of pest management practices on the environment.

4.6. Ecosystems and their Interactions			
4.6.4. GRADE 4	**4.6.7. GRADE 7**	**4.6.10. GRADE 10**	**4.6.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Understand that living things are dependent on nonliving things in the environment for survival. • Identify and categorize living and nonliving things. • Describe the basic needs of an organism. • Identify basic needs of a plant and an animal and explain how their needs are met. • Identify plants and animals with their habitat and food sources. • Identify environmental variables that affect plant growth. • Describe how animals interact with plants to meet their needs for shelter. • Describe how certain insects interact with soil for their needs. • Understand the components of a food chain. • Identify a local ecosystem and its living and nonliving components. • Identify a simple ecosystem and its living and nonliving components. • Identify common soil textures. • Identify animals that live underground.	A. Explain the flows of energy and matter from organism to organism within an ecosystem. • Identify and explain the characteristics of biotic and abiotic. • Describe and explain the adaptations of plants and animals to their environment. • Demonstrate the dependency of living components in the ecosystem on the nonliving components. • Explain energy flow through a food web. • Explain the importance of the predator/prey relationship and how it maintains the balances within ecosystems. • Understand limiting factors and predict their effects on an organism. • Identify niches for producers, consumers and decomposers within an ecosystem. • Compare and contrast the major ecosystems of Pennsylvania. • Identify the major characteristics of a biome. • Compare and contrast different biomes and their characteristics. • Identify the relationship of abiotic and biotic components and explain their interaction in an ecosystem. • Explain how different soil types determine the characteristics of ecosystems.	A. Explain the biotic and abiotic components of an ecosystem and their interaction. • Identify the major biomes and explain their similarities and differences. • Compare and contrast the interactions of biotic and abiotic components in an ecosystem. • Analyze the effects of abiotic factors on specific ecosystems. • Describe how the availability of resources affects organisms in an ecosystem. • Explain energy flow in a food chain through an energy pyramid. • Evaluate the efficiency of energy flow in a food chain. • Explain the concept of carrying capacity in an ecosystem. • Explain trophic levels. • Identify a specific environmental impact and predict what change may take place to affect homeostasis. • Examine and explain how organisms modify their environments to sustain their needs. • Assess the effects of latitude and altitude on biomes. • Interpret possible causes of population fluctuations. • Explain how erosion and sedimentation have changed the quality of soil related habitats.	A. Analyze the interdependence of an ecosystem. • Analyze the relationships among components of an ecosystem. • Evaluate the efficiency of energy flow within an ecosystem. • Explain limiting factors and their impact on carrying capacity. • Understand how biological diversity impacts the stability of an ecosystem. • Analyze the positive or negative impacts of outside influences on an ecosystem. • Analyze how different land use practices can affect the quality of soils.
B. Understand the concept of cycles. • Explain the water cycle. • Explain the carbon dioxide/oxygen cycle (photosynthesis).	B. Explain the concepts of cycles. • Identify and explain cycles within an ecosystem. • Analyze the role of different cycles within an ecosystem.	B. Explain how cycles affect the balance in an ecosystem. • Describe an element cycle and its role in an ecosystem. • Explain the consequences of interrupting natural cycles.	B. Analyze the impact of cycles on the ecosystem. • Evaluate the materials necessary for natural cycles. • Explain the processes involved in the natural cycles.

4.6. Ecosystems and their Interactions			
4.6.4. GRADE 4	**4.6.7. GRADE 7**	**4.6.10. GRADE 10**	**4.6.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
C. Identify how ecosystems change over time.	C. Explain how ecosystems change over time. • Explain how ecosystems change. • Identify the succession stages of a given ecosystem. • Explain how specific organisms may change an ecosystem. • Explain a change in an ecosystem that relates to humans.	C. Analyze how ecosystems change over time. • Identify and explain the succession stages in an ecosystem. • Identify causes of succession. • Analyze consequences of interrupting natural cycles.	C. Analyze how human action and natural changes affect the balance within an ecosystem. • Analyze the effects of substances that move through natural cycles. • Analyze the effects of natural occurrences and their effects on ecosystems. • Analyze effects of human action on an ecosystem. • Compare the stages of succession and how they influence the cycles existing in an ecosystem.

4.7. Threatened, Endangered and Extinct Species			
4.7.4. GRADE 4	**4.7.7. GRADE 7**	**4.7.10. GRADE 10**	**4.7.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Identify differences in living things. • Explain why plants and animals are different colors, shapes and sizes and how these differences relate to their survival. • Identify characteristics that living things inherit from their parents. • Explain why each of the four elements in a habitat is essential for survival. • Identify local plants or animals and describe their habitat.	A. Describe diversity of plants and animals in ecosystems. • Select an ecosystem and describe different plants and animals that live there. • Identify adaptations in plants and animals. • Recognize that adaptations are developed over long periods of time and are passed on from one generation to the next. • Understand levels of ecosystem organization (e.g., individuals, populations, species).	A. Explain the significance of diversity in ecosystems. • Explain the role that specific organisms have in their ecosystem. • Identify a species and explain what effects its increase or decline might have on the ecosystem. • Identify a species and explain how its adaptations are related to its niche in the environment.	A. Analyze biological diversity as it relates to the stability of an ecosystem. • Examine and explain what happens to an ecosystem as biological diversity changes. • Explain the relationship between species' loss and bio-diversity. • Examine and explain how a specialized interaction between two species may affect the survival of both species.

4.7. Threatened, Endangered and Extinct Species			
4.7.4. GRADE 4	**4.7.7. GRADE 7**	**4.7.10. GRADE 10**	**4.7.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
B. Know that adaptations are important for survival. • Explain how specific adaptations can help a living organism to survive. • Explain what happens to a living thing when its food, water, shelter or space is changed.	B. Explain how species of living organisms adapt to their environment. • Explain the role of individual variations in natural selection. • Explain how an adaptation is an inherited structure or behavior that helps an organism survive and reproduce. • Describe how a particular trait may be selected over time and account for a species' adaptation. • Compare and contrast animals and plants that have very specific survival requirements with those that have more general requirements for survival. • Explain how living things respond to changes in their environment. • Explain how one species may survive an environmental change while another might not.	B. Explain how structure, function and behavior of plants and animals affect their ability to survive. • Describe an organism's adaptations for survival in its habitat. • Compare adaptations among species.	B. Examine the effects of extinction, both natural and human caused, on the environment. • Predict how human or natural action can produce change to which organisms cannot adapt. • Identify species that became extinct through natural causes and explain how that occurred. • Identify a species that became extinct due to human actions and explain what occurred.

4.7. Threatened, Endangered and Extinct Species			
4.7.4. GRADE 4	**4.7.7. GRADE 7**	**4.7.10. GRADE 10**	**4.7.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
C. Define and understand extinction. • Identify plants and animals that are extinct. • Explain why some plants and animals are extinct. • Know that there are local and state laws regarding plants and animals.	C. Explain natural or human actions in relation to the loss of species. • Identify natural or human impacts that cause habitat loss. • Explain how habitat loss can affect the interaction among species and the population of a species. • Analyze and explain the changes in an animal population over time. • Explain how a habitat management practice affects a population. • Explain the differences among threatened, endangered and extinct species. • Identify Pennsylvania plants and animals that are on the threatened or endangered list. • Describe state laws passed regarding threatened and endangered species in Pennsylvania. • Explain why one species may be more susceptible to becoming endangered than another species.	C. Identify and explain why adaptations can lead to specialization. • Explain factors that could lead to a species' increase or decrease. • Explain how management practices may influence the success of specific species. • Identify and explain criteria used by scientists for categorizing organisms as threatened, endangered or extinct.	C. Analyze the effects of threatened, endangered or extinct species on human and natural systems. • Identify and explain how a species' increase, decline or elimination affects the ecosystem and/or human social, cultural and economic structures. • Explain why natural populations do not remain constant. • Analyze management strategies regarding threatened or endangered species. • Identify laws, agreements or treaties at national or international levels regarding threatened or endangered species. • Analyze the role of zoos and wildlife preserves on species that have been identified as threatened or endangered. • Examine the influence of wildlife management in preserving different species in Pennsylvania (e.g., bobcat, elk, bald eagle).

4.8. Humans and the Environment			
4.8.4. GRADE 4	**4.8.7. GRADE 7**	**4.8.10. GRADE 10**	**4.8.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Identify the biological requirements of humans. • Explain how a dynamically changing environment provides for sustainability of living systems. • Identify several ways that people use natural resources.	A. Describe how the development of civilization relates to the environment. • Explain how people use natural resources in their environment. • Locate and identify natural resources in different parts of the world. • Compare and contrast how people use natural resources throughout the world.	A. Analyze how society's needs relate to the sustainability of natural resources. • Explain why some societies have been unable to meet their natural resource needs. • Compare and contrast the use of natural resources and the environmental conditions in several countries. • Describe how uses of natural resources impact sustainability.	A. Explain how technology has influenced the sustainability of natural resources over time. • Describe how technology has changed the use of natural resources by business and industry. • Analyze the effect of natural resource conservation on a product over time (e.g., automobile manufacturing, aluminum can recycling, paper products).
B. Know that environmental conditions influence where and how people live. • Identify how regional natural resources influence what people use. • Explain the influence of climate on how and where people live.	B. Explain how people use natural resources. • Describe how natural resources are used for survival. • Explain how natural resources and technological changes have affected the development of civilizations. • Explain how climate and extreme weather events (e.g., drought, flood) influence people's lives.	B. Analyze the relationship between the use of natural resources and sustaining our society. • Explain the role of natural resources in sustaining society. • Analyze the effects of a natural resource's availability on a community or region.	B. Analyze technology's role on natural resource sustainability. • Explain how technology has decreased the use of raw natural resources. • Explain how technology has impacted the efficiency of the use of natural resources. • Analyze the role of technology in the reduction of pollution.
C. Explain how human activities may change the environment. • Identify everyday human activities and how they affect the environment. • Identify examples of how human activities within a community affect the natural environment.	C. Explain how human activities may affect local, regional and national environments. • Describe what effect consumption and related generation of wastes have on the environment. • Explain how a particular human activity has changed the local area over the years.	C. Analyze how human activities may cause changes in an ecosystem. • Analyze and evaluate changes in the environment that are the result of human activities. • Compare and contrast the environmental effects of different industrial strategies (e.g., energy generation, transportation, logging, mining, agriculture).	C. Analyze how pollution has changed in quality, variety and toxicity as the United States developed its industrial base. • Analyze historical pollution trends and project them for the future. • Compare and contrast historical and current pollution levels at a given location.

4.8. Humans and the Environment			
4.8.4. GRADE 4	**4.8.7. GRADE 7**	**4.8.10. GRADE 10**	**4.8.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
D. Know the importance of natural resources in daily life. • Identify items used in daily life that come from natural resources. • Identify ways to conserve our natural resources. • Identify major land uses in the community.	D. Explain the importance of maintaining the natural resources at the local, state and national levels. • Explain how human activities and natural events have affected ecosystems. • Explain how conservation practices have influenced ecosystems. • Define the roles of Pennsylvania agencies that deal with natural resources.	D. Explain how the concept of supply and demand affects the environment. • Identify natural resources for which societal demands have been increasing. • Identify specific resources for which human consumption has resulted in scarcity of supply (e.g., buffalo, lobsters). • Describe the relationship between population density and resource use and management.	D. Analyze the international implications of environmental occurrences. • Identify natural occurrences that have international impact (e.g., El Nino, volcano eruptions, earthquakes). • Analyze environmental issues and their international implications.

4.9. Environmental Laws and Regulations			
4.9.4. GRADE 4	**4.9.7. GRADE 7**	**4.9.10. GRADE 10**	**4.9.12. GRADE 12**
Pennsylvania's public schools shall teach, challenge and support every student to realize his or her maximum potential and to acquire the knowledge and skills needed to:			
A. Know that there are laws and regulations for the environment. • Identify local and state laws and regulations regarding the environment. • Explain how the recycling law impacts the school and home. • Identify and describe the role of a local or state agency that deals with environmental laws and regulations.	A. Explain the role of environmental laws and regulations. • Identify and explain environmental laws and regulations (e.g., Clean Air Act, Clean Water Act, Recycling and Waste Reduction Act, Act 26 on Agricultural Education). • Explain the role of local and state agencies in enforcing environmental laws and regulations (e.g., Department of Environmental Protection, Department of Agriculture, Game Commission).	A. Explain why environmental laws and regulations are developed and enacted. • Explain the positive and negative impacts associated with passing environmental laws and regulations. • Understand conflicting rights of property owners and environmental laws and regulations. • Analyze the roles that local, state and federal governments play in the development and enforcement of environmental laws. • Identify local and state environmental regulations and their impact on environmental health. • Explain the positive and negative impacts of the Endangered Species Act.	A. Analyze environmental laws and regulations as they relate to environmental issues. • Analyze and explain how issues lead to environmental law or regulation (e.g., underground storage tanks, regulation of water discharges, hazardous, solid and liquid industrial waste, endangered species). • Compare and contrast environmental laws and regulations that may have a positive or negative impact on the environment and the economy. • Research and describe the effects of an environmental law or regulation and how it has impacted the environment.

Academic Standards for Environment and Ecology

XII. GLOSSARY

Abiotic:	A nonliving factor or element (e.g., light, water, heat, rock, energy, mineral).
Acid deposition:	Precipitation with a pH less than 5.6 that forms in the atmosphere when certain pollutants mix with water vapor.
Biological diversity:	The variety and complexity of species present and interacting in an ecosystem and the relative abundance of each.
Biotic:	An environmental factor related to or produced by living organisms.
Closing the loop:	A link in the circular chain of recycling events that promotes the use of products made with recycled materials.
Commodities:	Economic goods or products before they are processed and/or given a brand name, such as a product of agriculture.
Composting:	The process of mixing decaying leaves, manure and other nutritive matter to improve and fertilize soil.
Consumer:	1) Those organisms that obtain energy by feeding on other organisms and their remains. 2) A person buying goods or services for personal needs or to use in the production of other goods for resale.
Decomposer:	An organism, often microscopic in size, that obtains nutrients by consuming dead organic matter, thereby making nutrients accessible to other organisms; examples of decomposers include fungi, scavengers, rodents and other animals.
Delineate:	To trace the outline; to draw; to sketch; to depict or picture.
Ecosystem:	A community of living organisms and their interrelated physical and chemical environment.
Endangered Species:	A species that is in danger of extinction throughout all or a significant portion of its range.
Environment:	The total of the surroundings (air, water, soil, vegetation, people, wildlife) influencing each living being's existence, including physical, biological and all other factors; the surroundings of a plant or animal, including other plants or animals, climate and location.
Equilibrium:	The ability of an ecosystem to maintain stability among its biological resources (e.g., forest, fisheries, crops) so that there is a steady optimum yield.
Extinction:	The complete elimination of a species from the earth.
Groundwater:	Water that infiltrates the soil and is located in underground reservoirs called aquifers.
Hazardous waste:	A solid that, because of its quantity or concentration or its physical, chemical or infectious characteristics, may cause or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed.
Homeostasis:	The tendency for a system by resisting change to remain in a state of equilibrium.
Incinerating:	Burning to ashes; reducing to ashes.
Integrated pest management:	A variety of pest control methods that include repairs, traps, bait, poison, etc. to eliminate pests.
Lentic:	Relating to or living in still water.
Lotic:	Relating to or living in actively moving water.
Mitigation:	The policy of constructing or creating man-made habitats, such as wetlands, to replace those lost to development.
Niche (ecological):	The role played by an organism in an ecosystem; its food preferences, requirements for shelter, special behaviors and the timing of its activities (e.g., nocturnal, diurnal), interaction with other organisms and its habitat.
Nonpoint source pollution:	Contamination that originates from many locations that all discharge into a location (e.g., a lake, stream, land area).
Nonrenewable resources:	Substances (e.g., oil, gas, coal, copper, gold) that, once used, cannot be replaced in this geological age.
Point source pollution:	Pollutants discharged from a single identifiable location (e.g., pipes, ditches, channels, sewers, tunnels, containers of various types).
Pest:	A label applied to an organism when it is in competition with humans for some resource.
Recycling:	Collecting and reprocessing a resource or product to make into new products.
Regulation:	A rule or order issued by an executive authority or regulatory agency of a government and having the force of law.

Renewable:	A naturally occurring raw material or form of energy that will be replenished through natural ecological cycles or sound management practices (e.g., the sun, wind, water, trees).
Risk management:	A strategy developed to reduce or control the chance of harm or loss to one's health or life; the process of identifying, evaluating, selecting and implementing actions to reduce risk to human health and to ecosystems.
Shredder:	Through chewing and/or grinding, microorganisms feed on non-woody coarse particulate matter, primarily leaves.
Stream order:	Energy and nutrient flow that increases as water moves toward the oceans (e.g., the smallest stream (primary) that ends when rivers flow into oceans).
Succession:	The series of changes that occur in an ecosystem with the passing of time.
Sustainability:	The ability to keep in existence or maintain. A sustainable ecosystem is one that can be maintained.
Trophic levels:	The role of an organism in nutrient and energy flow within an ecosystem (e.g., herbivore, carnivore, decomposer).
Waste stream:	The flow of (waste) materials from generation, collection and separation to disposal.
Watershed:	The land area from which surface runoff drains into a stream, channel, lake, reservoir or other body of water; also called a drainage basin.
Wetlands:	Lands where water saturation is the dominant factor determining the nature of the soil development and the plant and animal communities (e.g., sloughs, estuaries, marshes).

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