Academic Standards for Science and Technology and Engineering Education

January 29, 2010 -- FINAL DRAFT
Secondary Standards
(Biology, Chemistry, and Physics)

Pennsylvania Department of Education

These standards are offered as a voluntary resource for Pennsylvania's schools and await action by the State Board of Education.
The course level standards are offered as a voluntary resource for Pennsylvania's schools.

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VIII. INTRODUCTION

Learning about science and technology is vitally important in today's increasingly complicated world. The rate of new discoveries and the development of increasingly sophisticated tools make science and technology rapidly changing subjects. As stated in Content Standard E of the National Science Education Standards, "the relationship between science and technology is so close that any presentation of science without developing an understanding of technology would portray an inaccurate picture of science."

In the near future, society will benefit from basic research discoveries that will lead to new tools, materials, and medical treatments. Learning about the world around us, by observing and experimenting, is the core of science and technology and is strongly reflected in Pennsylvania's Academic Standards for Science and Technology.

This document describes what students should know and be able to do in the following four standard categories:

- 3.1. Biological Sciences
- 3.2. Physical Sciences: Chemistry and Physics
- 3.3. Earth and Space Sciences
- 3.4. Technology and Engineering Education

These standards describe what students should know and be able to do in biology, chemistry, and physics courses. In addition to course standards, the standards for grades 10 and 12 are shown to clarify the targets for instruction and student learning. Although the standards are not a curriculum or a prescribed series of activities, school entities will use them to develop a local school curriculum that will meet local students' needs. Additionally, *Science as Inquiry* is logically embedded in the Science and Technology and Engineering Education standards as inquiry is the process through which students develop a key understanding of sciences. *Unifying Themes* in the sciences capture the big ideas of science.

SECONDARY STANDARDS
(Biology, Chemistry, Physics)
Science and Technology and Engineering Education

To clarify the coding of the standards, an example of the numbering system follows:

- Biological Sciences (3.1) is a **standard category.**
  - Organisms and Cells (3.1.A) is an **organizing category** under Biological Sciences.
    - Common Characteristics of Life (3.1.A1) is a **strand** under Organisms and Cells.
      - **Standard statements** indicate grade level appropriate learning for which students should demonstrate proficiency. For example, "Describe the similarities and differences of physical characteristics in plants and animals" (3.1.**4**.A1) is a fourth grade standard statement.

1 Common Characteristics of Life	3.1.10.A1. Explain the characteristics of life common to all **organisms**.	3.1.B.A1.	3.1.C.A1.	3.1.P.A1.	3.1.12.A1. Relate changes in the environment to various **organisms**' ability to compensate using homeostatic mechanisms.

SECONDARY STANDARDS
(Biology, Chemistry, Physics)
Science and Technology and Engineering Education

The following descriptors explain the intent of each standard category:

3.1. Biological Sciences	Biology of organisms and cells 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 how life has evolved. 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.
3.2. Physical Sciences: 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 relationships between properties and structure of matter. Laboratory investigations of chemical interactions provide a basis for students to understand atomic theory 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.
3.3. Earth and Space Sciences	The dynamics of earth science include the studies of forces of nature that build up and wear down the earth's surface. Dynamics include energy flow across the earth's surface and its role in weather and climate. Space science is concerned with the origin and evolution of the universe. The understanding of these concepts uses principles from physical sciences, geography and mathematics.
3.4. Technology and Engineering Education	Technology and Engineering Education is the use of accumulated knowledge to process resources to meet human needs and improve the quality of life. It includes developing, producing, using and assessing technologies. It is human innovation in action and involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. Its goal is to provide technological literacy to all students, including all students who traditionally have not been served by technology and engineering programs.

SECONDARY STANDARDS
(Biology, Chemistry, Physics)
Science and Technology and Engineering Education

Science as Inquiry: Understanding of science content is enhanced when concepts are grounded in inquiry experiences. The use of scientific inquiry will help ensure that students develop a deep understanding of science content, processes, knowledge and understanding of scientific ideas, and the work of scientists; therefore, inquiry is embedded as a strand throughout all content areas. Teaching science as inquiry provides teachers with the opportunity to help all students in grades K-12 develop abilities necessary to understand and do scientific inquiry. These are very similar across grade bands and evolve in complexity as the grade level increases.

Grades K-4	Grades 5-7	Grades 8-10	Grades 11-12
• Distinguish between scientific fact and opinion. • Ask questions about objects, organisms, and events. • Understand that all scientific investigations involve asking and answering questions and comparing the answer with what is already known. • Plan and conduct a simple investigation and understand that different questions require different kinds of investigations. • Use simple equipment (tools and other technologies) to gather data and understand that this allows scientists to collect more information than relying only on their senses to gather information. • Use data/evidence to construct explanations and understand that scientists develop explanations based on their evidence and compare them with their current scientific knowledge. • Communicate procedures and explanations giving priority to evidence and understanding that scientists make their results public, describe their investigations so they can be reproduced, and review and ask questions about the work of other scientists.	• Understand how theories are developed. • Identify questions that can be answered through scientific investigations and evaluate the appropriateness of questions. • Design and conduct a scientific investigation and understand that current scientific knowledge guides scientific investigations. • Describe relationships using inference and prediction. • Use appropriate tools and technologies to gather, analyze, and interpret data and understand that it enhances accuracy and allows scientists to analyze and quantify results of investigations. • Develop descriptions, explanations, and models using evidence and understand that these emphasize evidence, have logically consistent arguments, and are based on scientific principles, models, and theories. • Analyze alternative explanations and understanding that science advances through legitimate skepticism. • Use mathematics in all aspects of scientific inquiry. • Understand that scientific investigations may result in new ideas for study, new methods, or procedures for an investigation or new technologies to improve data collection.	• Compare and contrast scientific theories. • Know that both direct and indirect observations are used by scientists to study the natural world and universe. • Identify questions and concepts that guide scientific investigations. • Formulate and revise explanations and models using logic and evidence. • Recognize and analyze alternative explanations and models.	• Examine the status of existing theories. • Evaluate experimental information for relevance and adherence to science processes. • Judge that conclusions are consistent and logical with experimental conditions. • Interpret results of experimental research to predict new information, propose additional investigable questions, or advance a solution. • Communicate and defend a scientific argument.

Content Area Strand										
	3.1.3.A9.	3.1.4.A9.	3.1.5.A9.	3.1.6.A9.	3.1.7.A9.	3.1.8.A9.	3.1.B.A9.	3.1.C.A9.	3.1.P.A9.	3.1.12.A9.
	3.1.3.B6.	3.1.4.B6.	3.1.5.B6.	3.1.6.B6.	3.1.7.B6.	3.1.8.B6.	3.1.B.B6.	3.1.C.B6.	3.1.P.B6.	3.1.12.B6.
	3.1.3.C4.	3.1.4.C4.	3.1.5.C4.	3.1.6.C4.	3.1.7.C4.	3.1.8.C4.	3.1.B.C4.	3.1.C.C4.	3.1.P.C4.	3.1.12.C4.
	3.2.3.A6.	3.2.4.A6.	3.2.5.A6.	3.2.6.A6.	3.2.7.A6.	3.2.8.A6.	3.2.B.A6.	3.2.C.A6.	3.2.P.A6.	3.2.12.A6.
	3.2.3.B7.	3.2.4.B7.	3.2.5.B7.	3.2.6.B7.	3.2.7.B7.	3.2.8.B7.	3.2.B.B7.	3.2.C.B7.	3.2.P.B7.	3.2.12.B7.
	3.3.3.A8.	3.3.4.A8.	3.3.5.A8.	3.3.6.A8.	3.3.7.A8.	3.3.8.A8.	3.3.B.A8.	3.3.C.A8.	3.3.P.A8.	3.3.12.A8.
	3.3.3.D3.	3.3.4.D3.	3.3.5.D3.	3.3.6.D3.	3.3.7.D3.	3.3.8.D3.	3.3.B.D3.	3.3.C.D3.	3.3.P.D3.	3.3.12.D3.

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3.1. Biological Sciences					
3.1.A. Organisms and Cells					
	3.1.10.A. GRADE 10	**3.1.B.A. BIOLOGY**	**3.1.C.A. CHEMISTRY**	**3.1.P.A. PHYSICS**	**3.1.12.A .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:					
1 Common Characteristics of Life	3.1.10.A1. Explain the characteristics of life common to all **organisms**.	3.1.B.A1. Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts)	3.1.C.A1. Explain the chemistry of **metabolism.**	3.1.P.A1. Intentionally Blank	3.1.12.A1. Relate changes in the environment to various **organisms**' ability to compensate using homeostatic mechanisms.

3.1. Biological Sciences					
3.1.A. Organisms and Cells					
	3.1.10.A. GRADE 10	**3.1.B.A. BIOLOGY**	**3.1.C.A. CHEMISTRY**	**3.1.P.A. PHYSICS**	**3.1.12.A .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:					
2 Energy Flow	3.1.10.A2. Explain cell processes in terms of chemical reactions and energy changes.	3.1.B.A2. Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.	3.1.C.A2. Describe how changes in energy affect the rate of chemical reactions.	3.1.P.A2. Intentionally Blank	3.1.12.A2. Evaluate how **organisms** must derive energy from their environment or their food in order to survive.

3.1. Biological Sciences					
3.1.A. Organisms and Cells					
	3.1.10.A. GRADE 10	**3.1.B.A. BIOLOGY**	**3.1.C.A. CHEMISTRY**	**3.1.P.A. PHYSICS**	**3.1.12.A .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:					
3 Life Cycles	3.1.10.A3. Compare and contrast the **life cycles** of different **organisms**.	3.1.B.A3. Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.	3.1.C.A3. Intentionally Blank	3.1.P.A3. Intentionally Blank	3.1.12.A3. Intentionally Blank
4 Cell Cycles	3.1.10.A4. Describe the **cell cycle** and the process and significance of **mitosis**.	3.1.B.A4. Summarize the stages of the **cell cycle**. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of **mitosis** in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.	3.1.C.A4. Relate **mitosis** and **meiosis** at the molecular level.	3.1.P.A4. Intentionally Blank	3.1.12.A4. Explain how the **cell cycle** is regulated.

3.1. Biological Sciences					
3.1.A. Organisms and Cells					
	3.1.10.A. GRADE 10	**3.1.B.A. BIOLOGY**	**3.1.C.A. CHEMISTRY**	**3.1.P.A. PHYSICS**	**3.1.12.A .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:					
5 Form and Function	3.1.10.A5. Relate life processes to sub-cellular and cellular structures to their functions.	3.1.B.A5. Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.	3.1.C.A5. Intentionally Blank	3.1.P.A5. Intentionally Blank	3.1.12.A5. Analyze how structure is related to function at all levels of biological organization from **molecules** to **organisms**.
6 Organization	3.1.10.A6. Identify the advantages of multi-cellularity in organisms.	3.1.B.A6. Explain how cells differentiate in multicellular organisms.	3.1.C.A6. Intentionally Blank	3.1.P.A6. Intentionally Blank	3.1.12.A6. Analyze how cells in different tissues/organs are specialized to perform specific functions.

3.1. Biological Sciences					
3.1.A. Organisms and Cells					
	3.1.10.A. GRADE 10	**3.1.B.A. BIOLOGY**	**3.1.C.A. CHEMISTRY**	**3.1.P.A. PHYSICS**	**3.1.12.A .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:					
7 Molecular Basis of Life	3.1.10.A7. Describe the relationship between the structure of **organic molecules** and the function they serve in living **organisms**. Explain how cells store and use information to guide their functions.	3.1.B.A7. Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.	3.1.C.A7. Illustrate the formation of **carbohydrates**, **lipids, proteins,** and **nucleic** acids.	3.1.P.A7. Intentionally Blank	3.1.12.A7. Evaluate metabolic activities using experimental knowledge of **enzymes**. Describe the potential impact of stem **cell** research on the **biochemistry** and **physiology** of life.

3.1. Biological Sciences					
3.1.A. Organisms and Cells					
	3.1.10.A. GRADE 10	**3.1.B.A. BIOLOGY**	**3.1.C.A. CHEMISTRY**	**3.1.P.A. PHYSICS**	**3.1.12.A .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:					
8 Unifying Themes	3.1.10.A8. Investigate the spatial relationships of **organisms**' **anatomical** features using specimens, models, or computer programs.	3.1.B.A8. CHANGE AND CONSTANCY Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. PATTERNS Demonstrate the repeating patterns that occur in biological polymers. SYSTEMS Describe how the unique properties of water support life.	3.1.C.A8. Intentionally Blank	3.1.P.A8. Intentionally Blank	3.1.12.A8. CHANGE AND CONSTANCY Describe and interpret dynamic changes in stable **system**s.
9 Science as Inquiry	3.1.10.A9. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.B.A9. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.C.A9. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.P.A9. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.12.A9. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.1. Biological Sciences					
3.1.B. Genetics					
	3.1.10.B. GRADE 10	**3.1.B.B. BIOLOGY**	**3.1.C.B. CHEMISTRY**	**3.1.P.B. PHYSICS**	**3.1.12.B. 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:					
1 Heredity	3.1.10.B1. Describe how **genetic** information is inherited and expressed.	3.1.B.B1. Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.	3.1.C.B1. Intentionally Blank	3.1.P.B1. Intentionally Blank	3.1.12.B1. Explain gene inheritance and expression at the molecular level.

3.1. Biological Sciences					
3.1.B. Genetics					
	3.1.10.B. GRADE 10	**3.1.B.B. BIOLOGY**	**3.1.C.B. CHEMISTRY**	**3.1.P.B. PHYSICS**	**3.1.12.B. 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:					
2 Reproduction	3.1.10.B2. Explain the process of **meiosis** resulting in the formation of **gametes**. Compare and contrast the function of **mitosis** and **meiosis**.	3.1.B.B2. Describe how the process of **meiosis** results in the formation of haploid gametes and analyze the importance of **meiosis** in sexual reproduction. Compare and contrast the function of **mitosis** and **meiosis**. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.	3.1.C.B2. Intentionally Blank	3.1.P.B2. Intentionally Blank	3.1.12.B2. Evaluate the process of **sexual reproduction** in influencing genetic variability in a population.

3.1. Biological Sciences					
3.1.B. Genetics					
	3.1.10.B. GRADE 10	**3.1.B.B. BIOLOGY**	**3.1.C.B. CHEMISTRY**	**3.1.P.B. PHYSICS**	**3.1.12.B. 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:					
3 Molecular Basis of Life	3.1.10.B3. Describe the basic structure of **DNA** and its function in **genetic** inheritance. Describe the role of **DNA** in **protein synthesis** as it relates to **gene expression.**	3.1.B.B3. Describe the basic structure of **DNA**, including the role of hydrogen bonding. Explain how the process of **DNA** replication results in the transmission and conservation of the genetic code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.	3.1.C.B3. Describe the structure of the **DNA** and **RNA** molecules.	3.1.P.B3. Intentionally Blank	3.1.12.B3. Analyze **gene expression** at the **mole**cular level. Explain the impact of environmental factors on gene **expression.**
4 Biotechnology	3.1.10.B4. Explain how **genetic technologies** have impacted the fields of medicine, **forensics,** and agriculture.	3.1.B.B4. Explain how **genetic technologies** have impacted the fields of medicine, **forensics,** and agriculture	3.1.C.B4. Intentionally Blank	3.1.P.B4. Intentionally Blank	3.1.12.B4. Evaluate the societal impact of **genetic engineering** techniques and applications.

3.1. Biological Sciences					
3.1.B. Genetics					
	3.1.10.B. GRADE 10	**3.1.B.B. BIOLOGY**	**3.1.C.B. CHEMISTRY**	**3.1.P.B. PHYSICS**	**3.1.12.B. 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:					
5 Unifying Themes	3.1.10 B5. PATTERNS Use models to demonstrate patterns in biomacromolecules. Compare and contrast Mendelian and non-Medalian patterns of inheritance.	3.1.B.B5. PATTERNS Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles) CONSTANCY AND CHANGE Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life.	3.1.C.B5. PATTERNS Use models to demonstrate patterns in **biomacromolecules.**	3.1.P.B5. Intentionally Blank	3.1.12 B5. PATTERNS Relate the monomer structure of **biomacromolecules** to their functional roles.

3.1. Biological Sciences					
3.1.B. Genetics					
	3.1.10.B. GRADE 10	**3.1.B.B. BIOLOGY**	**3.1.C.B. CHEMISTRY**	**3.1.P.B. PHYSICS**	**3.1.12.B. 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:					
		SCALE Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.			
6 Science as Inquiry	3.1.10 B6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.B.B6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.C.B6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.P.B6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.12 B6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.1. Biological Sciences					
3.1.C. Evolution					
	3.1.10.C. GRADE 10	**3.1.B.C. BIOLOGY**	**3.1.C.C. CHEMISTRY**	**3.1.P.C. PHYSICS**	**3.1.12.C. 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:					
1 Natural Selection	3.1.10.C1. Explain the mechanisms of biological **evolution**.	3.1.B.C1. Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their **DNA** sequences.	3.1.C.C1. Intentionally Blank	3.1.P.C1. Intentionally Blank	3.1.12.C1. Analyze how natural **selection** leads to **speciation**.

3.1. Biological Sciences					
3.1.C. Evolution					
	3.1.10.C. GRADE 10	**3.1.B.C. BIOLOGY**	**3.1.C.C. CHEMISTRY**	**3.1.P.C. PHYSICS**	**3.1.12.C. 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:					
2 Adaptation	3.1.10.C2. Explain the role of **mutations** and **gene recombination** in changing a population of **organisms**.	3.1.B.C2. Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single-celled **organisms** evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting **phenotype** may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.	3.1.C.C2. Use molecular models to demonstrate **gene mutation** and **recombination** at the molecular level.	3.1.P.C2. Intentionally Blank	3.1.12.C2. Analyze how **genotypic** and **phenotypic** variation can result in **adaptations** that influence an **organism's** success in an environment.

3.1. Biological Sciences					
3.1.C. Evolution					
	3.1.10.C. GRADE 10	**3.1.B.C. BIOLOGY**	**3.1.C.C. CHEMISTRY**	**3.1.P.C. PHYSICS**	**3.1.12.C. 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:					
3 Unifying Themes	3.1.10.C3. CONSTANCY AND CHANGE Interpret data from fossil records, anatomy and **physiology**, and **DNA** studies relevant to the **theory of evolution**.	3.1.B.C3. CONSTANCY AND CHANGE Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and **physiology**, and **DNA** studies relevant to the **theory of evolution**. PATTERNS Discuss the implications of a universal genetic code for evolution.	3.1.C.C3. Intentionally Blank	3.1.P.C3. Intentionally Blank	3.1.12.C3. CONSTANCY AND CHANGE Analyze the evidence to support various theories of **evolution** (**gradualism**, **punctuated equilibrium**). Evaluate survival of the fittest in terms of **species** that have remained unchanged over long **periods** of time.
4 Science as Inquiry	3.1.10.C4. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.B.C4. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.C.C4. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.P.C4. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.1.12.C4. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.2. Physical Sciences: Chemistry and Physics					
3.2.A. Chemistry					
	3.2.10.A. GRADE 10	**3.2.B.A. BIOLOGY**	**3.2.C.A. CHEMISTRY**	**3.2.P.A. PHYSICS**	**3.2.12.A. 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:					
1 Properties of Matter	3.2.10.A1. Predict properties of **elements** using trends of the **periodic table**. Identify properties of matter that depend on sample size. Explain the unique properties of water (**polarity**, high boiling point, forms **hydrogen bonds**, high **specific heat**) that support life on Earth.	3.2.B.A1. Intentionally Blank	3.2.C.A1. Differentiate between physical properties and chemical properties. Differentiate between pure substances and mixtures; differentiate between heterogeneous and homogeneous mixtures. Explain the relationship of an element's position on the periodic table to its atomic number, ionization energy, electro-negativity, atomic size, and classification of elements. Use electro-negativity to explain the difference between polar and non-polar covalent bonds.	3.2.P.A1. Intentionally Blank	3.2.12.A1. Compare and contrast **colligative properties** of **mixtures.** Compare and contrast the unique properties of water to other liquids.

3.2. Physical Sciences: Chemistry and Physics					
3.2.A. Chemistry					
	3.2.10.A. GRADE 10	**3.2.B.A. BIOLOGY**	**3.2.C.A. CHEMISTRY**	**3.2.P.A. PHYSICS**	**3.2.12.A. 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:					
2 Structure of Matter	3.2.10.A2. Compare and contrast different bond types that result in the formation of molecules and compounds. Explain why **compounds** are composed of integer ratios of **elements.**	3.2.B.A2. Intentionally Blank	3.2.C.A2. Compare the electron configurations for the first twenty elements of the **periodic table**. Relate the position of an element on the **periodic table** to its electron configuration and compare its reactivity to the reactivity of other elements in the table. Explain how atoms combine to form compounds through both ionic and covalent bonding. Predict chemical formulas based on the number of valence electrons. Draw Lewis dot structures for simple molecules and ionic compounds. Predict the chemical formulas for simple ionic and molecular compounds.	3.2.P.A2. Intentionally Blank	3.2.12.A2. Distinguish among the isotopic forms of **elements**. Explain the probabilistic nature of **radioactive decay** based on subatomic rearrangement in the atomic nucleus. Explain how light is absorbed or emitted by **electron orbital transitions.**

3.2. Physical Sciences: Chemistry and Physics					
3.2.A. Chemistry					
3.2.10.A. GRADE 10		**3.2.B.A. BIOLOGY**	**3.2.C.A. CHEMISTRY**	**3.2.P.A. PHYSICS**	**3.2.12.A. 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:					
			Use the **mole** concept to determine number of particles and **molar mass** for elements and compounds. Determine percent compositions, empirical formulas, and molecular formulas.		
3 Matter & Energy	3.2.10.A3. Describe phases of matter according to the **kinetic molecular theory**.	3.2.B.A3. Intentionally Blank	3.2.C.A3. Describe the three normal states of matter in terms of energy, particle motion, and phase transitions. Identify the three main types of radioactive decay and compare their properties. Describe the process of **radioactive decay** by using nuclear equations and explain the concept of half-life for an **isotope**. Compare and contrast **nuclear fission** and **nuclear fusion.**	3.2.P.A3. Intentionally Blank	3.2.12.A3. Explain how matter is transformed into energy in **nuclear reactions** according to the equation $E=mc^2$.

3.2. Physical Sciences: Chemistry and Physics					
3.2.A. Chemistry					
	3.2.10.A. GRADE 10	**3.2.B.A. BIOLOGY**	**3.2.C.A. CHEMISTRY**	**3.2.P.A. PHYSICS**	**3.2.12.A. 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:					
4 Reactions	3.2.10.A4. Describe chemical reactions in terms of atomic rearrangement and/or electron transfer. Predict the amounts of products and reactants in a chemical reaction using **mole** relationships. Explain the difference between **endothermic** and **exothermic** reactions. Identify the factors that affect the rates of reactions.	3.2.B.A4. Intentionally Blank	3.2.C.A4. Predict how combinations of substances can result in physical and/or chemical changes. Interpret and apply the laws of conservation of mass, constant composition (definite proportions), and multiple proportions. Balance chemical equations by applying the laws of conservation of mass. Classify chemical reactions as synthesis (combination), decomposition, single displacement (replacement), double displacement, and combustion. Use stoichiometry to predict quantitative relationships in a chemical reaction.	3.2.P.A4. Intentionally Blank	3.2.12.A4. Apply oxidation/reduction principles to **electrochemical reactions**. Describe the interactions between acids and bases.

3.2. Physical Sciences: Chemistry and Physics					
3.2.A. Chemistry					
	3.2.10.A. GRADE 10	**3.2.B.A. BIOLOGY**	**3.2.C.A. CHEMISTRY**	**3.2.P.A. PHYSICS**	**3.2.12.A. 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:					
5 Unifying Themes	3.2.10.A5. MODELS Describe the historical development of models of the atom and how they contributed to modern atomic theory. SCALE Apply the **mole** concept to determine number of particles and **molar mass** for **elements** and **compounds**.	3.2.B.A5. Intentionally Blank	3.2.C.A5. MODELS Recognize discoveries from Dalton (atomic theory), Thomson (the electron), Rutherford (the nucleus), and Bohr (planetary model of atom), and understand how each discovery leads to modern theory. Describe Rutherford's "gold foil" experiment that led to the discovery of the nuclear atom. Identify the major components (protons, neutrons, and electrons) of the nuclear atom and explain how they interact.	3.2.P.A5. Intentionally Blank	3.2.12.A5. MODELS/PATTERNS Use **VSEPR** theory to predict the **molecular geometry** of simple **molecules**. CONSTANCY AND CHANGE Predict the shift in **equilibrium** when a **system** is subjected to a stress.
6 Science as Inquiry	3.2.10.A6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.B.A6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.C.A6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page8)	3.2.P.A6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.12.A6. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.2. Physical Sciences: Chemistry and Physics					
3.2.B. Physics					
	3.2.10.B. GRADE 10	**3.2.B.B. BIOLOGY**	**3.2.C.B. CHEMISTRY**	**3.2.P.B. PHYSICS**	**3.2.12.B. 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:					
1 Force & Motion of Particles and Rigid Bodies	3.2.10.B1. Analyze the relationships among the net forces acting on a body, the **mass** of the body, and the resulting acceleration using Newton's Second Law of Motion. Apply Newton's Law of Universal Gravitation to the forces between two objects. Use Newton's Third Law to explain forces as interactions between bodies. Describe how interactions between objects conserve momentum.	3.2.B.B1. Intentionally Blank	3.2.C.B1. Intentionally Blank	3.2.P.B1. Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, **velocity**, and acceleration. Use force and **mass** to explain translational motion or simple harmonic motion of objects. Relate **torque** and rotational **inertia** to explain rotational motion.	3.2.12.B1. Analyze the principles of rotational motion to solve problems relating to **angular momentum** and **torque**.

3.2. Physical Sciences: Chemistry and Physics					
3.2.B. Physics					
	3.2.10.B. GRADE 10	**3.2.B.B. BIOLOGY**	**3.2.C.B. CHEMISTRY**	**3.2.P.B. PHYSICS**	**3.2.12.B. 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:					
2 Energy Storage and Transformations: Conservation Laws	3.2.10.B2. Explain how the overall energy flowing through a system remains constant. Describe the work-energy theorem. Explain the relationships between work and power.	3.2.B.B2. Intentionally Blank	3.2.C.B2. Explore the natural tendency for systems to move in a direction of disorder or randomness (entropy).	3.2.P.B2. Explain the translation and simple harmonic motion of objects using conservation of energy and conservation of momentum. Describe the rotational motion of objects using the conservation of energy and conservation of **angular momentum**. Explain how gravitational, electrical, and magnetic forces and torques give rise to rotational motion.	3.2.12.B2. Explain how energy flowing through an open **system** can be lost. Demonstrate how the law of conservation of momentum and conservation of energy provide alternate approaches to predict and describe the motion of objects.
3 Heat/Heat Transfer	3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of **convection**, **conduction**, and **radiation** between objects or regions that are at different temperatures.	3.2.B.B3. Intentionally Blank	3.2.C.B3. Describe the law of conservation of energy. Explain the difference between an **endothermic** process and an **exothermic** process.	3.2.P.B3. Analyze the factors that influence **convection**, **conduction**, and **radiation** between objects or regions that are at different temperatures.	3.2.12.B3. Describe the relationship between the average kinetic **molecular** energy, temperature, and phase changes.

3.2. Physical Sciences: Chemistry and Physics					
3.2.B. Physics					
	3.2.10.B. GRADE 10	**3.2.B.B. BIOLOGY**	**3.2.C.B. CHEMISTRY**	**3.2.P.B. PHYSICS**	**3.2.12.B. 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:					
4 Electrical and Magnetic Energy	3.2.10.B4. Describe quantitatively the relationships between voltage, current, and resistance to electrical energy and power. Describe the relationship between electricity and magnetism as two aspects of a single electromagnetic force.	3.2.B.B4. Intentionally Blank	3.2.C.B4. Intentionally Blank	3.2.P.B4. Explain how stationary and moving particles result in electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connections among them. Explain how electrical induction is applied in technology.	3.2.12.B4. Describe conceptually the attractive and repulsive forces between objects relative to their charges and the distance between them.
5 Nature of Waves (Sound and Light Energy)	3.2.10.B5. Understand that waves transfer energy without transferring matter. Compare and contrast the wave nature of light and sound. Describe the components of the electromagnetic spectrum. Describe the difference between sound and light waves.	3.2.B.B5. Intentionally Blank	3.2.C.B5. Intentionally Blank	3.2.P.B5. Explain how waves transfer energy without transferring matter. Explain how waves carry information from remote sources that can be detected and interpreted. Describe the causes of wave frequency, speed, and wave length.	3.2.12.B5. Research how principles of wave transmissions are used in a wide range of **technologies**. Research technologies that incorporate principles of wave transmission.

3.2. Physical Sciences: Chemistry and Physics					
3.2.B. Physics					
	3.2.10.B. GRADE 10	**3.2.B.B. BIOLOGY**	**3.2.C.B. CHEMISTRY**	**3.2.P.B. PHYSICS**	**3.2.12.B. 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:					
6 Unifying Themes	3.2.10.B6. PATTERNS SCALE MODELS CONSTANCY/ CHANGE Explain how the behavior of matter and energy follow predictable patterns that are defined by laws.	3.2.B.B6. Intentionally Blank	3.2.C.B6. Intentionally Blank	3.2.P.B6. PATTERNS SCALE MODELS CONSTANCY/CHANGE Use Newton's laws of motion and gravitation to describe and predict the motion of objects ranging from atoms to the galaxies.	3.2.12.B6. CONSTANCY/CHANGE Compare and contrast motions of objects using forces and conservation laws.
7 Science as Inquiry	3.2.7.B7. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.B.B7. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.C.B7. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.P.B7. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.2.12.B7. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.3. Earth and Space Sciences					
3.3.A. Earth Structure, Processes and Cycles					
	3.3.10.A. GRADE 10	**3.3.B.A. BIOLOGY**	**3.3.C.A. CHEMISTRY**	**3.3.P.A. PHYSICS**	**3.3.12.A. 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:					
1 Earth Features and the Processes that Change It	3.3.10.A1. Relate **plate tectonics** to both slow and rapid changes in the earth's surface. Describe the **rock cycle** and the processes that are responsible for the formation of **igneous**, **sedimentary,** and **metamorphic** rocks. Relate **geochemical cycles** to the conservation of matter. Explain how the Earth is composed of a number of dynamic, interacting systems exchanging energy or matter.	3.3.B.A1. Intentionally Blank	3.3.C.A1. Intentionally Blank	3.3.P.A1. Intentionally Blank	3.3.12.A1. Explain how parts are related to other parts in weather systems, solar systems, and earth systems, including how the output from one part can become an input to another part. Analyze the processes that cause the movement of material in the Earth's systems. Classify Earth's internal and external sources of energy such as **radioactive decay**, **gravity,** and solar energy.

3.3. Earth and Space Sciences					
3.3.A. Earth Structure, Processes and Cycles					
	3.3.10.A. GRADE 10	**3.3.B.A. BIOLOGY**	**3.3.C.A. CHEMISTRY**	**3.3.P.A. PHYSICS**	**3.3.12.A. 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:					
2 Earth's Resources/Materials	3.3.10.A2. Analyze the effects on the environment and the **carbon cycle** of using both renewable and nonrenewable sources of energy.	3.3.B.A2. Intentionally Blank	3.3.C.A2. Intentionally Blank	3.3.P.A2. Intentionally Blank	3.3.12.A2. Analyze the availability, location, and extraction of Earth's resources. Evaluate the impact of using renewable and nonrenewable energy resources on the Earth's **system.**
3 Earth's History	3.3.10.A3. Explain how the **evolution** of Earth has been driven by interactions between the **lithosphere**, **hydrosphere**, **atmosphere,** and **biosphere.**	3.3.B.A3. Intentionally Blank	3.3.C.A3. Intentionally Blank	3.3.P.A3. Intentionally Blank	3.3.12.A3. Describe the absolute and relative dating methods used to measure **geologic time**, such as index fossils, radioactive dating, **law of superposition,** and crosscutting relationships.
4 Sciences and Transfer of Energy	3.3.10.A4. Relate **geochemical cycles** to conservation of matter. Explain how the Earth's systems and its various cycles are driven by energy.	3.3.B.A4. Intentionally Blank	3.3.C.A4. Intentionally Blank	3.3.P.A4. Intentionally Blank	3.3.12.A4. Classify Earth's internal and external sources of energy such as **radioactive decay, gravity,** and **solar energy.** Relate the transfer of energy through radiation, conduction, and convection to global atmospheric processes.

3.3. Earth and Space Sciences					
3.3.A. Earth Structure, Processes and Cycles					
	3.3.10.A. GRADE 10	**3.3.B.A. BIOLOGY**	**3.3.C.A. CHEMISTRY**	**3.3.P.A. PHYSICS**	**3.3.12.A. 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:					
5 Water	3.3.10.A5. Explain how there is only one ocean. Explain the processes of the **hydrologic cycle.** Explain the dynamics of oceanic **currents** and their relationship to global circulation within the marine environment.	3.3.B.A5. Intentionally Blank	3.3.C.A5. Intentionally Blank	3.3.P.A5. Intentionally Blank	3.3.12.A5. Explain how the ocean dominates the Earth's carbon cycle.
6 Weather and Climate	3.3.10.A6. Interpret meteorological data to describe and/or predict weather. Explain the phenomena that cause global atmospheric processes such as storms, **currents,** and wind patterns.	3.3.B.A6. Intentionally Blank	3.3.C.A6. Intentionally Blank	3.3.P.A6. Intentionally Blank	3.3.12.A6. Explain how the unequal heating of the Earth's surface leads to atmospheric global circulation changes, climate, local short term changes, and weather. Relate the transfer of energy through **radiation**, conduction, and **convection** to global atmospheric processes.

3.3. Earth and Space Sciences					
3.3.A. Earth Structure, Processes and Cycles					
	3.3.10.A. GRADE 10	**3.3.B.A. BIOLOGY**	**3.3.C.A. CHEMISTRY**	**3.3.P.A. PHYSICS**	**3.3.12.A. 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:					
7 Unifying Themes	3.3.10.A7. SCALE/MODELS Interpret and create models of the Earth's physical features in various mapping representations. CONSTANCY AND CHANGE Relate constancy and change to the hydrologic and **geochemical cycles.** SCALE Apply an appropriate scale to illustrate major events throughout **geologic time.** CONSTANCY/CHANGE Describe factors that contribute to global climate change.	3.3.B.A7. Intentionally Blank	3.3.C.A7. Intentionally Blank	3.3.P.A7. Intentionally Blank	3.3.12.A7. MODELS Interpret and analyze a combination of ground-based observations, satellite data, and computer models to demonstrate Earth **systems** and their interconnections. CONSTANCY/CHANGE Infer how human activities may impact the natural course of Earth's cycles. PATTERNS Summarize the use of data in understanding **seismic events**, **meteorology,** and **geologic time.**
8 Science as Inquiry	3.3.10.A8. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.B.A8. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.C.A8. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.P.A8. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.12.A8. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.3. Earth and Space Sciences				
3.3.B. Origin and Evolution of the Universe				
3.3.10.B. GRADE 10	**3.3.B.B. BIOLOGY**	**3.3.C.B. CHEMISTRY**	**3.3.P.B. PHYSICS**	**3.3.12.B. 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:				
1 Composition and Structure	3.3.10.B1. Explain how gravity is responsible for planetary orbits. Explain what caused the sun, Earth, and most of the other planets to form between 4 and 5 billion years ago. Provide evidence to suggest the Big Bang Theory. Describe the basic **nuclear processes** involved in energy production in a star.	3.3.B.B1. Intentionally Blank	3.3.C.B1. Intentionally Blank	3.3.P.B1. Intentionally Blank	3.3.12.B1. Describe the **life cycle** of stars based on their mass. Analyze the influence of **gravity** on the formation and **life cycles** of galaxies, including our own Milky Way **galaxy**; stars; planetary **systems**; and residual material left from the creation of the **solar system**. Relate the **nuclear processes** involved in energy production in stars and supernovas to their **life cycles.**

3.3. Earth and Space Sciences				
3.3.B. Origin and Evolution of the Universe				
3.3.10.B. GRADE 10	**3.3.B.B. BIOLOGY**	**3.3.C.B. CHEMISTRY**	**3.3.P.B. PHYSICS**	**3.3.12.B. 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:				
2 Unifying Themes	3.3.10.B2. SCALE AND MEASUREMENT Explain how scientists obtain information about the universe by using technology to detect **electromagnetic radiation** that is emitted, reflected, or absorbed by stars and other objects. CONSTANCY AND CHANGE Describe changes in the universe over billions of years. SCALE AND MEASUREMENT Explain the scale used to measure the sizes of stars and galaxies and the distances between them.	3.3.B.B2. Intentionally Blank	3.3.C.B2. Intentionally Blank	3.3.P.B2. Intentionally Blank	3.3.12.B2. MODELS AND SCALE Apply mathematical models and computer simulations to study evidence collected relating to the extent and composition of the universe. PATTERNS AND CONSTANCY AND CHANGE Analyze the evidence supporting theories of the origin of the universe to predict its future.
3 Science as Inquiry	3.3.10.B3. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.B.B3. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.C.B3. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.P.B3. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)	3.3.12.B3. See *Science as Inquiry* in the Introduction for grade level indicators. (As indicated on page 8)

3.4. Technology and Engineering Education					
3.4.A. The Scope of Technology					
3.4.10.A. GRADE 10					**3.4.12.A. 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:					
1 Characteristics Of Technology	3.4.10.A1. Illustrate how the development of **technologies** is often driven by profit and an economic market.				3.4.12.A1. Compare and contrast the rate of technological development over time.
2 Core Concepts of Technology	3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.				3.4.12.A2. Describe how management is the process of planning, organizing, and controlling work.
3 Technology Connections	3.4.10.A3. Examine how **technology** transfer occurs when a new user applies an existing **innovation** developed for one purpose in a different function.				3.4.12.A3. Demonstrate how technological progress promotes the advancement of science, **technology**, engineering and mathematics (**STEM**).

3.4. Technology and Engineering Education					
3.4.B. Technology and Society					
3.4.10.B. GRADE 10					**3.4.12.B. 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:					
1 Effects of Technology	3.4.10.B1. Compare and contrast how the use of **technology** involves weighing the trade-offs between the positive and negative effects.				3.4.12.B1. Analyze ethical, social, economic, and cultural considerations as related to the development, selection, and use of **technologies**.
2 Technology and Environment	3.4.10.B2. Demonstrate how humans devise **technologies** to reduce the negative consequences of other **technologies**.				3.4.12.B2. Illustrate how, with the aid of **technology**, various aspects of the environment can be monitored to provide information for decision making.
3 Society and Development of Technology	3.4.10.B3. Compare and contrast how a number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads, contribute to shaping the design of and demand for various **technologies**.				3.4.12.B3. Intentionally Blank

3.4. Technology and Engineering Education					
3.4.B. Technology and Society					
3.4.10.B. GRADE 10					**3.4.12.B. 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:					
4 Technology and History	3.4.10.B4. Recognize that technological development has been evolutionary, the result of a series of refinements to a basic **invention**.				3.4.12.B4. Intentionally Blank

3.4. Technology and Engineering Education					
3.4.C. Technology and Engineering Design					
3.4.10.C. GRADE 10					**3.4.12.C. 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:					
1 Design Attributes	3.4.10.C1. Apply the components of the technological design process.				3.4.12.C1. Intentionally Blank
2 Engineering Design	3.4.10.C2. Analyze a **prototype** and/or create a working model to test a design concept by making actual observations and necessary adjustments.				3.4.12.C2. Apply the concept that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

3.4. Technology and Engineering Education					
3.4.C. Technology and Engineering Design					
3.4.10.C. GRADE 10					**3.4.12.C. 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:					
3 Research & Development, Invention & Innovation, Experimentation / Problem Solving and Troubleshooting	3.4.10.C3. Illustrate the concept that not all problems are technological and not every problem can be solved using **technology**.				3.4.12.C3. Apply the concept that many technological problems require a multi-disciplinary approach.

3.4. Technology and Engineering Education					
3.4.D. Abilities for a Technological World					
3.4.10.D. GRADE 10					**3.4.12.D. 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:					
1 Applying the Design Process	3.4.10.D1. Refine a design by using **prototypes** and modeling to ensure quality, efficiency, and productivity of a final product.				3.4.12.D1. Intentionally Blank
2 Using and Maintaining Technological Systems	3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.				3.4.12.D2. Verify that engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.
3 Assessing Impact of Products and Systems	3.4.10.D3. Synthesize data, analyze trends, and draw conclusions regarding the effect of **technology** on the individual, society, and the environment.				3.4.12.D3. Intentionally Blank

3.4. Technology and Engineering Education					
3.4.E. The Designed World					
3.4.10.E. GRADE 10					**3.4.12.E. 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:					
1 Medical Technologies	3.4.10.E1. Assess how medical **technologies** over time have impacted prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, and genetic engineering.				3.4.12.E1. Compare and contrast the emerging **technologies** of **telemedicine**, **nanotechnology**, prosthetics, and biochemistry as they relate to improving human health.
2 Agricultural and Related Biotechnologies	3.4.10.E2. Compare and contrast how the engineering design and management of agricultural **systems** require knowledge of artificial ecosystems and the effects of technological development on flora and fauna.				3.4.12.E2. Compare and contrast the **technologies** of **biotechnology**, conservation, bio-fuels, and ecosystems as they relate to managing Earth's resources effectively.
3 Energy and Power Technologies	3.4.10.E3. Compare and contrast the major forms of energy: thermal, radiant, electrical, mechanical, chemical, nuclear and others.				3.4.12.E3. Compare and contrast energy and power **systems** as they relate to pollution, renewable and non-renewable resources, and conservation.

3.4. Technology and Engineering Education					
3.4.E. The Designed World					
3.4.10.E. GRADE 10					**3.4.12.E. 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:					
4 Information and Communication Technologies	3.4.10.E4. Evaluate the purpose and effectiveness of information and communication **systems**.				3.4.12.E4 Synthesize the effects of information and communication **systems** and **subsystems** as an integral part of the development of the Information Age.
5 Transportation Technologies	3.4.10.E5. Analyze the development of transportation services and methods and their impact on society.				3.4.12.E5. Explain how the design of intelligent and non-intelligent transportation **systems** depends on many processes and innovative techniques.
6 Manufacturing Technologies	3.4.10.E6. Illustrate how manufacturing **systems** may be classified into types such as customized production, batch production, and continuous production.				3.4.12.E6. Compare and contrast the importance of science, **technology**, engineering and math (**STEM**) as it pertains to the manufactured world.

3.4. Technology and Engineering Education					
3.4.E. The Designed World					
3.4.10.E. GRADE 10					**3.4.12.E. 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:					
7 Construction Technologies	3.4.10.E7. Evaluate structure design as related to function, considering such factors as style, convenience, safety, and efficiency.				3.4.12.E7. Analyze the **technologies** of prefabrication and new structural materials and processes as they pertain to constructing the modern world.

IX. GLOSSARY

Adaptation: A characteristic of an organism that has been favored by natural selection and increases its fitness.

Anatomical: Relating to the structure of the body.

Angular Momentum: The resistance of an object to changes of rotation.

Asexual Reproduction: Offspring produced from only one parent.

Atmosphere: The gaseous mass or envelope surrounding a celestial body, especially the one surrounding the Earth, and retained by the celestial body's gravitational field.

Atoms: The smallest unit of an element that retains the chemical properties of that element.

Biochemistry: The study of the body's chemical reactions.

Biomacromolecules: Carbon-containing polymers in living systems commonly referred to as the molecules of life.

Biosphere: The parts of the land, sea, and atmosphere in which organisms are able to live.

Biotechnology: Any procedure or methodology that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific use. Recently, some have used the term to refer especially to genetic engineering, which is only one of many applications.

Carbon Cycle: A cycle by which carbon is exchanged between the biosphere, pedosphere, geosphere, hydrosphere and atmosphere of the Earth.

Cell Cycle: The process by which cells duplicate themselves.

Colligative Properties: Properties of solutions that depend on the number of particles in a given volume of solvent and not on the mass of the particles.

Compounds: A substance consisting of two or more different elements chemically bonded together in a fixed proportion by mass.

Conduction: The transfer of heat through solids.

Convection: Transfer of heat by moving the molecules of a gas and/or liquid.

Coulomb's Law: Electrical charges attract or repel one another with a force proportional to the product of their charges and inversely proportional to the square of their separation distance.

Current: The flow of electrons through a conductor.

Density: The ratio of its mass (m) to its volume (V), a measure of how tightly the matter within it is packed together.

Digestion: How the body breaks down eaten food into molecules.

DNA: The fundamental substance of which genes are composed. Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions directing the biological development of all cellular forms of life, and many viruses.

Electricity: The flow of electrons through a conductor or the additional or loss of electrons from a material.

Electrochemical Reactions: Any process either caused or accompanied by the passage of an electric current and involving in most cases the transfer of electrons between two substances—one a solid and the other a liquid.

Electromagnetic Force: The force that charged objects exert on one another.

Electromagnetic Spectrum: Electromagnetic waves can exhibit a distribution of frequencies ranging below radio wave to light beyond the visible.

Electron Orbital Transitions: The probability distribution of an electron in an atom or molecule.

Elements: A type of atom that is distinguished by its atomic number; i.e., by the number of protons in its nucleus. The term is also used to refer to a pure chemical substance composed of atoms with the same number of protons.

Endothermic: A process or reaction that absorbs energy in the form of heat.

Engineering Design Process: The process or method used by engineers to solve a problem. The steps include:

1. Define a problem
2. Generate ideas
3. Select a solution and test it
4. Make the item
5. Evaluate the item
6. Communicate the solution with others
7. Present the results.

Enzymes: Protein that catalyzes chemical reactions in cells.

Equilibrium: A condition in which all acting influences are cancelled by others, resulting in a stable, balanced or unchanging system.

Evolution: The change in genetic composition of a population over successive generations leading to the formation of a new species.

Exothermic: A process or reaction that releases energy usually in the form of heat, but it can also release energy in form of light (e.g. explosions), sound or electricity (e.g., a battery).

Extinction: The cessation of existence of a species.

Families: A taxonomic rank; a way of classifying organisms into groups based on similarities.

Food Chain: A relationship of who eats whom.

Food Web: A complex relationship where most organisms are eaten by more than one type of consumer.

Forensics: The use of DNA for identification. Some examples of DNA use are to establish paternity in child support cases; establish the presence of a suspect at a crime scene, and identify accident victims.

Frequency: The number of repeated wave cycles per second.

Galaxy: A massive, gravitationally bound system consisting of stars, an interstellar medium of gas and dust and dark matter.

Gamete: A sex cell containing one set of chromosomes, sperm or egg.

Gene Expression: The process by which inheritable information from a gene, such as the DNA sequence, is made into a functional gene product, such as protein or RNA.

Gene Recombination: The process by which a strand of genetic material (usually DNA but can also be RNA) is broken and then joined to a different DNA molecule.

Genetic Engineering: The technology entailing all processes of altering the genetic material of a cell to make it capable of performing the desired functions, such as mass-producing substances like insulin.

Genetic(s): The study of inheritance.

Genotypic: Referring to the actual genetic composition of an organism.

Geochemical Cycles: The Earth is a containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs in the solid earth, oceans, atmosphere and organisms.

Geologic Time: A chronologic schema to describe the timing and relationships between events that have occurred during the history of Earth.

Geology: The science and study of the solid matter that constitutes the Earth.

Gradualism: Evolution model stating that mutations and phenotypic changes leading to the formation of new species are gradual and explain the fossil record gaps as simply missing because fossils are hard to find.

Gravity: The fundamental force of attraction that all objects with mass have for each other.

Hydrogen Bonds: A special type of dipole-dipole force that exists between an electronegative atom and a hydrogen atom bonded to Nitrogen, Oxygen or Fluorine.

Hydrologic Cycle: Describes the continuous movement of water on, above and below the surface of the Earth.

Hydrosphere: The water on or surrounding the surface of the globe, including the water of the oceans and the water in the atmosphere.

Igneous: Rock produced under conditions involving intense heat, as rocks of volcanic origin or rocks crystallized from molten magma.

Inertia: The resistance an object has to a change in its state of motion.

Innovation: The introduction of something new or a new idea, method or device. An innovation can be clearly complex or seemingly simple.

Invention: An invention is a creation of the mind, and both the process to arrive at this creation or the capabilities to create it are referred to as invention. An invention is also supposed to be new, although it is unspecified for whom. An invention is a novel device, material, or technique. It is also useful to contrast invention with two other highly related words: discovery and innovation. Although invention and discovery are synonymous in certain contexts, it is also common to use invention for a creation of the mind and discovery for a novel observation, usually of a natural phenomenon. (We quote Reference.com to explain the difference between invention and innovation.)

Kinetic Molecular Theory: Explains the forces between molecules and the energy that they possess; explains macroscopic properties of gases, such as pressure, temperature or volume, by considering their molecular composition and motion.

Law of Superposition: A general law stating that in any sequence of sediments or rocks that has not been overturned, the youngest sediments or rocks are at the top of the sequence and the oldest are at the bottom.

Life Cycles: The lifetime of an organism from birth to death.

Lithosphere: The outer part of the Earth, consisting of the crust and upper mantle.

Lymphocytes: White blood cells.

Magnets: A material that attracts or repels the same material and attracts iron and steel.

Mass: How much matter there is in an object.

Meiosis	A type of cell division consisting or two rounds of nuclear and cellular division.
Mendelian Patterns of Inheritance	Predicting the inheritance of offspring traits
Metamorphic:	Rock that was once one form of rock but has changed to another under the influence of heat, pressure or some other agent without passing through a liquid phase.
Meteorology:	The interdisciplinary scientific study of the atmosphere that focuses on weather processes and forecasting.
Mitosis:	Process by which one cell divides into two cells.
Mixtures:	A substance that is not the same from one sample to the next, and a mixture can be separated into its parts; Two or more substances that are mixed together but not chemically joined.
Molar Mass:	The mass of one mole of a substance, chemical element or chemical compound.
Mole:	Avogadro's number of the constituent entities of that substance; Avogadro's number, approximately 6.02214×10^{23}, makes the weight of a mole in grams equal to the weight of an entity in daltons.
Molecular Biology:	The study of how genes work.
Molecules:	The smallest particle of a substance that retains the chemical and physical properties of the substance and is composed of two or more atoms; a group of like or different atoms held together by chemical forces.
Multicellular:	An organism made up of a multiple cells.
Mutations:	Permanent transmissible change in the genetic material.
Nanotechnology:	Deals with materials and machines on an incredibly tiny scale -- less than one billionth of a meter. A nanometer (nm) is one-billionth of a meter, smaller than the wavelength of visible light and a hundred-thousandth the width of a human hair [source: Berkeley Lab]. The arrangement of carbon molecules and the ability to roll atoms into carbon nano tubes can create products that are incredibly strong but lightweight.

Natural Selection: A process in nature in which organisms possessing certain genes that code for traits that make them better adjusted to an environment tend to survive, reproduce, increase in number or frequency, and therefore, are able to transmit and perpetuate these traits.

Neurons: Nerve cells.

Newton's Laws: Three laws that explain the motion of objects caused by forces.

Nuclear Processes: The splitting (fission) or merging together (fusion) of the nuclei of atom(s).

Nuclear Reactions: A process in which two nuclei or nuclear particles collide to produce products different from the initial particles.

Nucleic Acids: The bimolecular DNA and RNA.

Ohm's Law: Voltage is equal to the *current* times the *resistance*.

Organic Molecules: Molecules that use carbon as their chemical backbones.

Organisms: A living individual.

Period: The time in seconds for one wave cycle to occur.

Periodic Table: A tabular method of displaying the chemical elements; used to illustrate recurring trends in the properties of the elements. The layout of the table has been refined and extended over time, as new elements have been discovered and new theoretical models have been developed to explain chemical behavior.

Phenotypic: Referring to the observable expression of an organism's genes.

Physiology: The study of the body's cells function.

Plate Tectonics: The branch of geology studying the folding and faulting of the earth's crust.

Polarity: Description of how equally bonding electrons are shared between atoms.

Protein Synthesis: The creation of proteins using DNA and RNA.

Prototype: A rudimentary working model of a product or information system, usually built for demonstration purposes or as part of the development process.

Punctuated Equilibrium: Evolution model stating that over long periods of time, mutations simply accumulate but do not cause any drastic phenotypic changes, followed by short periods where these mutations are suddenly expressed and new species formed. This would account for the lack of transitional fossils in many phylogenic branches.

Radiation: Transfer of heat through light.

Radioactive Decay: The process in which an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic waves.

Red Blood Cells: Blood cells that carry oxygen through the body.

Resistance: A material that cause a reduction in voltage between two points.

Rock Cycle: The process by which rocks are formed, altered, destroyed, and reformed by geological processes and which is recurrent, returning to a starting point.

Sedimentary: Rock that has formed through the deposition and solidification of sediment.

Seismic Events: The rupture of geological faults, huge amounts of gas migration, mainly methane deep within the earth, but also by volcanic activity, landslides, mine blasts and nuclear experiments.

Sexual Reproduction Reproduction by the union of a sperm and an egg.

Simple Harmonic Motion: A motion that repeats over identical time intervals.

Speciation: The evolutionary process by which new biological species arise.

Species: A group of organisms capable of interbreeding and producing fertile offspring.

Specific Heat: The measure of the heat energy required to increase the temperature of a unit quantity of a substance by a certain temperature interval.

STEM: Science, Technology, Engineering and Math

Stem Cells: Cells that can divide to different type of cells.

Strains: Groups sharing common ancestry with clear-cut physiological distinctions but usually not structural distinctions.

Subsystem: A set of elements, which is a system itself, and a part of a larger system.

System: A set of interacting or interdependent entities, real or abstract, forming an integrated whole. An open system usually interacts with some entities in their environment. A closed system is isolated from its environment.

Technology: The application of knowledge to the practical aims of human life or to changing and manipulating the human environment. Technology is a broad concept that deals with a species' usage and knowledge of tools and crafts, and how it affects a species' ability to control and adapt to its environment.

Telemedicine: The use of telecommunications and information technologies for the provision of health care at a distance.

Theory of Evolution: Theory that explains the process of change in the inherited traits of a population of organisms from one generation to the next. There are two major mechanisms driving evolution: natural selection and genetic drift.

Topography: The three-dimensional arrangement of physical attributes (such as shape, height, and depth) of a land surface in a place or region; physical features that make up the topography of an area include mountains, valleys, plains, and bodies of water; human-made features such as roads, railroads and landfills are also often considered part of a region's topography.

Torque: A force applied at right angles to an object’s center of rotation that cause rotation.

Unicellular: An organism made up of a single cell.

Velocity: The speed and direction of an object or wave.

Voltage: The difference of electrical potential between two points that cause current to flow.

VSEPR: A model which is used for predicting the shapes of individual molecules based upon their extent of electron-pair electrostatic repulsion.

Wavelength: The physical length of one cycle or period of a wave.