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DELAWARE SCIENCE STANDARDS AND GRADE LEVEL EXPECTATIONS	Environmental Science: Your World, Your Turn (Withgott) © 2011
SCIENCE STANDARD 1	
Nature and Application of Science and Technology - Science is a human endeavor involving knowledge learned through inquiring about the natural world. Scientific claims are evaluated and knowledge changes as a result of using the abilities and understandings of inquiry. The pursuit of scientific knowledge is a continuous process involving diverse people throughout history. The practice of science and the development of technology are critical pursuits of our society.	
Strand - Understandings and Abilities of Scientific Inquiry	
- Enduring Understanding: Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying the explanation.	
- Essential Questions: What makes a question scientific? What constitutes evidence? When do you know you have enough evidence? Why is it necessary to justify and communicate an explanation?	
Grades 9-12	
1. Understand that: Scientists conduct investigations for a variety of reasons including to explore new phenomena, to replicate other's results, to test how well a theory predicts, to develop new products, and to compare theories.	**SE/TE:** 6, 16, 23, SH20
- Be able to: Identify and form questions that generate a specific testable hypothesis that guide the design and breadth of the scientific investigation.	**SE/TE:** 15-17, 22, SH20
2. Understand that: Science is distinguished from other ways of knowing by the use of empirical observations, experimental evidence, logical arguments and healthy skepticism.	**SE/TE:** 12-14, 20, 33, SH18
- Be able to: Design and conduct valid scientific investigations to control all but the testable variable in order to test a specific hypothesis.	**SE/TE:** 17-18, 32, SH20-SH21
3. Understand that: Theories in science are well-established explanations of natural phenomena that are supported by many confirmed observations and verified hypotheses. The application of theories allows people to make reasonable predictions. Theories may be amended to become more complete with the introduction of new evidence.	**SE/TE:** 23, 31

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- Be able to: Collect accurate and precise data through the selection and use of tools and technologies appropriate to the investigations. Display and organize data through the use of tables, diagrams, graphs, and other organizers that allow analysis and comparison with known information and allow for replication of results.	**SE/TE:** 17-20, 33, SH9-SH17
4. Understand that: Investigating most real-world problems requires building upon previous scientific findings and cooperation among individuals with knowledge and expertise from a variety of scientific fields. The results of scientific studies are considered valid when subjected to critical review where contradictions are resolved and the explanation is confirmed.	**SE/TE:** 21-23, 30-33
- Be able to: Construct logical scientific explanations and present arguments which defend proposed explanations through the use of closely examined evidence.	**SE/TE:** 13
5. Understand that: In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. (American Association for the Advancement of Science, 2001)	**SE/TE:** 13
- Be able to: Communicate and defend the results of scientific investigations using logical arguments and connections with the known body of scientific information.	**SE/TE:** 13
6. Understand that: Knowledge and skill from sources other than science are essential to scientific inquiry. These include mathematics, reading, writing, and technology.	**SE/TE:** 246-247, SH2-SH8, SH14-SH17
- Be able to: Use mathematics, reading, writing and technology when conducting scientific inquiries.	**SE/TE:** 246-247, SH2-SH8, SH14-SH17

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Strand - Science, Technology, and Society	
- Enduring Understanding: The development of technology and advancement in science influence and drive each other forward.	
- Essential Question: How do science and technology influence each other?	
Grades 9-12	
1. The pursuit of science can generate the need for advanced technology. Advanced technology, in turn, can provide the opportunity to pursue new scientific knowledge.	**SE/TE:** 246-247
2. The social, economic, and political forces of a society have a significant influence on what science and technology programs are pursued, funded, and implemented.	**SE/TE:** 36-41, 42-47, 48-55, 58-61, 96, 192-193, 256, 266, 284-285, 412-413, 480, 574-575
Strand - History and Context of Science	
- Enduring Understanding: Understanding past processes and contributions is essential in building scientific knowledge.	
- Essential Question: How have past scientific contributions influenced current scientific understanding of the world? What do we mean in science when we say that we stand on the shoulders of giants?	
Grades 9-12	
1. New disciplines of science emerge as older disciplines interface into an integrated study of the natural world. As the body of scientific knowledge grows, the boundaries between individual disciplines diminish.	**SE/TE:** 12-15, 21-23

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DELAWARE SCIENCE STANDARDS AND GRADE LEVEL EXPECTATIONS	Environmental Science: Your World, Your Turn (Withgott) © 2011
SCIENCE STANDARD 2	
Materials and Their Properties - Materials exist throughout our physical world. The structures of materials influence their physical properties, chemical reactivity and use.	
Strand - Properties and Structure of Materials	
- Enduring Understanding: The structures of materials determine their properties.	
- Essential Question: How do the properties and structures of materials determine their uses?	
Grades 9-12	
1. All matter is composed of minute particles called atoms. Most of the mass of an atom is concentrated in the nucleus. In the nucleus, there are neutrons with no electrical charge and positively charged protons. Negatively charged electrons surround the nucleus and overall, the atom is electrically neutral.	**SE/TE:** 64-65, 93-94
2. Elements and compounds are pure substances. Elements cannot be decomposed into simpler materials by chemical reactions. Elements can react to form compounds. Elements and/or compounds may also be physically combined to form mixtures.	**SE/TE:** 64-67
3. Isotopes of a given element differ in the number of neutrons in the nucleus. Their chemical properties remain essentially the same.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, 537
4. The periodic table arranges the elements in order of atomic number (the number of protons). The elements are grouped according to similar chemical and physical properties. Properties vary in a regular pattern across the rows (periods) and down the columns (families or groups). As a result, an element's chemical and physical properties can be predicted knowing only its position on the periodic table.	**SE/TE:** SH32
5. An atom's electron structure determines its physical and chemical properties. Metals have valence electrons that can be modeled as a sea of electrons where the valence electrons move freely and are not associated with individual atoms. These freely moving electrons explain the metallic properties such as conductivity, malleability, and ductility.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65

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6. Ionic compounds form when atoms transfer electrons. Covalent compounds form when atoms share electrons. Both types of interactions generally involve valence electrons and produce chemical bonds that determine the chemical property of the compound.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65-66, 71
7. A change in physical properties does not change the chemical composition of the substance. The physical properties of elements and compounds (such as melting and boiling points) reflect the nature of the interactions among their atoms, ions, or molecules and the electrical forces that exist between.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 13, 492
8. A change of phase may occur when there is a change in the potential energy of the atoms or molecules of a substance.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 13, 492
9. Temperature, pressure, and volume are important properties of a gas. A change in two of these properties results in predictable changes in the third.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 455
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Explain that matter is composed of tiny particles called atoms that are unique to each element, and that atoms are composed of subatomic particles called protons, neutrons, and electrons.	**SE/TE:** 64-65, 93-94
- Describe the relative charge, approximate mass, and location of protons, neutrons, and electrons in an atom.	**SE/TE:** 65, 93-94, 537
- Classify matter as mixtures (which are either homogeneous or heterogeneous) or pure substances (which are either compounds or elements.)	**SE/TE:** 67
- Explain that elements are pure substances that cannot be separated by chemical or physical means. Recognize that compounds are pure substances that can be separated by chemical means into elements.	**SE/TE:** 64
- Classify various common materials as an element, compound or mixture.	**SE/TE:** 67

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- Describe isotopes of elements in terms of protons, neutrons, electrons, and average atomic masses. Recognize that isotopes of the same element have essentially the same chemical properties that are determined by the proton and electron number.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, 537
- Use the Periodic Table to identify an element's atomic number, valence electron number, atomic mass, group/family and be able to classify the element as a metal, non-metal or metalloid.	**SE/TE:** SH32
- Determine the physical and chemical properties of an element based on its location on the Periodic Table.	**SE/TE:** SH32
- Investigate differences between the properties of various elements in order to predict the element's location on the Periodic Table.	**SE/TE:** SH32
- Use the Periodic Table to predict the types of chemical bonds (e.g., ionic or covalent) in a variety of compounds.	**SE/TE:** SH32
- Use models or drawings to illustrate how molecules are formed when two or more atoms are held together in covalent bonds by "sharing" electrons. Use models or drawings to illustrate how ionic compounds are formed when two or more atoms "transfer" electrons and are held together in ionic bonds.	**SE/TE:** 65
- Explain how an atom's electron arrangement influences its ability to transfer or share electrons and is related its position on the periodic table. Recognize that an atom in which the positive and negative charges do not balance is an ion.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, SH32
- Recognize that metals have the physical properties of conductivity, malleability, luster, and ductility.	**SE/TE:** 392-394, 398
- Explore the extent to which a variety of solid materials conduct electricity in order to rank the materials from good conductors to poor conductors. Based on the conductivity data, determine patterns of location on the Periodic Table for the good conductors versus the poor conductors.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 392-394, 398

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- Recognize that physical changes alter some physical properties of a substance but do not alter the chemical composition of the substance.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 13, 492
- Conduct investigations to determine the effect of heat energy on the change of state (change of phase) of water. Sketch and interpret graphs representing the melting, freezing, evaporation and condensation of water.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 492
- Recognize that molecular and ionic compounds are electrically neutral.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65
- Apply the kinetic molecular theory to explain that a change in the energy of the particles may result in a temperature change or a change of phase (change in state).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517-518
- Use a model or a diagram to explain water's properties (e.g., density, polarity, hydrogen bonding, boiling point, cohesion, and adhesion) in the three states of matter. Cite specific examples of how water's properties are important (i.e., water as the "universal").	**SE/TE:** 69-71, 92
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Construct models or diagrams (Lewis Dot structures, ball and stick models, or other models) of common compounds and molecules (i.e., NaCl, SiO2, O2, H2, CO2) and distinguish between ionically and covalently bonded compounds. Based on the location of their component elements on the Periodic Table, explain the elements tendency to transfer or share electrons.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, SH32
- Explain why the average atomic mass of an element reflects the relative natural abundance of the element and therefore is not a whole number.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 64-65, SH32
- Explain that unstable isotopes undergo spontaneous nuclear decay, emitting energy or particles and energy.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, 537
- Compare and contrast the energy released by nuclear reactions to that released by chemical reactions.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 537-538

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- Describe the composition of alpha, beta, and gamma radiation and the shielding necessary to prevent penetration.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 458, 484, 601
- Use the half life of a radioactive isotope to calculate the amount of remaining radioactive substance after an integral number of half-lives.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 537
- Use kinetic molecular theory to explain changes in gas volume, pressure, and temperature.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517-518
- Perform simple calculations to show that if the temperature is held constant, changes in pressure and volume of an enclosed gas have an inverse relationship. (Boyles Law).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 455
- Perform simple calculations to show that if the pressure is held constant, changes in temperature (in Kelvin) and volume of an enclosed gas have a direct relationship. (Charles Law).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 455
- Perform simple calculations to show that if the volume is held constant, changes in pressure and temperature (in Kelvin) of an enclosed gas have a direct relationship (Gay-Lussac's Law).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 455
- Use the Periodic Table to show trends within periods and groups (families) regarding atomic size, size of ions, ionization energies and electronegativity.	**SE/TE:** SH32
Strand - Mixtures and Solutions	
- Enduring Understanding: The properties of a mixture are based on the properties of its components.	
- Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?	
Grades 9-12	
1. Properties of solutions, such as pH, solubility, and electrical conductivity depend upon the concentration and interactions of the solute and solvents.	**SE/TE:** 71
2. A variety of methods can be used to separate mixtures into their component parts based upon the chemical and physical properties of the individual components.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67

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Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Recognize that mixtures can be separated by physical means into pure substances.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67
- Explain the effect of water's polarity on the solubility of substances (e.g., alcohol, salt, oil).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 69-70
- Separate mixtures into their component parts according to their physical properties such as melting point, boiling point, magnetism, solubility and particle size. Explain how the properties of the components of the mixture determine the physical separation techniques used.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67
- Describe how the process of diffusion or the movement of molecules from an area of high concentration to an area of low concentration (down the concentration gradient) occurs because of molecular collisions.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67
- Explore how various solutions conduct electricity and rank the liquids from good conductors to poor conductors. Explain the characteristics that allow some solutions to have better electrical conductivity than others.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 68
- Measure the pH of a solution using chemical indicators to determine the relative acidity or alkalinity of the solution. Identify the physical properties of acids and bases.	**SE/TE:** 71
- Investigate factors that affect the materials' solubility in water and construct solubility curves to compare the extent to which the materials dissolve.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 70
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Express the concentration of various solutions in terms of the amount of solute dissolved in the solvent (molarity).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 70-71
- Collect data to calculate the unknown concentration of a solution by performing an acid-base titration using an appropriate indicator. Describe neutralization reactions using chemical equations.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 71

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Strand - Conservation of Matter	
- Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.	
- Essential Questions: How does conservation of mass apply to the interaction of materials in a closed system?	
Grades 9-12	
1. The total mass of the system remains the same regardless of how atoms and molecules in a closed system interact with one another, or how they combine or break apart.	**SE/TE:** 83, 89
2. Radioactive isotopes are unstable and undergo spontaneous and predictable nuclear reactions emitting particles and/or radiation, and become new isotopes that can have very different properties. In these nuclear changes, the total of the mass and energy remains the same.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 537
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Conduct and explain the results of simple investigations to demonstrate that the total mass of a substance is conserved during both physical and chemical changes.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 83, 89
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Recognize that one mole is the amount of any substance that contains 6.02 x 1023 (Avogadro's number) representative particles of that substance. This quantity of particles will have the mass equivalent to the molecular weight (molar mass).	
- Express various quantities of matter in terms of moles (e.g., 6.0 g carbon = .50 moles of carbon; 36 g H2O = 2.0 moles H2O).	
- Determine how the mass of the products compares to the mass of the reactants in chemical investigations. Show how this comparison links to the appropriate balanced chemical equation.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 83, 89

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Strand - Chemical Reactions	
- Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy.	
- Essential Question: What determines the type and extent of a chemical reaction?	
Grades 9-12	
1. Chemical reactions result in new substances with properties that are different from those of the component parts (reactants).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, 467, 499
2. There are different types of chemical reactions. Precipitation reactions produce insoluble substances (e.g., double replacement). The transfer of electrons between atoms is a reduction-oxidation (redox) reaction (e.g., single-replacement combustion, synthesis, decomposition). Some acid/base reactions involve the transfer of hydrogen ions.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 84-85, 142-143, 519, 545-546
3. The rate of a chemical reaction depends on the properties and concentration of the reactants, temperature, and the presence or absence of a catalyst.	
4. Energy is transformed in chemical reactions. Energy diagrams can illustrate this transformation. Exothermic reactions release energy. Endothermic reactions absorb energy.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 545
5. A catalyst lowers the activation energy of a chemical reaction. The catalyst remains unchanged and is not consumed in the overall reaction. Enzymes are protein molecules that catalyze chemical reactions in living systems.	**SE/TE:** 67
6. Certain small molecules (monomers) react with one another in repetitive fashion (polymerization) to form long chain macromolecules (polymers). The properties of the macromolecules depend on the properties of the molecules used in their formation and on the lengths and structure of the polymer chain. Polymers can be natural or synthetic.	**SE/TE:** 67

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Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Recognize that chemical changes alter the chemical composition of a substance forming one or more new substances. The new substance may be a solid, liquid, or gas.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 545
- Balance simple chemical equations and explain how these balanced chemical equations represent the conservation of matter.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 83-85, 89, 519, 546
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Conduct experiments and provide evidence (e.g., formation of a precipitate, evolution of gas, change of color, release/absorption of energy in the form of heat, light, or sound) to determine if a chemical reaction has occurred.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 545
- Identify, name and write formulae for covalent and ionic compounds.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65-68
- Describe chemical reactions using correct chemical formulae and balance the resulting chemical equation.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65, 84-85, 142-143, 519, 546
- Classify various reactions as synthesis (combination), single replacement, double replacement, decomposition or combustion.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 84-85, 142-143, 519, 545-546
- Explain whether or not a chemical reaction would occur given a set of reactants. Predict the product(s) if the reactions would occur.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 84-85, 142-143
- Investigate factors (e.g., presence of a catalyst, temperature, concentration) that influence reaction rates.	**SE/TE:** 67
- Analyze reaction diagrams for some common chemical reactions to compare the amount of heat energy absorbed by the reaction to the amount of heat energy released. Explain, using the diagrams, that if the products of the reactions are at a higher level than the reactants, the reaction has absorbed heat energy (endothermic), but if the products of the reaction are at a lower level than the reactants, then heat energy has been released (exothermic).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 545

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Strand - Material Technology	
- Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.	
- Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?	
Grades 9-12	
1. Materials' properties determine their use. New materials can improve the quality of life. However, their development and production often raise social, economic, and environmental issues that require analyses of the risks and benefits.	**SE/TE:** 398-399, 403-404, 411, 414-417
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Research and report on a variety of manufactured goods and show how the chemical properties of the component materials were used to achieve the desired qualities.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 398-399, 403-404, 411, 414-417
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Identify polymers as large molecules with a carbon backbone. Recognize that polymers are comprised of repeating monomers. Investigate synthetic and naturally occurring polymers and relate their chemical structure to their current or potential use.	**SE/TE:** 67
- Research and report on materials that are used in response to human and societal needs. These materials might include but are not limited to synthetic polymers such as Kevlar or Gortex; or radioactive isotopes such as U235, or C14, etc… Recognize the intended (and realized) benefits as well as any risks or trade-offs required in their production and use.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 398-399, 403-404, 411, 414-417

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SCIENCE STANDARD 3	
Energy and Its Effects - The flow of energy drives processes of change in all biological, chemical, physical, and geological systems. Energy stored in a variety of sources can be transformed into other energy forms, which influence many facets of our daily lives. The forms of energy involved and the properties of the materials involved influence the nature of the energy transformations and the mechanisms by which energy is transferred. The conservation of energy is a law that can be used to analyze and build understandings of diverse physical and biological systems.	
Strand - The Forms and Sources of Energy	
- Enduring Understanding: Energy takes many forms. These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and with energy fields (potential energy).	
- Essential Question: How do we know that things have energy?	
Grades 9-12	
1. Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy.	**SE/TE:** 519
2. An object has kinetic energy because of its linear motion, rotational motion, or both. The kinetic energy of an object can be determined knowing its mass and speed. The object's geometry also needs to be known to determine its rotational kinetic energy. An object can have potential energy when under the influence of gravity, elastic forces or electric forces and its potential energy can be determined from its position.	**SE/TE:** 517-518, 545
3. Mechanical waves result from the organized vibrations of molecules in substances. Kinetic energy can be transferred very quickly over large distances by mechanical waves.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517-518, 545
4. Thermal (heat) energy is associated with the random kinetic energy of the molecules of a substance.	**SE/TE:** 518
5. Magnetic energy and electrical energy are different aspects of a single electromagnetic energy, which results from the motion of electrical charges.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517-518, 545
6. Chemical energy is derived from the making and breaking of chemical bonds.	**SE/TE:** 519

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7. Nuclear energy is a form of potential energy that is released when a portion of the mass of the nucleus is converted to energy through nuclear fusion, nuclear fission, or radioactive decay.	**SE/TE:** 519, 537-538, 541, 544-547
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Recognize that electromagnetic energy (radiant energy) is carried by electromagnetic waves.	**SE/TE:** 519
- Use diagrams to illustrate the similarities shared by all electromagnetic waves and differences between them. Show how wavelength is used to distinguish the different groups of EM waves (radio waves, microwaves, IR, visible and UV waves, X-rays, and gamma waves).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519
- Conduct investigations involving moving objects to examine the influence that the mass and the speed have on the kinetic energy of the object. Collect and graph data that supports that the kinetic energy depends linearly upon the mass, but nonlinearly upon the speed. Recognize that the kinetic energy of an object depends on the square of its speed, and that KE =½ mv2.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517-518
- Collect and graph data that shows that the potential energy of an object increases linearly with the weight of an object (mg) and with its height above a pre-defined reference level, h. (GPE = mgh).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517-519
- Conduct investigations and graph data that indicate that the energy stored in a stretched elastic material increases nonlinearly with the extent to which the material was stretched.	
- Recognize that the energy stored in a stretched elastic material is proportional to the square of the stretch of the material, and a constant that reflects the elasticity of the material. (Elastic PE = ½ kx2)	
- Explain that heat energy represents the total random kinetic energy of molecules of a substance.	**SE/TE:** 518
- Recognize that chemical energy is the energy stored in the bonding of atoms and molecules.	**SE/TE:** 519, 545

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- Describe the differences between nuclear energy and chemical energy, that chemical energy is derived from the energy of the electrons that move around the nucleus, while nuclear energy is associated with the protons and neutrons in the nucleus.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 537-538
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Conduct investigations to identify how the rotational kinetic energy of an object depends on the object's mass, angular speed (rpm), and its geometry (for example; solid and hollow spheres, solid and hollow cylinders, rings).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517
- Conduct investigations to show that rolling objects have two kinds of kinetic energy, linear kinetic energy (LKE), and rotational kinetic energy (RKE). For example, a ball released on a ramp from a height, h, will consistently reach the bottom of the ramp with less linear kinetic energy than its GPE at the top of the ramp. The RKE of the rolling object explains the difference.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 517
- Explain that when a chemical reaction takes place and energy is released, the reaction results in molecules that have a lower chemical energy and if energy must be added for a chemical reaction to take place, the molecules that result from that reaction have higher chemical energy.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 545
- Recognize that nuclear energy takes the form of mass, and that energy is released from a nuclear reaction as a consequence of the annihilation of mass.	**SE/TE:** 519, 537-538, 541, 546
- Explain why large amounts of energy are released when small amounts of mass are annihilated (E = mc2).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 537-538, 541, 546

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Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Explain that the quantity of radiant energy delivered to a surface every second can be viewed in two different ways. Use the concept of waves to describe that the energy delivered by electromagnetic radiation depends on the amplitude and frequency of the electromagnetic waves. Use the particle model of electromagnetic radiation (energy is carried by packets of electromagnetic energy called photons) to explain that the radiant energy delivered depends on the frequency of the radiation and the number of packets striking the surface per second.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519
Strand - Forces and the Transfer of Energy	
- Enduring Understanding: Changes take place because of the transfer of energy. Energy is transferred to matter through the action of forces. Different forces are responsible for the transfer of the different forms of energy.	
- Essential Question: How can energy be transferred from one material to another? What happens to a material when energy is transferred to it?	
Grades 9-12	
1. Forces change the motion of objects. Newton's Laws can be used to predict these changes.	
2. Forces are mechanisms that can transfer energy from one object to another. A force acting on an object and moving it through a distance does work on that object and changes its kinetic energy, potential energy, or both. Power indicates the rate at which forces transfer energy to an object or away from it.	
3. The momentum of an object can be determined from the object's velocity and it's mass. An impulse represents how much the momentum of an object changes when a force acts on it. The impulse can be used to estimate the size of the force acting on the object.	
4. The Law of Conservation of Momentum can be used to predict the outcomes of collisions between objects and can aid in understanding the energy transfers and energy transformations in these collisions.	

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5. Gravity is a universal force of attraction that each mass exerts on any other mass. The strength of the force depends on the masses of the objects and the distance between them. The force of gravity is generally not important unless at least one of the two masses involved is huge (a star, the Earth or another planet or a moon).	
6. Electric forces between charged objects are attractive or repulsive. The electric forces between electrons and protons are attractive, determine the structure of atoms, and are involved in all chemical reactions. The electromagnetic forces acting between atoms or molecules are much stronger than the gravitational forces between the same atoms or molecules and are responsible for many common forces such as friction, tensions and supporting forces.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 64-65
7. Electromagnetic forces are responsible for the physical properties of materials (e.g., the boiling point of a liquid) and the mechanical properties of materials (e.g., surface tension).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 65
8. Electric currents create magnetic fields, and changing magnetic fields induce electric currents. The electric and magnetic forces that result from this interaction are the basis for electric motors, electric generators, and other modern technologies.	
9. The nuclear forces that hold the nucleus of an atom together are much stronger than the repulsive electric forces acting between the protons that would make the nucleus fly apart, therefore, most atoms have stable nuclei.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 64-65
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Recognize that electromagnetic waves transfer energy from one charged particle to another. Use graphics or computer animations to illustrate this transfer process. Give everyday examples of how society uses these transfer processes (for example, communication devices such as radios and cell phones).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519

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- Use diagrams to illustrate how the motion of molecules when a mechanical wave passes through the substance is different from the motion associated with their random kinetic energies.	
- Use diagrams or models to explain how mechanical waves can transport energy without transporting matter.	
- Reflect on why mechanical waves will pass through some states of matter better than others.	
- Recognize that the gravitational force is a universal force of attraction that acts between masses, but this force is only significant when one (or both) of the objects is massive (for example, a star, planet or moon).	
- Explain that as objects move away from the surface of a planet or moon, the gravitational pull on the object will decrease.	
- Use examples to illustrate that near the surface of a planet or moon, the gravitational force acting on an object remains nearly constant.	
- Recognize that on Earth, the object would have to be moved several hundred miles above the surface before the decrease in the force of gravity would become detectable.	
- Explain the difference between the mass of an object and its weight. Identify that near the surface of the Earth, the gravitational force acting on the object (its weight) depends only on its mass, and that this force can be simply calculated from knowledge of the mass (FG = mg).	
- Conduct investigations to determine the behavior of elastic materials. Graph the data and identify the relationship between the extent of the stretch and the size of the elastic force (i.e., Felastic = kx where x = stretch).	
- Describe the role that forces play when energy is transferred between interacting objects and explain how the amount of energy transferred can be calculated from measurable quantities.	

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- Give examples of common forces transferring energy to (or away from) objects. For example; a pulling force can transfer energy to an object (when the object is pulled along a floor), a pushing force can transfer energy away from an object (to slow its motion), and friction and air resistance always transfer kinetic energy away from moving objects.	
- Identify that "work" is the process by which a force transfers energy to an object, and use measured quantities to make calculations of the work done by forces (W = energy transferred = F·D).	
- Conduct investigations to determine what factors influence whether a force transfers energy to an object or away from the object, and how the direction of the force (relative to the direction of motion) influences the quantity of energy transferred by the force.	
- Recognize that power is a quantity that tells us how quickly energy is transferred to an object or transferred away from the object. Give examples that illustrate the differences between power, force and energy (for example, the energy needed to propel a vehicle is stored in the chemical energy of the fuel. Static friction is the force that propels the vehicle, and the power of the vehicle's engine helps to determine how quickly the vehicle can speed up …. and how quickly its engine uses fuel!).	
- Use models and diagrams to illustrate the structure of the atom. Include information regarding the distribution of electric charge and mass in the atom. Identify the forces that are responsible for the stability of the atom, and which parts of the atom exert and feel these forces.	**SE/TE:** 64-65
- Recognize that there are attractive forces acting within the nucleus that are different from electric forces, and that these forces are responsible for the stability of the nucleus.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 64-65

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Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Use the inverse square law to describe how the force of gravity changes over long distances (for example, describe the forces acting on the Voyager Space Probes as they moved through the solar system).	
- Conduct investigations to determine the relative sizes of static and kinetic frictional forces acting between two surfaces.	
- Conduct investigations to determine what variables (mass, normal force, surface area, surface texture, etc.) influence the size of frictional forces that act between two objects.	
- Give examples in which static friction is a force of propulsion, initiating the motion of an object. Use force diagrams to illustrate the forces acting on the object during this propulsion process.	
- Use force diagrams to describe how static friction can prevent an object (that is subject to another force) from moving.	
- Draw force diagrams to illustrate the action of friction when it acts to slow-down an object. Use an energy argument to describe how friction slows down a moving object.	
- Describe the factors that contribute to the size of an electric force acting between charged particles (i.e., the size of an electric force depends upon the size of the charges involved and the distance between the charges). Recognize that the electric force is an inverse square force like the gravitational force.	
- Use a sketch of this force to describe how its influence changes as the distance between the charges increases.	

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- Recognize that the gravitational forces acting between objects the size of people or even large trucks is negligible compared to their weight (for example, FGrav acting between two people standing 1m apart on the Earth's surface is less than one billionth the size of their weight). Also recognize that gravitational forces between particles at the molecular level are completely negligible when compared to electric forces that act between these particles (FGrav/Felectric<10-30).	
- Describe how many of the forces acting between objects (friction and normal forces) and acting within objects (tensions, compressions and elastic forces) are manifestations of the electromagnetic forces that act between atoms and molecules in substances.	
- Use diagrams or models to show how the electric forces acting between molecules can explain the presence of these forces.	
- Use diagrams to show the similarities between the magnetic field of a permanent magnet and the magnetic field created by an electric coil.	
- Conduct investigations to show how forces acting between permanent magnets and conducting coils carrying electric currents can be used to create electric motors.	
- Use diagrams to show how magnets and rotating coils can be used to create electric currents.	
- Use vector diagrams to illustrate the forces that act within the nucleus. Recognize that the stability of a nucleus depends upon the repulsive electric forces acting between the protons and the attractive nuclear forces acting between all protons and neutrons in the nucleus.	
- Use examples of mechanical or chemical systems to explain that the stability of an object is linked to the object's energy, and that stability can be used as an indicator how likely it is that an object will undergo a physical, chemical, or nuclear change.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 537, 541

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DELAWARE SCIENCE STANDARDS AND GRADE LEVEL EXPECTATIONS	Environmental Science: Your World, Your Turn (Withgott) © 2011
- Identify mid-sized nuclei as the most stable nuclei, and use the concept of stability to explain the basics of nuclear fission, fusion, and radioactive decay. Use models and diagrams to illustrate the differences between fission, fusion and radioactive decay.	**SE/TE:** 537, 541
- Use vector diagrams to illustrate how the total force is determined from a group of individual forces.	
- Make vector diagrams of objects moving with a constant velocity, identifying all of the forces acting on the object (for example, a car moving along a straight highway, an aircraft in flight, an elevator ascending at constant speed, etc.).	
- Reflect on how forces can collectively act on the object and not change its motion (basis of Newton's 1st Law).	
- Conduct investigations to reach qualitative and quantitative conclusions regarding the effects of the size of the total force and the object's mass on its resulting acceleration (Newton's 2nd Law, a = Ftotat/m). Observe how the direction of the acceleration relates to the direction of the total force.	
- Use examples to illustrate the differences between mass and force and explain why only forces can change the motion of objects.	
- Explain why an object with a large mass is usually more difficult to start moving than an object with a smaller mass.	
- Use Newton's Second Law to calculate the acceleration of objects that are subject to common forces (for example, gravity, constant pushing or pulling forces and/or friction).	
- Use vector diagrams to show how the direction of the acceleration (relative to the direction of the velocity) can be used to determine if the speed of the object will increase or decrease, and if the direction of motion will change.	

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- Describe what the size of the acceleration of an object indicates about the object's motion (how quickly the object's velocity will change). Give examples of objects having large accelerations (motorcycles starting from rest, vehicles stopping abruptly, cars negotiating sharp curves), and objects having small accelerations (tractor trailers starting from rest, large ships slowing down, and vehicles traveling on long gradual curves on highways).	
- Conduct investigations to show that the acceleration due to gravity is the same for all objects near the surface of the earth. Use graphical analysis to determine the acceleration due to gravity from experimental data.	
- Use algebraic relationships that relate the acceleration of an object to its speed and position to make predictions about the motion of objects as they move along straight and circular paths.	
- Conduct investigations (or demonstrate) that under a variety of conditions when two objects collide they exert equal sized forces on each other. Use Newton's 2nd Law to explain why these two objects may react differently to equal sized forces.	
- Use vector diagrams and Newton's 3rd Law to explain how a bathroom scale indirectly indicates your weight.	
- Recognize that momentum of an object is a property of its motion that can be calculated from its mass and its velocity ($P = mv$), and that only forces can change the momentum of an object.	
- Conduct investigations to determine the relationship between the force acting on an object and the change it produces in the object's momentum (i.e., the impulse) ($\Delta P = F_{avg} \cdot \Delta t$).	
- Use the concept of impulse ($I = F_{avg} \cdot \Delta t$) to make estimates of average forces when the change in an object's momentum is known. For example, explain why collision forces will be reduced when the barriers are flexible (increasing Δt decreases F_{avg}), or how the severity of the injury to a falling athlete will be influenced by the surface the athlete lands on (i.e., turf, hard ground, concrete, etc.).	

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- Recognize that momentum (like energy) is a conserved quantity, and describe how this property of momentum makes it a useful tool in problem solving, especially problems involving collisions.	
- Describe that forces transfer energy from one object to another through a process called "work". Explain how calculating the work done by a force helps us make qualitative and quantitative predictions regarding the motion of objects. Use mathematics, graphing calculators and/or graphing analysis programs to investigate the work done by individual forces.	
- Give examples of forces doing work to transfer energy to a rotating object (increasing its rotational speed), or doing work to transfer energy away from a rotating object (decreasing its rotational speed).	
- Describe how the concept of torque is used to explain (and calculate) the rotational effect that forces have when they act on objects.	
- Conduct investigations to identify the factors that determine the torque produced by a force (Torque = force · lever distance). (For example, what conditions must be met to ensure that the sum of all torques acting on an object is zero, leaving the object in rotational equilibrium?).	

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Strand - Energy Interacting With Materials; the Transformation and Conservation of Energy	
- Enduring Understanding: Energy readily transforms from one form to another, but these transformations are not always reversible. The details of these transformations depend upon the initial form of the energy and the properties of the materials involved. Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.	
- Essential Question: What happens to the energy in a system — where does this energy come from, how is it changed within the system, and where does it ultimately go? How does the flow of energy affect the materials in the system?	
Grades 9-12	
1. Energy cannot be created nor destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes. Recognizing that energy is conserved, the processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.	**SE/TE:** 519
2. Most of the changes that occur in the universe involve the transformation of energy from one form to another. Almost all of these energy transformations lead to the production of some heat energy, whether or not heat energy is the desired output of the transformation process.	**SE/TE:** 519
3. Waves (e.g., sound and seismic waves, waves in water, and electromagnetic waves) carry energy that can have important consequences when transferred to objects or substances.	**SE/TE:** 519
4. When waves interact with materials, the energy they transfer often leads to the formation of other forms of energy. These interactions, which depend upon the nature of the material and the wavelength of the waves, can be used to create practical devices (e.g., sonar and ultra sound imaging, solar cells, remote control units, and communication devices).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519
5. Through reflection and refraction, electromagnetic waves can be redirected to produce concentrated beams or images of their source.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519

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6. When radiant energy is absorbed or emitted by individual atoms or molecules, the changes in energy involve the jump of an electron from one distinct energy level to another. These energy changes, which are characteristic of the atom or molecule, can be used to identify the material.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 64-65
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Describe why it is significant that energy cannot be created (made) nor destroyed (consumed), and identify that that this property of energy is referred to as the Law of the Conservation of Energy.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519
- Give examples that illustrate the transfer of energy from one object (or substance) to another, and examples of energy being transformed from one to another.	**SE/TE:** 519
- Use energy chains to trace the flow of energy through physical systems. Indicate the source of the energy in each example, and trace the energy until it leaves the system or adopts a form in the system that neither changes nor is transferred. Make qualitative estimates of all the forms of the energy involved and reflect on the consequences of the energy transfers and transformations that take place. For example, trace the flow of the radiant energy carried by sunlight that strikes the roof of a home. Reflect on how the color of the roof (light vs. dark) will have an impact on the ability to heat and cool the house, and possibly the functional lifetime of the roofing materials themselves.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 144-145, 148, 158-161, 519
- Use diagrams and energy chains to illustrate examples of the selective absorption of mechanical waves in natural phenomena and give examples of how the selective absorption of mechanical waves is used to conduct investigations in medicine, industry and science (for example ultrasound imagery, detecting the epicenter of earthquakes, testing structures for defects, and conducting explorations of the earth's crust and mantle).	
- Explain that what happens to electromagnetic waves that strike a substance (reflection, transmission, absorption) depends on the wavelength of the waves and the physical properties of the substance.	

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- Investigate how radio waves, microwaves, infrared waves, visible waves and ultraviolet waves behave when they strike different substances.	
- Record how effectively different materials reflect, absorb and transmit different kinds of EM waves. Draw conclusions based on this data and the physical properties of the substances (e.g., some substances absorb visible waves, but not radio waves. Other materials absorb UV waves, but not visible waves).	
- Give examples that illustrate how the selective absorption of EM waves explains physical phenomena. For example; how X-rays can be used to detect broken bones beneath the skin and how coating on eyeglasses and sunglasses protect the eyes by permitting visible waves to pass but absorb UV waves.	
- Use energy chains to trace the flow of energy in a selective absorption process (e.g., sunburn, Greenhouse Effect, microwave cooking).	
- Use energy chains to trace the flow of energy through systems involving sliding friction and air resistance (for example, the braking action in vehicles or bicycles or a vehicle rolling to rest).	
- Explain that through the action of resistive forces (friction and air resistance) mechanical energy is transformed into heat energy, and because of the random nature of heat energy, transforming all of the heat energy back into mechanical energy (or any other organized form of energy) is impossible. Give examples where organized forms of energy (GPE, elastic PE, the KE of large objects) are transformed into heat energy but the reverse transformations are not possible.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 518
- Reflect on why organized forms of energy are more useful than disorganized forms (heat energy).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 144
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Use energy chains to trace the flow of energy through systems that involve both static and kinetic friction.	

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- Use diagrams to illustrate how the constructive and destructive interference of waves occurs.	
- Give specific examples of how wave interference occurs in earth systems for both mechanical waves and electromagnetic waves. For example, in the case of mechanical waves, demonstrate regions of high volume (constructive interference) and low volume "dead spots" (destructive interference) in the space surrounding two speakers. Or consider the effect that wave interference has on the impact of seismic waves produced by earthquakes. In the case of EM waves, observe the colored patterns (fringes) on a soap bubble or in a thin layer of oil on a puddle of water.	
- Describe how wave interference is used to create useful devices, such as noise cancellation devices (mechanical waves), window coatings to selectively transmit or reflect IR waves, diffraction gratings for spectroscopy, and lasers (EM waves).	
- Explain why the Law of Conservation of Energy must be expanded to the Law of the Conservation of Mass/Energy when nuclear energy is involved in a process.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 537, 541
- Use the concept of stability to explain why energy is released during a fission process and during a fusion process.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 519, 537, 541, 546
- Use diagrams and energy chains to illustrate and explain the flow and transformations of energy that occur in fission and fusion processes, and during radioactive decay.	**SE/TE:** 537, 541
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Use the model of discrete electronic energy states in an atom to describe how the atom can emit or absorb packets of electromagnetic energy (photons) having specific energies. Demonstrate how prisms, diffraction gratings or other optical devices can be used to analyze the light coming from different substances, and how this analysis can be useful in the identification of elements and compounds.	

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- Use diagrams to show how concave reflecting devices and convex lenses can be used to collect and focus EM waves.	
- Recognize that the characteristics of these devices are different for different groups of EM waves (radio waves, microwaves, infrared waves, visible waves, etc.).	
- Create light ray diagrams to illustrate how converging devices are used to collect and focus waves in scientific devices (e.g., telescopes and microscopes).	
Strand - The Production, Consumption and Application of Energy	
- Enduring Understanding: People utilize a variety of resources to meet the basic and specific needs of life. Some of these resources cannot be replaced. Other resources can be replenished or exist in such vast quantities they are in no danger of becoming depleted. Often the energy stored in resources must be transformed into more useful forms and transported over great distances before it can be helpful to us.	
- Essential Question: What is a "responsible" use of energy? Are there alternative forms of energy that will serve our needs, or better ways of using traditional forms of energy?	
Grades 9-12	
1. Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels. Nuclear energy is an alternative form of energy. Through the use of fission reactors, nuclear energy is already widely used for the generation of electrical energy. Additional technologies are being developed to increase the use of other alternate energy sources.	**SE/TE:** 520-521, 522-528, 536-541, 544-547
2. The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences. Societal expectations for a sustainable environment will require new, cleaner technologies for the production and use of energy.	**SE/TE:** 7, 39-41, 324, 529-535, 536, 539-540, 542-543, 544-547

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Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Research the factors that contribute to the energy efficiency of cars and trucks. Examine the role that the power of the engine and the weight and physical size and shape of the vehicle have on the fuel efficiency of the vehicle. Identify and report on the sources of the fuels currently used by vehicles and alternative fuels being developed.	**SE/TE:** 504
Building upon the K-10 expectations, all students in Grade 11 will be able to:	
- Use energy chains to describe the flow of energy in a nuclear-fueled electric power facility. Indicate the source of energy of the facility, how and where energy leaves the facility, and in which parts of the facility energy transformations take place.	**SE/TE:** 538
- Compare and contrast the energy diagram of the nuclear-fueled power plant to a comparable energy diagram for a fossil-fueled electric power plant.	**SE/TE:** 538, 542-543
- Prepare a written report, a poster, or a computer-based presentation that explains the advantages and disadvantages of using fossil fuels, nuclear fuel, and alternative energy sources to generate electrical energy.	**SE/TE:** 541, 543, 547

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SCIENCE STANDARD 4	
Earth in Space - Our Solar System is a collection of gravitationally interacting bodies that include Earth and the Moon. Universal principles of gravitation allow predictions regarding the motions of objects within the Galaxy and beyond. Earth's motion, position, and posture account for a variety of cyclic events observable from Earth. While the composition of planets vary considerably, their components and the applicable laws of science are universal. The motions and interactions of objects within the Solar System are consistent with the hypothesis that it emerged from a large disk of gas and dust. Our Solar System is part of the Milky Way Galaxy, which, in turn, is one of many galaxies in the known Universe.	
Strand - The Earth/Moon/Sun System	
- Enduring Understandings: There are observable, predictable patterns of movement in the Sun, Earth, and Moon system that account for day/night. Observable, predictable patterns of movement in the Sun, Earth, Moon system occur because of gravitational interaction and energy from the Sun.	
- Essential Question: What causes these patterns?	
Grades 9-12	
1. The source of the Sun's energy is the fusion of hydrogen atoms into helium, a process common in relatively young stars.	**SE/TE:** 541
2. The Sun's influence on Earth include gravity, (which maintains Earth's orbit), electromagnetic radiation (which provides energy for living things), and energetic particles such as coronal mass ejections that can cause electromagnetic disturbances.	
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Describe how nuclear fusion reactions change over time and lead to the creation of elements (and the evolution of stars).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 541
- Explain how the process of nuclear fusion in our Sun consumes mass and releases, over billions of years, enormous amounts of energy.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 541
- Compare and contrast the age, temperature, and size of our Sun to other stars.	
- Discuss the many ways in which the Sun influences Earth including the role of gravity, coronal mass ejections, and electromagnetic radiation including gamma photons.	

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Strand - The Solar System	
- Enduring Understanding: Earth is part of a system that includes other planets. Most objects in the Solar System orbit the Sun and have distinctive physical characteristics and orderly motion which are a result of their formation and changes over time.	
- Essential Question: How did Earth's crust, atmosphere, and interior form and change over time?	
1. The motion and the basic elements (periodic table) that comprise our Solar System are consistent with the theory that the Solar System emerged from a large disk of gas and dust.	
2. The Earth's atmosphere, crust, and interior have changed since the formation of the planets. Driven by internal heat (radioactive decay and heat from accretion), the Earth's layers have separated by density into a solid core, molten mantle, and crust of solid rock composed of plates.	
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Explain the formation of solar systems using the Solar Nebular Theory including the origin of the planets and Sun from the nebula, the evolution of planets, and the dispersal of left over gas and dust.	
- Describe how the Earth formed (using the Solar Nebular Theory) into a solid core, molten mantle, crust of solid rock composed of plates, and early atmosphere as a result of the densities of the elements.	
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Use library and internet resources to identify characteristics of the Earth which permit it to support life, and compare those characteristics to properties of other planets. Based on the research, debate the possibility of life on other planets.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 452-453

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DELAWARE SCIENCE STANDARDS AND GRADE LEVEL EXPECTATIONS	Environmental Science: Your World, Your Turn (Withgott) © 2011
Strand - Stars and Galaxies	
- Enduring Understanding: The Universe is composed of galaxies that are composed of solar systems, all of which are composed of the same elements and governed by the same laws.	
- Essential Question: Is there an order to the Universe? Explain.	
1. The Universe consists of billions of galaxies, each of which is a gravitationally bound collection of stars.	
2. As a force, gravity causes tides, pulls matter together to make spherical stars and planets, maintains the orbits of planets, and gathers cosmic gas and dust to form stars and star systems.	
3. Stars are separated by vast distances. Light which reaches Earth from distant galaxies is millions of years old and is actually a view of the past.	
4. The Sun and our Solar System are part of the Milky Way galaxy consisting of billions of other stars that appear to be made of the same elements found on Earth.	
5. Most elements are formed as a result of natural astronomical processes, either in the Big Bang itself or in the natural evolution of stars.	
6. The Big Bang Theory is a core scientific theory that is supported by a large body of evidence and is well accepted by the scientific community. It states that the Universe began in a hot dense state of energy and matter, and the Universe has been expanding ever since.	
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Describe the relative size differences and distances between planetary systems, stars, multiple-star galaxies, star clusters, galaxies, and galactic groups in the Universe.	
- Explain why the force of gravity is responsible for many phenomena in the Universe including the formation and life cycle of galaxies, stars, and planetary systems. Explain how gravity influences the motion of bodies in the Universe including tides and maintaining orbits of planets.	

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- Describe how our knowledge of the history of the Universe is based on electromagnetic energy that has traveled vast distances and takes a long period of time to reach us.	
- Explain the life history of stars in terms of luminosity, size and temperature using the Hertzsprung-Russell Diagram. Compare and contrast stellar evolution based on mass (black hole, neutron star, white dwarf).	
- Explain the Big Bang Theory and how it is supported by evidence that includes microwave background radiation and red shift. Cite research supporting the Big Bang Theory as the most scientifically accepted theory explaining the formation of the Universe.	
Strand - Technology and Applications	
- Enduring Understanding: Technology expands our knowledge of the Universe.	
- Essential Questions: How has technology expanded our knowledge of the Universe?	
1. Spectroscopes are used to analyze starlight to reveal information about the composition and evolution of stars.	
2. Technology is vital in investigating the Universe.	
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Describe how the composition of stars can be determined by analysis of their spectra. Compare the elements that compose stars to those that compose Earth.	
- Discuss how technology (i.e., telescopes, computers, space probes, radio observatories) assists astronomers in discovering and investigating celestial bodies beyond the limits of our Solar System.	

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SCIENCE STANDARD 5	
Earth's Dynamic Systems - Earth's dynamic systems are made up of the solid earth (geosphere), the oceans, lakes, rivers, glaciers and ice sheets (hydrosphere), the atmosphere, and organisms (biosphere). Interactions among these spheres have resulted in ongoing changes to the system. Some of these changes can be measured on a human time scale, but others occur so slowly, that they must be inferred from geological evidence.	
Strand - Components of Earth	
- Enduring Understanding: Earth's systems can be broken down into individual components which have observable measurable properties.	
- Essential Question: How does understanding the properties of Earth materials and the physical laws that govern their behavior lead to prediction of Earth events?	
Grades 9-12	
1. Minerals are the building blocks of rocks. Common rock-forming minerals found in Delaware (calcite, quartz, mica, feldspar, and hornblende) can be identified by their chemical and physical properties.	**SE/TE:** 392-394, 397, 414-417
2. Rocks can be classified as igneous, metamorphic and sedimentary based on the method of formation. The natural cycling of rocks includes the formation of new sediment though erosion and weathering and of new rock through heat and compaction of the sediment.	**SE/TE:** 395-397, 414-417
3. Earth's geosphere is composed of layers of rocks which have separated due to density and temperature differences and classified chemically into a crust (which includes continental and oceanic rock), a hot, convecting mantle, and a dense metallic core.	**SE/TE:** 74-75, 76-78, 82, 92-95
4. Continental and oceanic rock differ in overall composition, density and age. These differences help explain the distribution and configuration of land masses and ocean basins.	**SE/TE:** 77, 82, 94

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Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Identify mineral specimens according to their chemical and physical properties. Mineral specimens include calcite, quartz, mica, feldspar, and hornblende. Properties include hardness (Moh's scale), streak, specific gravity, luster, cleavage, crystal shape, and color, and other properties that are useful for identification of specific minerals such as reaction with hydrochloric acid.	**SE/TE:** 392-394, 397, 414-417
- Identify a few of the most common elements in the Earth's crust, oceans, and atmosphere and confirm their location on the periodic table. (Example: Si, O, C, N, H, Al). Compare the relative abundance of elements found in the Earth's crust, oceans, and atmosphere. Trace carbon as it cycles through the crust, ocean, and atmosphere.	**SE/TE:** 83-85, 90-91
- Classify and describe features that are used to distinguish between igneous, sedimentary, and metamorphic rocks.	**SE/TE:** 395-397, 414-417
- Describe energy sources, processes, and transformations of Earth materials as they progress through the rock cycle to form new sedimentary, metamorphic, and igneous rocks. Discuss how the cycling of rock is continuous.	**SE/TE:** 395-397, 414-417
- Describe how igneous rocks are formed. Classify igneous rocks according to crystal size and mineral assemblage.	**SE/TE:** 395, 397, 415, 417
- Identify sandstone, shale and limestone by their composition and texture. Explain how sandstone, shale, and limestone can be changed into the metamorphic rocks quartzite, slate, and marble.	**SE/TE:** 396-397, 415-417
- Investigate the densities, composition, and relative age of continental (felsic) and oceanic (mafic) rocks. Explain why the continental crust, although thicker in most places, overlies oceanic crust. Use this information to explain why oceanic crust sub ducts below continental crust in convergent plate boundaries and explain the configuration of land masses and ocean basins.	**SE/TE:** 77, 82, 94

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Strand - Interactions Throughout Earth's Systems	
- Enduring Understanding: Earth's components form systems. These systems continually interact at different rates of time, affecting the Earth locally and globally.	
- Essential Question: How do changes in one part of the Earth system affect other parts of the system? In what ways can Earth processes be explained as interactions among spheres?	
Grades 9-12	
1. Earth's four spheres interact as part of a dynamic system in which changes over time are the result of external and internal energy sources.	**SE/TE:** 72-75, 92, 94-95
2. Tectonic plates press against one another in some places (convergence), pull apart in other places (divergence), or slide past each other. These plate movements may result in the formation of mountain ranges, and can lead to earthquakes, volcanic eruptions, and tsunamis. The consequences of these events impact the surrounding atmosphere, geosphere, hydrosphere, and the life existing within them.	**SE/TE:** 77-78, 82, 92-95, 277-279, 283, 286
3. Earthquakes result when rocks rupture and slide by one another releasing stored energy which travels through the geosphere in the form of waves. Local earthquake risks can be assessed and preparations made to minimize the hazards.	**SE/TE:** 78
4. The type and eruptive style of volcanoes is determined by the viscosity and gas pressure of the magma. The effects of these eruptions can have both local and global consequences.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 78
5. The atmosphere can be described as being in a state of dynamic equilibrium which is maintained in part by plate tectonic processes which recycle atmospheric gases trapped in the ground back into the atmosphere.	**SE/TE:** 83-89, 92, 94-95
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Explain how exposivity, type (shield, strato, etc.) and shape of a volcano is related to the properties of its magma and its location along different plate margins.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 78

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- Identify volcanic products (lava, mudflow, pyroclastic projectiles, ash, gases) associated with various types of volcanoes and their eruptions. Describe the effect of these products on life and property. Explain how the products of volcanic activity influence both long-term and short-term changes in the Earth system.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 78
- Describe how energy within the Earth's interior is released in the form of earthquake waves, and explain how these waves affect Earth's surface.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 78
- Describe how earthquake energy is represented on seismograms and describe how these waves can be used to determine the origin and intensity of earthquakes.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 78
- Describe the effects on life and property from consequences of earthquake such as landslides, liquification, surface faulting and tsunamis. Cite ways these hazards can be minimized.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 78
- Use models or computer simulations to demonstrate the processes and origin of landforms at diverging, converging and transform plate boundaries. Show on a map how plate tectonics, earthquakes, and volcanoes are spatially related.	**SE/TE:** 77-78
- Investigate how thermal convection relates to movement of materials. Apply this knowledge in explaining the cause of movement of the Earth's plates.	**SE/TE:** 76, 94
- Research and describe evidence that supports the Theory of Plate Tectonics to include rock magnetism and the age of the sea floor.	**SE/TE:** 77
- Explain how the Theory of Plate Tectonics demonstrates that scientific knowledge changes by evolving over time. Recognize that although some theories are initially rejected, they may be re-examined and eventually accepted in the face of new evidence.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 77

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Strand - Technology and Applications	
- Enduring Understanding: Technology enables us to better understand Earth's systems. It also allows us to analyze the impact of human activities on Earth's systems and the impact of Earth's systems on human activity.	
- Essential Question: How does technology extend human senses and understanding?	
Grades 9-12	
1. Advances in science and technology (such as satellite imaging, Global Positioning Satellite (GPS), and Geographic Information Systems (GIS)) have improved our understanding of global and local changes that result from Earth system interactions, and our capacity to anticipate and mitigate natural hazards such as volcanoes and earthquakes.	**SE/TE:** 246, 277, 279, 314-315
Building upon the K-8 expectations, all students in Grade 9 will be able to:	
- Explain how data from Global Positioning Systems can be used to predict and determine the direction and rate of movement of Earth's plates and sea floor spreading.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 77-78
- Explain how technology such as GPS, tilt meters, etc., can be used to predict earthquake and volcanic activity.	**SE/TE:** 314-315
- Describe ways in which people use historical data, geologic maps, and technologies to minimize earthquake damage.	**SE/TE:** 314-315

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SCIENCE STANDARD 6	
Life Processes - The natural world is defined by organisms and life processes which conform to principles regarding conservation and transformation of matter and energy. Living organisms use matter and energy to build their structures and conduct their life processes, have mechanisms and behaviors to regulate their internal environments and to respond to changes in their surroundings. Knowledge about life processes can be applied to improving human health and well being.	
Strand - Structure/Function Relationship	
- Enduring Understanding: Living systems, from the organismic to the cellular level, demonstrate the complementary nature of structure and function.	
- Essential Question: How does structure relate to function in living systems from the cellular to the organismic level?	
Grades 9-12	
1. In order to establish and maintain their complex organization and structure, organisms must obtain, transform, and transport matter and energy, eliminate waste products, and coordinate their internal activities.	
2. Cells take highly varied forms in different plants, animals, and microorganisms. Structural variations among cells determine the function each cell performs.	
3. Cells have distinct and separate structures (organelles), which perform and monitor processes essential for survival of the cell (e.g., energy use, waste disposal, synthesis of new molecules, and storage of genetic material). The highly specific function of each organelle is directly related to its structure.	
4. The cell membrane is dynamic and interacts with internal membranous structures as materials are transported into and out of the cell.	
5. The transportation of materials across the membrane can be passive (does not require the expenditure of cellular energy), or active (requires the expenditure of cellular energy) depending upon membrane structure and concentration gradients.	

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6. Cells store and use information to guide their functions. DNA molecules in each cell carry coded instructions for synthesizing protein molecules. The protein molecules have important structural and regulatory functions.	**SE/TE:** 68
7. Most multi-cellular animals have a nervous system composed of a brain and specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific molecules (neurotransmitters).	
8. In multi-cellular organisms, cells perform specialized functions as parts of sub-systems (e.g., tissues, organs, and organ systems), which work together to maintain optimum conditions for the benefit of the whole organism.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 101
9. The endocrine system consists of glands which secrete chemical messengers (hormones) that are transported via the circulatory system and act on other body structures.	
10. The immune system consists of cells, organs, and secretions that protect the organism from toxins, irritants, and pathogens.	
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Use microscopes to identify similarities and differences among a variety of cells (e.g., muscle, nerve, epithelial, blood, adipose), and explain how structural variations relate to the function that each of the cells performs.	
- Differentiate between prokaryotic cells and eukaryotic cells in terms of their general structures (cell membrane & genetic material) and degree of complexity. Give examples of prokaryotic organisms and organisms with eukaryotic cells.	
- Explain how organelles of single-celled organisms function as a system to perform the same basic life processes as are performed in multi-cellular organisms (e.g., acquisition of energy, elimination of waste, reproduction, gas exchange, growth, repair, and protein synthesis).	

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- Use fluid mosaic models of the plasma membrane to explain how its structure regulates the movement of materials across the membrane.	
- Show how water moves in and out of cells down a concentration gradient. Recognize that this process, known as osmosis, requires no input of energy.	
- Explain the role of cell membranes as highly selective barriers (e.g., diffusion, osmosis, active transport).	
- Distinguish between active and passive transport. Recognize that active transport requires energy input to move molecules from an area of low concentration to an area of high concentration (against the concentration gradient).	
- Design a controlled experiment to investigate the capacity of the cell membrane to regulate how materials enter and leave the cell.	
- Construct cell models (e.g., phenolphthalein-agar cubes, potato-iodine cubes) to investigate the relationship among cell size, surface area to volume ratio and the rates of diffusion into and out of the cell. Explain why large organisms have developed from many cells rather than one large cell.	
- Recognize that as a result of the coordinated structures and functions of organ systems, the internal environment of the human body remains relatively stable despite changes in the outside environment.	
- Explain how the cells of a multi-cellular organisms work together for the benefit of the colonial or singular organism.	

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Strand - Matter and Energy Transformations	
- Enduring Understanding: All organisms transfer matter and convert energy from one form to another. Both matter and energy are necessary to build and maintain structures within the organism.	
- Essential Question: How is matter transferred and energy transferred/transformed in living systems?	
Grades 9-12	
1. Cells carry out a variety of chemical transformations (i.e., cellular respiration, photosynthesis, and digestion) which allow conversion of energy from one form to another, the breakdown of molecules into smaller units, and the building of larger molecules from smaller ones. Most of these transformations are made possible by protein catalysts called enzymes.	**SE/TE:** 84-85, 89, 142-143, 159-160, 453, 517, 522
2. Plant cells contain chloroplasts, which convert light energy into chemical energy through the process of photosynthesis. This chemical energy is used by the plants to convert carbon dioxide and water into glucose molecules, that may be used for energy or to form plant structures. Photosynthesis adds oxygen to the atmosphere and removes carbon dioxide.	**SE/TE:** 84, 89, 142, 159-160, 453
3. All organisms, including plants, use the process of cellular respiration to transform stored energy in food molecules into usable energy. The energy produced is stored in the form of ATP and is used by organisms to conduct their life processes. Cellular respiration may require oxygen and adds carbon dioxide to the atmosphere.	**SE/TE:** 85, 89, 143, 160
4. Photosynthesis and cellular respiration are complementary processes resulting in the flow of energy and the cycling of matter in ecosystems.	**SE/TE:** 84-85, 89, 142-143, 160
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Use molecular models to explain how carbon atoms uniquely bond to one another to form a large variety of molecules, including those necessary for life (e.g., polysaccharides, polypeptides).	**SE/TE:** 65-69, 71

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- Observe formulas and diagrams of compounds found in food (fats, proteins, carbohydrates). Identify elements that comprise these compounds.	**SE/TE:** 65-69, 71, 90-91
- Explain that physically breaking down food into smaller pieces by mechanical digestion helps facilitate breakdown (by increasing surface area) into chemical components and that digestive enzymes are necessary for the breakdown of food into those chemical components (e.g., starch to glucose, lipids and glycerol to fatty acids, proteins to amino acids).	
- Observe and recognize that unicellular organisms take in food from their environment and chemically digest it (if needed) within their cell body.	
- Recognize that both mechanical and chemical processes are necessary in digestion for multi-cellular organisms to get molecules that come from food to enter the cells. Trace the process whereby nutrients are transported to cells where they serve as building blocks for the synthesis of body structures and as reactants for cellular respiration.	
- Explain the processes used by autotrophs to transform light energy into chemical energy in the form of simple sugars. Give examples of how these compounds are used by living things as sources of matter and energy.	**SE/TE:** 85, 89, 143, 160
- Describe the process by which water is removed from sugar molecules (dehydration synthesis) to form carbohydrates and is added to break them down (hydrolysis).	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 68
- Describe photosynthesis as an energy storing process and explain how environmental factors such as temperature, light intensity, and the amount of water available can affect photosynthesis.	**SE/TE:** 85, 89, 143, 160
- Identify the reactants and the products in equations that represent photosynthesis and cellular respiration. Explain how the equations demonstrate the Law of Conservation of Matter and Energy in terms of balanced equations.	**SE/TE:** 84-85, 89, 142-143, 160

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- Investigate and describe the complementary relationship (cycling of matter and the flow of energy) between photosynthesis and cellular respiration.	**SE/TE:** 84-85, 89, 142-143, 160
- Recognize that during photosynthesis, plants use energy from the sun and elements from the atmosphere and the soil to make specific compounds. Recognize that these compounds are used by living things as sources of matter and energy.	**SE/TE:** 85, 89, 143, 160
- Compare the amount of chemical potential energy stored in chemical bonds of a variety of foods (calorimetry). Recognize that equal amounts of different types of food contain different amounts of energy.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 148
- Recognize that during cellular respiration, chemical bonds between food molecules are broken (hydrolysis), and energy is transferred to ADP to create ATP (the energy storage molecule that fuels cellular processes). Acknowledge that all organisms must break the high energy chemical bonds in food molecules during cellular respiration to obtain the energy needed for life processes.	**SE/TE:** 85, 89, 143, 160
- Recognize that in general, synthesis reactions (i.e. photosynthesis) require energy while decomposition reactions (i.e. cellular respiration) usually release energy.	**SE/TE:** 84-85, 89, 142-143, 160
- Investigate the role of enzymes (e.g., protease, amylase and lipase) in the rate of chemical breakdown of a variety of foods.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67
- Explain how enzymes permit low temperature chemical reactions to occur in cells.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67
- Investigate how various factors (temperature, pH, enzyme/substrate concentration) affect the rate of enzyme activity.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 67

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Strand - Regulation and Behavior	
- Enduring Understanding: Organisms respond to internal and external cues, which allow them to survive.	
- Essential Question: How do responses to internal and external cues aid in an organism's survival?	
Grades 9-12	
1. The endocrine, nervous, and immune systems coordinate and help maintain homeostasis in humans and other organisms.	
2. Multi-cellular animals have nervous systems that generate behavioral responses. These responses result from interactions between organisms of the same species, organisms of different species, and from environmental changes.	
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Illustrate how nerve cells communicate with each other to transmit information from the internal and external environment often resulting in physiological or behavioral responses.	
- Draw a schematic to illustrate a positive and negative feedback mechanism that regulates body systems in order to help maintain homeostasis.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 73-74
- Recognize that in order to help maintain the health of an organism, the immune system works in nonspecific ways (e.g., skin, mucous, membranes) and specific ways (e.g., antibody-antigen interactions.)	
Strand - Life Processes and Technology Application	
- Enduring Understanding: The health of humans and other organisms is affected by their interactions with each other and their environment, and may be altered by human manipulation.	
- Essential Question: What can we do to benefit the health of humans and other organisms?	
Grades 9-12	
1. Certain chemicals, pathogens, and high-energy radiation seriously impair normal cell functions and the health of the organism.	**SE/TE:** 256-260, 261-266, 267-276, 284-285, 286-289, 438, 601

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2. The scientific investigation of cellular chemistry enables the biotechnology industry to produce medicines, foods, and other products for the benefit of society.	**SE/TE:** 375-377, 383, 386, 388-389
3. Many drugs exert their effects by mimicking or increasing the production or destruction of neurotransmitters.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 205
4. Biotechnology is a growing international field of research and industry. Many scientists, including those in Delaware, conduct cutting-edge research in biotechnology.	**SE/TE:** 375-377, 383, 386, 388-389
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Investigate how scientists use biotechnology to produce more nutritious food, more effective medicine, and new ways to mitigate pollution.	**SE/TE:** 375-377, 383, 386, 388-389
- Investigate how drugs can affect neurotransmission.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 205
- Explain how antibiotics (e.g., penicillin, tetracycline) kill bacterial cells without harming human cells due to differences between prokaryotic and eukaryotic cell structure.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 229, 379
- Describe how environmental factors (e.g., UV light or the presence of carcinogens or pathogens) alter cellular functions.	**SE/TE:** 256-260, 261-266, 267-276, 284-285, 286-289, 438, 601

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SCIENCE STANDARD 7	
Diversity and Continuity of Living Things - The natural world consists of a diversity of organisms that transmit their characteristics to future generations. Living things reproduce, develop, and transmit traits, and theories of evolution explain the unity and diversity of species found on Earth. Knowledge of genetics, reproduction, and development is applied to improve agriculture and human health.	
Strand - Reproduction, Heredity and Development	
- Enduring Understanding: Organisms reproduce, develop, have predictable life cycles, and pass on heritable traits to their offspring.	
- Essential Questions: How do organisms change as they go through their life cycles?	
Grades 9-12	
1. Hereditary/genetic information in chromosomes is contained in molecules of DNA. Genes are sections of DNA that direct syntheses of specific proteins associated with traits in organisms. These consist of various combinations of four different nucleotides that encode this information through their sequences.	**SE/TE:** 68
2. Known patterns of inheritance can be used to make predictions about genetic variation.	
3. Mutations in DNA of organisms normally occur spontaneously at low rates, but can occur at higher rates (i.e., exposure to pathogens, radiation and some chemicals). Most mutations have no effect on the organism, but some may be beneficial or harmful depending on the environment.	**SE/TE:** 127, 131, 268
4. Only random mutations in gametes can create the variation that is inherited by an organism's offspring. Somatic mutations are not inherited, but may lead to cell death, uncontrolled cell growth, or cancer.	**SE/TE:** 131
5. During the cell cycle, DNA of the parent cell replicates and the cell divides into two cells that are identical to the parent. This process is used for growth and repair of body tissues and for asexual reproduction.	

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6. Meiosis is the production of sex cells (gametes). The production and release of these gametes is controlled by hormones. In meiosis, the number of chromosomes is reduced by one-half and chromosomes may randomly exchange homologous parts to create new chromosomes with combinations not necessarily found in the parent cell. This may increase variation within the species.	
7. Upon fertilization, the fusion of the gametes restores the original chromosome number, and new gene combinations lead to increased genetic variation, which, in turn, increases the likelihood of survival of the species.	
8. The sex chromosomes contain different genes, and therefore, certain traits will show patterns of inheritance based on gender.	
9. Embryological development in plants and animals involves a series of orderly changes in which cells divide and differentiate. Development is controlled by genes whose expression is influenced by internal factors (i.e., hormones) and may also be influenced by environmental factors (i.e., nutrition, alcohol, radiation, drugs, and pathogens). Alteration in this balance may interfere with normal growth and development.	
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Describe the relationship between DNA, genes, chromosomes and proteins.	**SE/TE:** 68
- Explain that a gene is a section of DNA that directs the synthesis of a specific protein associated with a specific trait in an organism.	**SE/TE:** 68
- Trace how a DNA sequence, through transcription and translation, results in a sequence of amino acids.	**SE/TE:** 68
- Demonstrate that when DNA replicates, the complementary strands separate and the old strands serve as a template for the new complementary strands. Recognize that this results in two identical strands of DNA that are exact copies of the original.	**SE/TE:** 68

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- Illustrate how a sequence of DNA nucleotides codes for a specific sequence of amino acids.	**SE/TE:** 68
- Use Punnett squares, including dihybrid crosses, and pedigree charts to determine probabilities and patterns of inheritance (i.e. dominant/recessive, co-dominance, sex-linkage, multi-allele inheritance).	
- Analyze a karyotype to determine chromosome numbers and pairs. Compare and contrast normal and abnormal karyotypes.	
- Explain how crossing over and Mendel's Laws of Segregation and Independent Assortment contribute to genetic variation in sexually reproducing organisms.	
- Describe how exposure to radiation, chemicals and pathogens can increase mutations.	**SE/TE:** 268
- Explain that mutations in the DNA sequence of a gene may or may not affect the expression of the gene. Recognize that mutations may be harmful, beneficial, or have no impact on the survival of the organism.	**SE/TE:** 131
- Explain how the type of cell (gamete or somatic) in which a mutation occurs determines heritability of the mutation.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 131
- Predict the possible consequences of a somatic cell mutation.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 131, 268
- Describe the cell cycle as an orderly process that results in new somatic cells that contain an exact copy of the DNA that make up the genes and chromosomes found in the parent somatic cells.	
- Explain how the cell cycle contributes to reproduction and maintenance of the cell and/or organism.	
- Recognize that during the formation of gametes, or sex cells (meiosis), the number of chromosomes is reduced by one half, so that when fertilization occurs the diploid number is restored.	

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- Explain why sex-linked traits are expressed more frequently in males.	
- Compare and contrast the processes of growth (cell division) and development (differentiation).	
- Recognize that any environmental factor that influences gene expression or alteration in hormonal balance may have an impact on development.	
Strand - Diversity and Evolution	
- Enduring Understanding: The diversity and changing of life forms over many generations is the result of natural selection, in which organisms with advantageous traits survive, reproduce, and pass those traits to offspring.	
- Essential Questions: How does natural selection encourage inter and intra-specific diversity over time?	
Grades 9-12	
1. Evolution is a change in allelic frequencies of a population over time. The theory of evolution is supported by extensive biochemical, structural, embryological, and fossil evidence.	**SE/TE:** 126-132, 137, 139, 158-161
2. The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms. The millions of different species of plants, animals, and microorganisms that live on Earth today are related by descent with modification from common ancestors.	**SE/TE:** 126-132, 137, 139, 161
3. The process of natural selection occurs when some heritable variations that arise from random mutation and recombination give individuals within a species some survival advantages over others. These offspring with advantageous adaptations are more likely to survive and reproduce, thus increasing the proportion of individuals within a population with advantageous characteristics. When populations become isolated, these changes may accumulate and eventually result in new species.	**SE/TE:** 127-130, 132, 158-161, 264, 366, 369

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4. Evolution does not proceed at the same rate in all populations; nor does it progress in a linear or set direction. Environmental changes have a strong influence on the evolutionary process. Other factors that influence evolution include: sexual selection, mutation, genetic drift, and genetic modification.	**SE/TE:** 126-132, 137, 139, 161
5. Organisms are classified into a hierarchy of groups and subgroups based on similarities in structure, comparisons in DNA and protein and evolutionary relationships.	**SE/TE:** 201, 221
6. Genetically diverse populations are more likely to survive changing environments.	**SE/TE:** 128
7. Biological evolution is the foundation for modern biology and is used to make predictions for medical, environmental, agricultural and other societal purposes.	**SE/TE:** 126-132, 137, 139, 158-161
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Recognize random mutation (changes in DNA) and recombination within gametes as the sources of heritable variations that give individuals within a species survival and reproductive advantage or disadvantage over others in the species.	**SE/TE:** 127, 131
- Analyze natural selection simulations and use data generated from them to describe how environmentally-favored traits are perpetuated over generations resulting in species survival, while less favorable traits decrease in frequency or may lead to extinction.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 127-129, 132
- Explain how biochemical evidence, homologous structures, embryological development and fossil evidence support or refute prior hypotheses of common ancestry.	**SE/TE:** 127
- Describe that evolution involves changes in the genetic make-up of whole populations over time, not changes in the genes of an individual organism.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 126-132, 137, 139, 158-161
- Explain how species evolve through descent with modification, thus allowing them to adapt to different environments.	**SE/TE:** 126-129, 131-132, 161

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- Discuss how environmental pressure, genetic drift, mutation and competition for resources influence the evolutionary process. Recognize that a change in a species over time does not follow a set pattern or timeline.	**SE/TE:** 127
- Compare and contrast the role of sexual selection to the role of natural selection on the evolutionary process.	**SE/TE:** 130
- Relate a population's survival to the reproductive success of adapted individuals in that population.	**SE/TE:** 129, 161
- Explain the roles of geographical isolation and natural selection on the evolution of new species.	**SE/TE:** 127-130, 132, 158-161, 264, 366, 369
- Predict possible evolutionary implications for a population due to environmental changes over time (e.g., volcanic eruptions, global climate change, industrial pollution).	**SE/TE:** 131
- Explain why homogeneous populations may be more vulnerable to environmental changes than heterogeneous populations.	**SE/TE:** 128
- Explain how evolutionary relationships between species are used to group organisms together.	**SE/TE:** 201, 221
- Explain how antibiotic resistance populations evolve from common bacterial populations.	**SE/TE:** 264
-Research how invasive species have genetically altered an indigenous population.	**SE/TE:** 153-155, 156-157, 158-161, 210
Strand - Technology Applications	
- Enduring Understanding: The development of technology has allowed us to apply our knowledge of genetics, reproduction, development and evolution to meet human needs and wants.	
- Essential Question: How does the understanding and manipulation of genetics, reproduction, development and evolution affect the quality of human life?	
Grades 9-12	
1. The expanding ability to manipulate genetic material, reproductive processes, and embryological development creates choices that raise ethical, legal, social, and public policy questions.	**SE/TE:** 375-377, 383, 386, 388-389

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2. Recombinant DNA technology, which is a form of genetic engineering, involves the insertion of DNA from one cell into a cell of a different organism where the inserted DNA is expressed. Genetic engineering is being applied in biology, agriculture, and medicine in order to meet human wants and needs.	**SE/TE:** 375
3. DNA is analyzed to determine evolutionary relationships, study populations, identify individuals, and diagnose genetic disorders.	**SE/TE:** 68, 375
Building upon the K-9 expectations, all students in Grade 10 will be able to:	
- Explain how DNA evidence can be used to determine evolutionary relationships.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 201
- Investigate how the human ability to manipulate genetic material and reproductive processes can be applied to many areas of medicine, biology, and agriculture. Evaluate the risks and benefits of various ethical, social and legal scenarios that arise from this ability.	**SE/TE:** 375-377, 383, 386, 388-389
- Discuss examples of how genetic engineering technology can be applied in biology, agriculture and medicine in order to meet human wants and needs.	**SE/TE:** 375-377, 383, 386, 388-389
- Explain the basic process of bacterial transformation and how it is applied in genetic engineering.	*Opportunities to address this standard can be found on the following pages:* **SE/TE:** 375-377
- Explain how developments in technology (e.g., gel electrophoresis) have been used to identify individuals based on DNA as well as to improve the ability to diagnose genetic diseases.	**SE/TE:** 375

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SCIENCE STANDARD 8	
Ecology - Organisms are linked to one another in an ecosystem by the flow of energy and the cycling of materials. Humans are an integral part of the natural system and human activities can alter the stability of ecosystems.	
Strand - Interactions within the Environment	
- Enduring Understanding: Organisms and their environments are interconnected. Changes in one part of the system will affect other parts of the system.	
- Essential Question: How can change in one part of an ecosystem affect change in other parts of the ecosystem?	
Grades 9-12	
1. Earth's ecosystems are interconnected by biological, chemical, and physical processes. Changes in one ecosystem may have local and/or global consequences.	**SE/TE:** 100-103, 149-155, 211, 335-336, 491-496, 510-513
2. Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate complex ecosystems that are stable over long periods of time and tend to have cyclic fluctuations around an equilibrium.	**SE/TE:** 133-140, 149-155, 158, 161
3. Ecosystems undergo major changes as a result of such factors as climate change, introduction of new species, and habitat destruction. These can be the result of natural processes and/ or human impact.	**SE/TE:** 153-155, 161, 209-211, 220-223, 335-336, 483, 489-490, 491-496, 497-507, 510-513, 530-533, 539-540, 544-547, 592-593
4. Changes in the physical, chemical, or biological conditions of an ecosystem can alter the diversity of species in the system. Over time, ecosystems change and populations of organisms adapt, move, or become extinct.	**SE/TE:** 207-211, 220-223, 308
5. The carrying capacity for a specific population in an ecosystem depends on the resources available. Given adequate biotic and abiotic resources and no disease or predators, populations increase at rapid rates. Resources, (limiting factors), predation and climate, limit the growth of populations in specific niches in an ecosystem.	**SE/TE:** 115, 117, 120-123, 231, 328

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6. Populations can increase through exponential growth. Higher populations result in competition for limited resources and increases in environmental pollution.	**SE/TE:** 4-5, 8-11, 30-33, 114, 227, 233, 242-247, 250-253
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Identify and measure biological, chemical and physical indicators within a given ecosystem (pH, dissolved oxygen, macroinvertebrate and other indicator species, salinity).	**SE/TE:** 181-182, 187, 194-197, 357, 499
- Using models, computer simulations, or graphic representations, demonstrate how, changes in these indicators may affect interactions within ecosystems. Evaluate the current health of the ecosystem and suggest possible interventions for mitigation.	**SE/TE:** 181-182, 187, 194-197, 357, 362-363, 499
- Explain how feedback loops keep an ecosystem (at the local and global level) in a state of dynamic equilibrium (e.g., positive and negative feedback loops associated with global climate).	**SE/TE:** 73-75
- Explain how niches help to increase the diversity within an ecosystem and maximize the number of populations that can live in the same habitat.	**SE/TE:** 133-135
- Using graphs of population data of a predator and its prey, describe the patterns observed. Explain how the interactions of predator and prey generate these patterns, and predict possible future trends in these populations.	**SE/TE:** 136
- Analyze and explain the short-term impact of a natural disaster on the biological, chemical, and physical components of the affected ecosystem and their associated interrelationships, including geochemical cycles and food webs.	**SE/TE:** 149-152, 257, 277-283, 286-289
- Based on knowledge of populations and interactions in an ecosystem, predict the possible long-term outcomes (e.g., extinction, adaptation, succession) of a natural disaster on populations in the ecosystem.	**SE/TE:** 118-119, 132, 149-152, 207-211, 244, 257, 277-283, 286-289

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- Explain the significance of the introduction of non-native and invasive species to a stable ecosystem and describe the consequent harm to the native species and the environment (e.g., zebra mussels, purple loosestrife, phragmites, Japanese Beetles).	**SE/TE:** 153-155, 156-157, 158-161, 210
- Describe how the biotic and abiotic factors can act as selective pressures on a population and can alter the diversity of the ecosystem over time.	**SE/TE:** 209-211, 217, 220, 223
- Identify limiting factors in an ecosystem and explain why these factors prevent populations from reaching biotic potential. Predict the effects on a population if these limiting factors were removed. Explain why a population reaching unlimited biotic potential can be detrimental to the ecosystem.	**SE/TE:** 115-117, 120, 122-123
- Determine the carrying capacity for a population in an ecosystem using graphical representations of population data.	**SE/TE:** 123
- Describe how birth rate, death rate, emigration, and immigration contribute to a population's growth rate.	**SE/TE:** 111-112, 117, 120-123, 238-239, 241
Strand - Energy Flow and Material Cycles in the Environment	
- Enduring Understandings: Matter needed to sustain life is continually recycled among and between organisms and the environment. Energy from the Sun flows irreversibly through ecosystems and is conserved as organisms use and transform it.	
- Essential Questions: How do matter and energy link organisms to each other and their environments? Why is sunlight essential to life on Earth?	
Grades 9-12	
1. The Law of Conservation of Matter applies to ecosystems. Matter needed to sustain life in ecosystems is continually recycled (e.g., carbon cycle, water cycle, nitrogen cycle, mineral cycles) among organisms and between organisms and the environment.	**SE/TE:** 83-89, 92-95
2. The Law of Conservation of Energy applies to ecosystems. All energy is conserved as it passes from the Sun through an ecosystem. During energy transformations, some energy is converted to unusable heat. A continual input of energy from the Sun keeps the process going.	**SE/TE:** 144-145, 160

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3. At each level of a food pyramid some energy is stored, but much is dissipated as heat. Consequently the number of trophic levels is finite, and the number of individuals in a population that feed at higher levels is limited.	**SE/TE:** 144-145, 148, 158
4. Biomagnification is an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted. Biomagnification increases as trophic levels increase.	**SE/TE:** 275-276, 286-288, 440
5. Understanding the process of biomagnification is very important in protecting human beings and other organisms from the adverse effects of chemical exposure, and has become a critical consideration in the regulation of chemical use.	**SE/TE:** 275-276, 286-288, 440
Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Illustrate how elements on Earth cycle among the biotic and abiotic components of the biosphere.	**SE/TE:** 83-89, 92-95
- Recognize that the amount of matter in a closed ecosystem will remain constant.	**SE/TE:** 83-89, 92-95
- Relate an ecosystem's requirement for the continual input of energy to the inefficiency of energy transfer.	**SE/TE:** 144-145, 148, 158
- Explain how ecosystems that do not rely on radiant energy obtain energy to maintain life.	**SE/TE:** 191
- Explain how the inefficiency of energy transfer determines the number of trophic levels and affects the relative number of organisms at each trophic level in an ecosystem.	**SE/TE:** 144-145, 148, 158
- Relate a chemical's properties to its accumulation within organisms, such as PCBs in the fatty tissues of fish.	**SE/TE:** 275-276, 286-288, 440
- Relate the accumulation of a chemical in an organism to the organism's trophic level. Explain why bioaccumulation is a greater problem for organisms at higher trophic levels.	**SE/TE:** 275-276, 286-288, 440

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- Explain how biomagnification has led to unsafe food supplies, such as mercury accumulation in tuna.	**SE/TE:** 275-276, 286-288, 440
- Analyze how an understanding of biomagnification has led to the regulation of chemical use and disposal.	**SE/TE:** 275-276, 286-288, 440
Strand - Human Impact	
- Enduring Understanding: Humans can alter the living and non-living factors within an ecosystem, thereby creating changes to the overall system.	
- Essential Question: How do humans have an impact on the diversity and stability of ecosystems?	
Grades 9-12	
1. Exponential growth of the global human population and the resulting increase in consumption places severe stress on finite resources.	**SE/TE:** 4-5, 8-11, 30-33, 114, 227, 233, 242-247, 250-253
2. Human decisions concerning the use of resources can affect the stability and biodiversity of the ecosystems and the natural recycling processes which maintain the quality of air, water, and land.	**SE/TE:** 212-217, 324-329, 337-343, 346-349, 362-364, 386-389, 405-411, 414-417, 432-434, 441-443, 446-449, 469-473, 474-475, 476-479, 480
3. Human activities have a major effect on other species. For example, increased land use reduces habitat available to other species, pollution changes the chemical composition of air, soil, and water, and introduction of non-native species disrupts the ecological balance.	**SE/TE:** 153-155, 161, 207-211, 220, 223, 242-247, 250-253, 273-274, 295-298, 302-304, 316-319, 335-336, 346-349, 359-362, 388-389
4. Advances in technology can help mitigate human impact on the environment and increase the carrying capacity of the ecosystem.	**SE/TE:** 247, 368
5. People manage the Earth and its resources by preservation, conservation, appropriate utilization, and restoration. The complexity and interaction of these ecosystems requires individual and collaborative efforts on a local, regional, national, and international scale.	**SE/TE:** 212-217, 324-329, 337-343, 346-349, 362-364, 386-389, 405-411, 414-417, 432-434, 441-443, 446-449, 469-473, 474-475, 476-479, 480

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Building upon the K-11 expectations, all students in Grade 12 will be able to:	
- Examine and describe how social and biological factors influence the exponential growth of the human population (e.g., economic, cultural, age at reproduction, fertility rate, birth/death rate, and environmental factors).	**SE/TE:** 228-231, 233, 234-241, 250-253
- Examine and describe how the exponential growth of the human population has affected the consumption of renewable and non-renewable resources.	**SE/TE:** 242-244, 253
- Evaluate decisions about the use of resources in one country and how these decisions can impact the diversity and stability of ecosystems globally.	**SE/TE:** 9-10, 242-243, 297, 361, 534-535
- Analyze ways in which human activity (i.e., producing food, transporting materials, generating energy, disposing of waste, obtaining fresh water, or extracting natural resources) can affect ecosystems and the organisms within.	**SE/TE:** 153-155, 161, 207-211, 220, 223, 242-247, 250-253, 273-274, 295-298, 302-304, 316-319, 335-336, 346-349, 359-362, 388-389
- Research and discuss ways in which humans use technology to reduce the negative impact of human activity on the environment. (e.g., phytoremediation, smokestack scrubbers).	**SE/TE:** 247, 270-271
- Describe how advances in technology can increase the carrying capacity of an ecosystem (i.e., advances in agricultural technology have led to increases in crop yields per acre).	**SE/TE:** 247, 368
http://www.doe.k12.de.us/infosuites/staff/ci/content_areas/science.shtml	