| National Science Education Standards Addressed by Challenger's Operation Montserrat | | Ohio Academic Content Standards for Technology and Science | Operation Montserrat | Space Station Alpha |
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| | | **Technology** | | |
| **Science Content Standards (National Science Education Standards) 5-8** | | *Computer Literacy* | | |
| | | use computer hardware and software applications | X | X |
| **A) Science as Inquiry As a result of activities in grades 5-8, all students should develop:** | | usage of technology tools for productivity, communication, and research | X | X |
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| 1.Abilities necessary to do scientific inquiry | | *Information Literacy* | | |
| c) Use appropriate tools and techniques to gather, analyze, and interpret data. | | acquisition, interpretation, and dissemination of information | X | X |
| d) Develop descriptions, explanations, predictions, and models using evidence. | | methods for locating, evaluating, and using information | X | X |
| g) Communicate scientific procedures and explanations. | | utilization of the Internet and other electronic information resources | X | X |
| h) Use mathematics in all aspects of scientific inquiry. | | | | |
| | | *Technological literacy* | | |
| 2. Understandings about scientific inquiry | | problem-based learning utilizing mathematics, science and technology principles | X | X |
| c) Mathematics is important in all aspects of scientific inquiry. | | encompasses unique knowledge, capabilities, devices, and ways of thinking | X | X |
| d) Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations. | | | | |
| | | **Earth and Space Science** | | |
| **C) Life Science As a result of their activities in grades 5-8, all students should develop understanding of:** | | **Grade Five** | | |
| | | *Earth Systems* | | |
| 1. Structure and function in living systems | | Explain how the supply of many non-renewable resources is limited and can be extended through reducing, reusing and recycling but cannot be extended indefinitely. | X | |
| a) Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems. | | Investigate ways Earth's renewable resources (e.g., fresh water, air, wildlife and trees) can be maintained. | X | |
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| 4. Populations and ecosystems | | **Grade Six** | | |
| d) The number of organisms an ecosystem can support depends on the resources available and abiotic factors, such as quantity of light and water, rang of temperatures, and soil composition. Given adequate biotic and abiotic resources and no disease or predators, populations (including humans) increas at rapid rates. Lack of resources and other factors, such as predation and climate, limit the growth of populations in specific niches in the ecosystem. | | *Earth Systems* | | |
| | | Describe the rock cycle and explain that there are sedimentary, igneous and metamorphic rocks that have distinct properties (e.g., colo texture) and are formed in different ways. | X | |
| 5. Diversity and adaptations of organisms | | Explain that rocks are made of one or more minerals. | X | |
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| **D) Earth and Space Science As a result of their activities in grades 5-8, all students should develop an understanding of:** | | **Grade Seven** | | |
| | | *Earth Systems* | | |
| 1. Structure of the earth system | | Explain the biogeochemical cycles which move materials between the lithosphere (land), hydrosphere (water) and atmosphere (air). | X | |
| a) The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core. | | Describe the water cycle and explain the transfer of energy between the atmosphere and hydrosphere. | X | |
| b) Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions. | | Analyze data on the availability of fresh water that is essential for life and for most industrial and agricultural processes. Describe how rivers, lakes and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unava | X | |
| c) Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion. | | Make simple weather predictions based on the changing cloud types associated with frontal systems. | | |
| d) Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues. | | Read a weather map to interpret local, regional and national weather. | X | |
| f) Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground. | | Describe the connection between the water cycle and weather-related phenomenon (e.g., tornadoes, floods, droughts, hurricanes). | X | |
| g) Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans. | | | | |
| h) The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has different properties at different elevations. | | **Grade Eight** | | |
| i) Clouds, formed by the condensation of water vapor, affect weather and climate. | | *Earth Systems* | | |
| k) Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks. | | Explain that most major geological events (e.g., earthquakes, volcanic eruptions, hot spots and mountain building) result from plate motion. | X | |
| | | Explain that some processes involved in the rock cycle are directly related to thermal energy and forces in the mantle that drive plate motions. | X | |
| **F) Science in Personal and Social Perspectives As a result of activities in grades 5-8, all students should develop understanding of:** | | Describe how landforms are created through a combination of destructive (e.g., weathering and erosion) and constructive processes (e.g., crustal deformation, volcanic eruptions and deposition of sediment). | X | |
| | | Explain that folding, faulting and uplifting can rearrange the rock layers so the youngest is not always found on top. | X | |
| 1. Personal health | | | | |
| b) The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions. | | **Grade Nine** | | |
| g) Natural environments may contain substances (for example, radon and lead) that are harmful to human beings. Maintaining environmental health involves establishing or monitoring quality standards related to use of soil, water, and air. | | *The Universe* | | |
| | | Describe that stars produce energy from nuclear reactions and that processes in stars have led to the formation of all elements beyond hydrogen and helium. | | X |
| 2. Populations, resources, and environments | | | | |
| a) Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides, wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids. | | *Earth Systems* | | |

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| b) Human activities also can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal. Such activities can accelerate many natural changes. | | Explain the relationships of the oceans to the lithosphere and atmosphere (e.g., transfer of energy, ocean currents, landforms). | X | |
| c) Natural hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of chang may result in either too little attention and significant human costs or too much cost for unneeded preventive measures. | | | | |
| | | *Processes that Shape Earth* | | |
| 4. Risks and benefits | | Explain the results of plate tectonic activity (e.g., magma generation, igneous intrusion, metamorphism, volcanic action, earthquakes, faulting and folding). | X | |
| a) Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks. | | | | |
| b) Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking). | | **Grade Ten** | | |
| c) Individuals can use a systematic approach to thinking critically about risks and benefits. Examples include applying probability estimates to risks and comparing them to estimated personal and social benefits. | | *Earth Systems* | | |
| d) Important personal and social decisions are made based on perceptions of benefits and risks. | | Explain climate and weather patterns associated with certain geographic locations and features (e.g., tornado alley, tropical hurricanes and lake effect snow). | X | |
| | | Describe ways that human activity can alter biogeochemical cycles (e.g., carbon and nitrogen cycles) as well as food webs and energy pyramids (e.g., pest control, legume rotation crops vs. chemical fertilizers). | X | |
| **National Science Education Standards Addressed by Challenger's Space Station Alpha** | | | | |
| **Science Content Standards (National Science Education Standards) 9-12** | | *Historical Perspectives and Scientific Revolutions* | | |
| | | Describe advances and issues in Earth and space science that have important long-lasting effects on science and society (e.g., geolog time scales, global warming, depletion of resources, exponential population growth). | X | X |
| **A) Science as Inquiry As a result of activities in grades9-12, all students should develop:** | | | | |
| | | **Grade Eleven** | | |
| 1.Abilities necessary to do scientific inquiry | | *Earth Systems* | | |
| c) Use technology and mathematics to improve investigations and communications. | | Explain the impact of oceanic and atmospheric currents on weather and climate. | X | |
| | | Use appropriate data to analyze and predict upcoming trends in global weather patterns (e.g., el Niño and la Niña, melting glaciers and icecaps, changes in ocean surface temperatures). | | |
| 2. Understandings about scientific inquiry | | Explain how interactions among Earth's lithosphere, hydrosphere, atmosphere and biosphere have resulted in the ongoing changes of Earth's system. | X | |
| b) Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories. | | Describe the effects of particulates and gases in the atmosphere including those originating from volcanic activity. | X | |
| c) Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used. | | Describe the normal adjustments of Earth, which may be hazardous for humans. Recognize that humans live at the interface between the atmosphere driven by solar energy and the upper mantle where convection creates changes in Earth's solid crust. Realize th | X | |
| d) Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results. | | Explain ways in which humans have had a major effect on other species (e.g., the influence of humans on other organisms occurs through land use, which decreases space available to other species and pollution, which changes the chemical composition of air, | X | |
| | | Explain how human behavior affects the basic processes of natural ecosystems and the quality of the atmosphere, hydrosphere and lithosphere. | X | |
| **B) Physical Science As a result of their activities in grades 9-12, all students should develop an understanding of:** | | | | |
| | | *Historical Prespectices And Scientific Revolutions* | | |
| 1. Structure of atoms | | Use historical examples to show how new ideas are limited by the context in which they are conceived; are often rejected by the social establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many differ | | X |
| a) Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together. | | Describe advances in Earth and space science that have important long-lasting effects on science and society (e.g., global warming, heliocentric theory, plate tectonics theory). | X | X |
| b) The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in th number of neutrons, these atoms are called different isotopes of the element. | | | | |
| d) d) Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation. The decay of any one nucleus cannot be predicted, but a large group of identical nuclei decay at a predictable rate. This predictability can be used to estimate the age of materials that contain radioactive isotopes. | | **Grade Twelve** | | |
| | | *The Universe* | | |
| 2. Structure and properties of matter | | Explain how scientists obtain information about the universe by using technology to detect electromagnetic radiation that is emitted, reflected or absorbed by stars and other objects. | | X |
| a) Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element. | | Explain how information about the universe is inferred by understanding that stars and other objects in space emit, reflect or absorb electromagnetic radiation, which we then detect. | | X |
| b) An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "Periodic Table" is a consequence of the repeating pattern of outermost electrons and their permitted energies. | | Explain how astronomers infer that the whole universe is expanding by understanding how light seen from distant galaxies has longer apparent wavelengths than comparable light sources close to Earth. | | |
| e) Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; and in gases molecules or atoms move almost independently of each other and are mostly far apart. | | | | |
| | | **Life Science** | | |
| 3. Chemical reactions | | | | |
| c) A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions. | | **Grade Five** | | |
| | | *Diversity and Interdependence of Life* | | |
| 4. Motion and forces | | Describe the role of producers in the transfer of energy entering ecosystems as sunlight to chemical energy through photosynthesis. | X | |
| c) The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them. | | Explain how almost all kinds of animals' food can be traced back to plants. | X | |
| e) Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators. | | Trace the organization of simple food chains and food webs (e.g., producers, herbivores, carnivores, omnivores and decomposers). | X | |
| | | Summarize that organisms can survive only in ecosystems in which their needs can be met (e.g., food, water, shelter, air, carrying capacity and waste disposal). The world has different ecosystems and distinct ecosystems support the lives of different typ | X | |

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| 6. Interaction of energy and matter | | Support how an organism's patterns of behavior are related to the nature of that organism's ecosystem, including the kinds and numbers of other organisms present, the availability of food and resources, and the changing physical characteristics of the eco | X | |
| b) Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength. | | Analyze how all organisms, including humans, cause changes in their ecosystems and how these changes can be beneficial, neutral or detrimental (e.g., beaver ponds, earthworm burrows, grasshoppers eating plants, people planting and cutting trees, and peopl | X | |
| c) Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance. | | | | |
| d) In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures some materials become superconductors and offer no resistance to the flow of electrons. | | **Grade Six** | | |
| | | *Diversity and Interdependence of Life* | | |
| **C) Life Science As a result of their activities in grades 9-12, all students should develop understanding of:** | | Describe how organisms may interact with one another. | X | |
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| 1. The cell | | **Grade Seven** | | |
| c) Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires. | | *Diversity and Interdependence of Life* | | |
| | | Investigate how organisms or populations may interact with one another through symbiotic relationships and how some species have become so adapted to each other that neither could survive without the other (e.g., predator–prey, parasitism, mutualistism, c | X | |
| 2. Molecular basis of heredity | | Explain how the number of organisms an ecosystem can support depends on adequate biotic (living) resources (e.g., plants, animals) and abiotic (non-living) resources (e.g., light, water, soil). | X | |
| a) In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome. | | Investigate how overpopulation impacts an ecosystem. | X | |
| c) Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring. | | Explain that some environmental changes occur slowly while others occur rapidly (e.g., forest and pond succession, fires and decomposition). | X | |
| | | Summarize the ways that natural occurrences and human activity affect the transfer of energy in Earth's ecosystems (e.g., fire, hurricanes, roads, oil spills). | X | |
| 4. Origin and evolution of the universe | | Explain that photosynthetic cells convert solar energy into chemical energy that is used to carry on life functions or is transferred to consumers and used to carry on their life functions. | X | |
| c) Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements. | | | | |
| | | **Grade Eight** | | |
| **E) Science and Technology As a result of activities in grades 9-12, all students should develop:** | | (No 8th grade Life Science indicators.) | | |
| | | **Grade Nine** | | |
| 1. Abilities of technological design | | (No 9th grade Life Science indicators.) | | |
| 2. Understandings about science and technology | | | | |
| b) Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research. | | **Grade Ten** | | |
| c) Creativity, imagination, and a good knowledge base are all required in the work of science and engineering. | | *Heredity* | | |
| d) Science and technology are pursued for different purposes. Scientific inquiry is driven by the desire to understand the natural world, and technological design is driven by the need to meet human needs and solve human problems. Technology, by its nature, has a more direct effect on society than science because its purpose is to solve human problems, help humans adapt, and fulfill human aspirations. Technological solutions may create new problems. Science, by its nature, answers questions that may or may not directly influence humans. Sometimes scientific advances challenge people's beliefs and practical explanations concerning various aspects of the world. | | Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism. | | X |
| **F) Science in Personal and Social Perspectives As a result of activities in grades 9-12, all students should develop understanding of:** | | Describe that spontaneous changes in DNA are mutations, which are a source of genetic variation. When mutations occur in sex cells, they may be passed on to future generations; mutations that occur in body cells may affect the functioning of that cell or | | X |
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| 1. Personal and community health | | *Diversity and Interdependence of Life* | | |
| a) Hazards and the potential for accidents exist. Regardless of the environment, the possibility of injury, illness, disability, or death may be present. Humans have a variety of mechanisms--sensory, motor, emotional, social, and technological—that can reduce and modify hazards. | | Describe how matter cycles and energy flows through different levels of organization in living systems and between living systems and the physical environment. Explain how some energy is stored and much is dissipated into the environment as thermal energy | X | |
| | | Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather). | X | |
| 2. Populations growth | | Relate how distribution and abundance of organisms and populations in ecosystems are limited by the ability of the ecosystem to recyc materials and the availability of matter, space and energy. | X | |
| a) Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations. | | Conclude that ecosystems tend to have cyclic fluctuations around a state of approximate equilibrium that can change when climate changes, when one or more new species appear as a result of immigration or when one or more species disappear. | X | |
| b) The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed. | | Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying c | X | |
| c) Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically. | | | | |
| | | *Historical Perspectives and Scientific Revolutions* | | |
| 5. Natural and human-induced hazards | | Use historical examples to explain how new ideas are limited by the context in which they are conceived. These ideas are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributio | | X |
| d) Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards--ranging from those wi minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations. | | | | |
| | | **Grade Eleven** | | |
| | | *Characteristics and Structure of Life* | | |
| | | Describe how the maintenance of a relatively stable internal environment is required for the continuation of life, and explain how stability is challenged by changing physical, chemical and environmental conditions as well as the presence of pathogens. | | X |
| | | Recognize that chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed. Some of this energy is released as thermal energy. | | X |
| | | Investigate the impact on the structure and stability of ecosystems due to changes in their biotic and abiotic components as a result of human activity. | X | |
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| | *Diversity and Interdependence of Life* | | |
| | Predict some possible impacts on an ecosystem with the introduction of a non-native species. | X | |
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| | **Grade Twelve** | | |
| | *Characteristics and Structure of Life* | | |
| | Recognize that information stored in DNA provides the instructions for assembling protein molecules used by the cells that determine th characteristics of the organism. | | X |
| | Explain that the Sun is essentially the primary source of energy for life. Plants capture energy by absorbing light and using it to form strong (covalent) chemical bonds between the atoms of carbon-containing (organic) molecules. | | X |
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| | *Heredity* | | |
| | Based on the structure and stability of ecosystems and their nonliving components, predict the biotic and abiotic changes in such systems when disturbed (e.g. introduction of non-native species, climatic change, etc.). | X | |
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| | **Physical Science** | | |
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| | **Grade Five** | | |
| | *Nature of Energy* | | |
| | Describe that electrical current in a circuit can produce thermal energy, light, sound and/or magnetic forces. | | X |
| | Trace how electrical current travels by creating a simple electric circuit that will light a bulb. | | X |
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| | **Grade Six** | | |
| | *Nature of Matter* | | |
| | Describe that chemical and physical changes occur all around us (e.g., in the human body, cooking, industry). | | X |
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| | *Nature of Energy* | | |
| | Explain that the energy found in nonrenewable resources such as fossil fuels (e.g., oil, coal, natural gas) originally came from the Sun and may renew slowly over millions of years. | | X |
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| | **Grade Seven** | | |
| | *Nature of Energy* | | |
| | Identify different forms of energy (e.g., electrical, mechanical, chemical, thermal, nuclear, radiant and acoustic). | | X |
| | Explain how energy can change forms but the total amount of energy remains constant. | | X |
| | Trace energy transformation in a simple closed system (e.g., a flashlight). | | X |
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| | **Grade Eight** | | |
| | *Nature of Energy* | | |
| | Demonstrate that waves transfer energy. | | X |
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| | **Grade Nine** | | |
| | *Nature of Matter* | | |
| | Recognize that all atoms of the same element contain the same number of protons, and elements with the same number of protons may or may not have the same mass. Those with different masses (different numbers of neutrons) are called isotopes. | | X |
| | Illustrate that atoms with the same number of positively charged protons and negatively charged electrons are electrically neutral. | | X |
| | Describe radioactive substances as unstable nuclei that undergo random spontaneous nuclear decay emitting particles and/or high energy wavelike radiation. | | X |
| | Show that when elements are listed in order according to the number of protons (called the atomic number), the repeating patterns of physical and chemical properties identify families of elements. Recognize that the periodic table was formed as a result | | X |
| | Describe how ions are formed when an atom or a group of atoms acquire an unbalanced charge by gaining or losing one or more electrons. | | X |
| | Explain that the electric force between the nucleus and the electrons hold an atom together. Relate that on a larger scale, electric force hold solid and liquid materials together (e.g., salt crystals, water). | | X |
| | Show how atoms may be bonded together by losing, gaining or sharing electrons and that in a chemical reaction, the number, type of atoms and total mass must be the same before and after the reaction (e.g., writing correct chemical formulas and writing bal | | X |
| | Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity. | | X |
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| | *Nature of Energy* | | |
| | Explain how thermal energy exists in the random motion and vibrations of atoms and molecules. Recognize that the higher the temperature, the greater the average atomic or molecular motion, and during changes of state the temperature remains constant. | | X |
| | Summarize how nuclear reactions convert a small amount of matter into a large amount of energy. (Fission involves the splitting of a large nucleus into smaller nuclei; fusion is the joining of two small nuclei into a larger nucleus at extremely high ener | | X |
| | Trace the transformations of energy within a system (e.g., chemical to electrical to mechanical) and recognize that energy is conserved. Show that these transformations involve the release of some thermal energy. | | X |
| | Demonstrate that electromagnetic radiation is a form of energy. Recognize that light acts as a wave. Show that visible light is a part of the electromagnetic spectrum (e.g., radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma | | X |
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| | *Historical Perspectives and Scientific Revolutions* | | |
| | Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by th scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions | | X |
| | Describe advances and issues in physical science that have important, long-lasting effects on science and society (e.g., atomic theory, quantum theory, Newtonian mechanics, nuclear energy, nanotechnology, plastics and ceramics and communication technology | | X |
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| | **Grade Ten** | | |
| | (No 10th Grade Physical Science indicators.) | | |

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| **Grade Eleven** | | | |
| *Nature of Matter* | | | |
| Explain that elements with the same number of protons may or may not have the same mass and those with different masses (different numbers of neutrons) are called isotopes. Some of these are radioactive. | | | X |
| *Forces and Motion* | | | |
| Explain how electric motors and generators work (e.g., relate that electricity and magnetism are two aspects of a single electromagnetic force). Investigate that electric charges in motion produce magnetic fields and a changing magnetic field creates an | | | X |
| **Grade Twelve** | | | |
| *Nature of Matter* | | | |
| Explain how atoms join with one another in various combinations in distinct molecules or in repeating crystal patterns. | | | X |
| Recognize that at low temperatures some materials become superconducting and offer little or no resistance to the flow of electrons. | | | X |
| *Forces & Motion* | | | |
| Recognize that the nuclear forces that hold the nucleus of an atom together, at nuclear distances, are stronger than the electric forces that would make it fly apart. | | | X |
| Recognize that nuclear forces are much stronger than electromagnetic forces, and electromagnetic forces are vastly stronger than gravitational forces. The strength of the nuclear forces explains why greater amounts of energy are released from nuclear rea | | | X |
| *Nature of Energy* | | | |
| Explain the characteristics of isotopes. The nucleus of radioactive isotopes is unstable and spontaneously decays emitting particles and/or wavelike radiation. It cannot be predicted exactly when, if ever, an unstable nucleus will decay, but a large grou | | | X |
| Describe how different atomic energy levels are associated with the electron configurations of atoms and electron configurations (and/or conformations) of molecules. | | | X |
| Explain how atoms and molecules can gain or lose energy in particular discrete amounts (quanta or packets); therefore they can only absorb or emit light at the wavelengths corresponding to these amounts. | | | X |
| *Historical Perspectives and Scientific Revolutions* | | | |
| Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by th scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions | | | X |
| Describe concepts/ideas in physical sciences that have important, long-lasting effects on science and society (e.g., quantum theory, theory of relativity, age of the universe). | | | X |
| **Science and Technology** | | | |
| **Grade Five** | | | |
| *Understanding Technology* | | | |
| Investigate positive and negative impacts of human activity and technology on the environment. | | X | |
| **Grade Six** | | | |
| (No 6th Grade Science and Technology indicators.) | | | |
| **Grade Seven** | | | |
| (No 7th Grade Science and Technology indicators.) | | | |
| **Grade Eight** | | | |
| *Understanding Technology* | | | |
| Examine how science and technology have advanced through the contributions of many different people, cultures and times in history. | | | X |
| **Grade Nine** | | | |
| (No 9th Grade Science and Technology indicators.) | | | |
| **Grade Ten** | | | |
| *Understanding Technology* | | | |
| Describe examples of scientific advances and emerging technologies and how they may impact society. | | | X |
| **Grade Eleven** | | | |
| (No 11th Grade Science and Technology indicators.) | | | |
| **Grade Twelve** | | | |
| (No 12th Grade Science and Technology indicators.) | | | |
| **Scientific Inquiry** | | | |
| **Grade Five** | | | |
| *Doing Scientific Inquiry* | | | |
| Select and safely use the appropriate tools to collect data when conducting investigations and communicating findings to others(e.g., thermometers, timers, balances, spring scales, magnifiers, microscopes and other appropriate tools). | | X | |
| Evaluate observations and measurements made by other people and identify reasons for any discrepancies. | | X | |
| Use evidence and observations to explain and communicate the results of investigations. | | X | |
| **Grade Six** | | | |
| *Doing Scientific Inquiry* | | | |
| Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations. | | X | |

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| | | **Grade Seven** | | |
| | | *Doing Scientific Inquiry* | | |
| | | Choose the appropriate tools and instruments and use relevant safety procedures to complete scientific investigations. | X | |
| | | Analyze alternative scientific explanations and predictions and recognize that there may be more than one good way to interpret a given set of data. | X | |
| | | Use graphs, tables and charts to study physical phenomena and infer mathematical relationships between variables (e.g., speed, density). | X | |
| | | | | |
| | | **Grade Eight** | | |
| | | *Doing Scientific Inquiry* | | |
| | | Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations. | X | |
| | | Read, construct and interpret data in various forms produced by self and others in both written and oral form (e.g., tables, charts, maps, graphs, diagrams, symbols). | X | |
| | | Apply appropriate math skills to interpret quantitative data (e.g., mean, median, mode). | X | |
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| | | **Grade Nine** | | |
| | | *Doing Scientific Inquiry* | | |
| | | Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts. | X | |
| | | Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology. | X | |
| | | Draw logical conclusions based on scientific knowledge and evidence from investigations. | X | |
| | | | | |
| | | **Grade Ten** | | |
| | | *Doing Scientific Inquiry* | | |
| | | Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology. | X | |
| | | Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations. | X | |
| | | | | |
| | | **Grade Eleven** | | |
| | | *Doing Scientific Inquiry* | | |
| | | Summarize data and construct a reasonable argument based on those data and other known information. | X | |
| | | | | |
| | | **Grade Twelve** | | |
| | | (No 12th Grade Scientific Inquiry indicators.) | | |
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| | | **Scientific Ways of Knowing** | | |
| | | | | |
| | | **Grade Five** | | |
| | | *Nature of Science* | | |
| | | Develop descriptions, explanations and models using evidence to defend/support findings. | X | |
| | | | | |
| | | **Grade Six, Seven, Eight** | | |
| | | (No 6, 7, or 8th Grade Scientific Ways of Knowing indicators.) | | |
| | | | | |
| | | **Grade Nine** | | |
| | | *Scientific Theories* | | |
| | | Recognize that scientific knowledge and explanations have changed over time, almost always building on earlier knowledge. | | X |
| | | | | |
| | | *Science and Society* | | |
| | | Investigate how the knowledge, skills and interests learned in science classes apply to the careers students plan to pursue. | X | X |
| | | | | |
| | | **Grade Ten** | | |
| | | (No 10th Grade Scientific Ways of Knowing indicators.) | | |
| | | **Grade Eleven** | | |
| | | *Science and Society* | | |
| | | Describe costs and trade-offs of various hazards - ranging from those with minor risk to a few people, to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict | X | X |
| | | Research the role of science and technology in careers that students plan to pursue. | X | X |
| | | | | |
| | | **Grade Twelve** | | |
| | | *Nature of Science* | | |
| | | Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator-prey relationships, properties of semiconductors). | X | |
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