HIGH SCHOOL

State Goal 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments, and solve problems.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Critical to Understand and Master at High School: H.11.01 Formulate testable questions and hypotheses, referencing prior experiences and knowledge.	**AD:** Distinguish between questions that can be answered by science and those that cannot be answered by science. **B:** Determine the relationship between light intensity and dissolved oxygen contents for a small vessel containing *Anacharis*. **C:** Identify the factors that affect the solubility of chemical substances. **P:** Identify ways to make an electromagnet. **ESS:** Observe the effect of chemical weathering on limestone or other rocks. **ESS:** Develop a question to explore and identify the components of various soils. **AD:** Formulate a hypothesis referencing prior research and knowledge.	Language Arts: Compare and contrast hypothesis and thesis statements. Language Arts: Discuss how hypotheses and theses guide a lab report or paper. Religion: List and discuss questions that are not testable in science. Physical Education: Develop a testable question regarding whether a percentage of students can achieve a goal (e.g., 50 percent of class jump higher than 20 inches).
H.11.02 Design investigations that test questions and hypotheses; critically revise questions based on the experimental design, methods, controls, and variables; write a prediction for the results.	**AD:** Design procedures for an investigation that specifically tests a hypothesis. **AD:** Determine the dependent, independent, and control variables necessary to test the hypothesis. **AD:** Make revisions to the hypothesis to narrow the focus to a testable question, if necessary.	Language Arts: Compare and contrast the parts of a lab paper to a persuasive writing essay or research paper. Math: Compare and contrast experimental design and geometric proofs. Math: Test the prediction that the probability of flipping "heads" with a coin is exactly 50.0 percent.

B: Biology **ESS:** Earth and Space Sciences **C:** Chemistry **P:** Physics **AD:** All Disciplines

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H.11.03 Use observation methods, technologies, and design techniques (e.g., experimental control) to measure, record, and organize accurately the data from observations of scientific investigations.	**AD:** Set up a data table that organizes the recording of your observations and measurements. **AD:** Develop and monitor a control for an experiment or investigation. **AD:** Discuss the terms "random assignment" and "placebo" and write about the ramifications for how this might reduce bias in trials of new drugs. **AD:** Distinguish between accuracy and precision.	Art: Discuss the importance of observation in both the sciences and the arts. Math: Relate the notion of accuracy and precision to both calculations and graphing. Technology/Art: Use a digital camera to record a sequence (e.g., 100 meter dash; oak tree each day from mid September to early November).
H.11.04 Use appropriate mathematics and technologies to represent measurements and observations (e.g., mean, spread, probability of event, graphical representation) and to analyze inferences.	**AD:** Conduct multiple trials of an investigation to eliminate error. **AD:** Manipulate and analyze data from an experiment using equations, statistical tools, and graphical representation.	Math: Gather statistics on the average salaries of workers with college degrees versus those with only high school degrees or no high school degree, and make inferences about the value of each degree (data at U.S. Census Bureau). Language Arts: Explore how statistics can be manipulated in the media.
H.11.05 Use evidence, logic, and inference to formulate scientific explanations and models for a set of observations; use additional tests and analysis to revise and improve explanations and models.	**AD:** Describe what makes a good explanation and model of a physical system (e.g., they are based on observations and evidence that can be reproduced). **AD:** Be able to distinguish among several explanations and select the one most consistent with data. **AD:** In an investigation, propose additional tests or experiment revision to analyze inconsistencies in results.	Language Arts: Define evidence and explain the different types of evidence (e.g., opinion, fact, statistics). Math: Write a proof for a particular theorem. Religion: Discuss how statistics can be used to persuade people to make decisions that are counter to their beliefs. Art: Make a scale model of something you are studying in science.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.11.06 Recognize and analyze in a respectful dialogue any alternative explanations and models that use scientific criteria and evidence.	**AD:** Carefully consider alternative explanations without prejudice by requesting to see data that support the alternative. **AD:** Support a particular explanation by referring to the strength of the evidence backing it.	Religion/Language Arts/History: Determine the components of a respectful conversation by discussing major religious figures such as Jesus, Gandhi, Martin Luther King, Jr., and St. Catherine of Siena.
H.11.07 Communicate results and use evidence and logic to defend scientific explanations.	**AD:** Write a complete lab report using available technology to report, display, and defend conclusions. **AD:** Read scientific journals to recognize that scientists follow the same process to communicate their results and receive feedback on the strength of their explanations.	Language Arts: Determine and practice appropriate oral presentation skills. History: Prepare a debate on a historical topic. Drama: Prepare a monologue and incorporate appropriate facial and body language. Art: Discuss how artistic expression is a way to communicate with others.
H.11.08 Identify improvements to a current technological design and propose design revisions in writing and with diagrams.	**B:** Design a garden that will provide a habitat to butterflies. **C:** Design an apparatus that allows you to separate 2 substances from a liquid mixture. **P:** Construct a bridge that could replace a current bridge with a specific design problem (e.g., too wide, too narrow). **ESS:** Design a landfill that prevents pollutants from entering the surrounding environment. **AD:** Write a proposal for a design (e.g., a needed new airport) that includes written descriptions and diagrams. Include specific parameters needed to construct your design (e.g., location, materials).	Language Arts: Learn how to provide meaningful constructive criticism to peers. Art: Use CAD to diagram technological design changes (e.g., improve the pattern of streets in your neighborhood). Business and Economics: Identify an object that has undergone extensive changes (e.g., car, clothing, washing machine, computer, camera) and describe improvements in its design.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.11.09 Select criteria for a successful design solution to an identified problem given available materials, tools, efficiency, cost effectiveness, and safety.	**AD:** Present a design solution to the class using diagrams and models. **AD:** Make a list of the costs and benefits of each design solution in the class and compare them.	Economics and History: Use a cost-benefit analysis to evaluate a solution to a historical problem (e.g., using lead-free gasoline to decrease pollution, halting World War II with an atomic bomb, building a dam to provide electricity). Religion: Discuss whether or not there should be other considerations when making design decisions such as ethics.
H.11.10 Develop and construct a proposed solution using blueprints, schematics, flowcharts, CAD-CAM software, or animations.	**AD:** Use available technology and tools to construct or model the design solution. **B:** Make blueprints or drawings of butterfly habitats. **C:** Draw plans for a distillation and filtration apparatus. **P:** Build a prototype bridge. **ESS:** Construct a model landfill.	Technology: Use CAD to complete a project (e.g., blueprints, schematics, flowcharts, or animation). Art: Design an accurate, creative flow chart for making your favorite kind of sandwich.
H.11.11 Test model and complete the simulation, making sure to record data and observations.	**AD:** Determine if the design solution solves the problem by testing it and recording data and observations. **B:** Take the butterfly habitat design to a butterfly specialist to be evaluated. **C:** Run tests on a liquid that contains 2 dissolved solids in it. **P:** Test the bridge to see that it can carry the necessary load. **ESS:** Pour simulated pollutants into the model landfill to see if they remain contained. If not, test the rate of migration.	Math: Write a challenging problem that requires sophisticated, multi-step math to solve. Record the solution and justify each step. Technology: Offer constructive criticism of various computer simulation games such as SimCity. Civics: Hold a school-wide event using ideas from all grade levels at the school. Make notes of what worked and what did not work.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.11.12 Use design criteria to evaluate a technological solution by listing advantages, disadvantages, and sources of error; list revisions and justification.	**AD:** Analyze the costs and benefits of a given technological solution to determine if it is viable. **AD:** Consider alternatives to the solution tested that would make it better. **AD:** Justify changes to the design using data and observations from your tests.	Language Arts: Learn how to provide meaningful constructive criticism to peers. Civics: Organize a debriefing meeting to discuss observations and results of a school-wide event. Make recommendations for next year.
H.11.13 Report to an audience the level of success of the design (strengths, weaknesses) based on the test results and the performance criteria. Use available technology to write a report of findings for the design solution to an audience that may include professional and technical experts.	**AD:** Present the results of your design by discussing the plans, tests, and performance of your design. **AD:** Answer questions from the audience about the reasons for decisions you made in the design process. **AD:** Develop a report of your findings that can be published along with other reports by your classmates. Share the publication with experts.	Language Arts: Determine and practice appropriate oral presentation skills using visual aids. Debate: Participate in a debate competition where your presentation will be judged by professionals.
H.11.14 Use both large and small numbers showing decimals or exponents and significant figures to describe and relate objects or events in science.	**B:** Explain how, with only 4 nucleotides, scientists can build a map of combinations of genes in the Human Genome Project. **C:** Convert grams of a substance to moles and then convert moles to molecules or atoms. **P:** Describe how an object reaches terminal velocity and why. **ESS:** Describe how radiometric dating helps scientists understand billions of years of Earth's history.	Math: Explain the role of significant figures and scientific notation in science and mathematics. Math: Use significant figures and scientific notation while solving problems. Language Arts: Write an essay describing the vastness of the universe or the microscopic world of atoms and molecules.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.11.15 Develop sophisticated skills of observing, measuring, replicating (e.g., scales, microscopes), organizing data tables, and applying computer (calculator) or algebraic functions to manipulate and analyze data.	**B:** Analyze a water sample to see if it is contaminated by bacteria by using a microscope and calculate the rate of growth of the bacterial population over time. **C:** Use a graphing calculator to display the rate of absorption of a solid into a liquid to the point of saturation. **P:** Use a computer simulation of an inclined ramp to compare the acceleration of different masses down a ramp. **ESS:** Describe why 3 or more seismic stations are needed to locate the epicenter of an earthquake and use real data to triangulate the epicenter of an earthquake.	Math: Use algebraic equations or geometric theorems to solve problems. Art: Create a scaled drawing of a photograph or picture. Technology: Use a function on your calculator to analyze a set of data.
H.11.16 Show how the language and skills of math can be used to represent objects or events in the sciences (e.g., mathematical models and formulas, equations, variables, symbols, graphs, statistics, precision and accuracy, significant figures).	**B:** Use a mathematical model to help understand the density (e.g., organisms of a species per acre) and diversity (e.g., number of species) of plant organisms in an environment. **C:** Be able to balance chemical equations. **P/ESS:** Use vectors to describe the motion of objects through space, such as GPS monitoring of tectonic plates moving over the surface of Earth. **ESS:** Model the folding of sedimentary rocks by graphing the forces necessary to create the structures.	Math: Demonstrate with examples why mathematics can be considered the language of physics or all science. Language Arts: Translate mathematical equations from science into sentences using words. Compare the lengths of the sentences to the lengths of the equations and discuss the efficiency of the language of math.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.11.17 Use both oral and written communication with evidence, logic, and argument to convey effectively findings from scientific investigations.	**AD:** Write a complete lab report that follows the format suggested by your teacher and includes appropriate data tables, charts, graphs, complete sentences, proper grammar, and conclusions backed by evidence. **AD:** Compare your investigations with publications by scientists in journals to see similarities in written communication techniques and use of evidence to support conclusions.	Language Arts: Write a persuasive paper about a current event or finding in medical sciences. History: Utilize debate skills to present two sides of a historical event (e.g., use of nuclear bomb in World War II, whether the Civil War was justified).
H.11.18 Communicate ideas and findings in the sciences with accurate representations (2-D, 3-D) such as models, diagrams, dynamic settings, and sketches.	**ESS/C:** List attributes of volcanoes and then critique whether or not mixing vinegar (acid) and baking soda (sodium bicarbonate) in the top of a cone is a good simulation for a volcanic eruption (e.g., analyze the chemical reaction). **AD:** Include in all lab reports at least 1 diagram or sketch to clarify an experimental setup or observation. **AD:** Prepare a demonstration for the class using a setup of your own design to illustrate a phenomenon.	Art: Use CAD to design models, diagrams, dynamic settings, and sketches. Civics/Art: Make a model of playground that you would like to see installed at a local elementary school.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Significant to Develop at High School: H.11.19 Describe that scientific explanations for the natural world must adhere to certain criteria, such that the explanations are logically consistent, rely on evidence, are revised by analysis and constructive review, and are based on current knowledge and technologies. (11A)	**B:** Prepare a position paper that describes the theory of evolution as a viable scientific explanation of inherited variation (descent with modification) among organisms. **C:** Evaluate the scientific explanations made by advertisers of a popular cleaning product. **P:** Describe how the law of universal gravitation fits logically with a number of observations made of objects on Earth and in space. **ESS:** Explain how the pattern of earthquakes and volcanoes around the world supports the theory of plate tectonics.	History: Discuss how to formulate a logical argument. Language Arts: Determine and apply the criteria for evaluating an argument presented in a persuasive essay. Religion: Differentiate between criteria necessary for a scientific explanation and criteria necessary for an explanation based on faith.

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State Goal 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Critical to Understand and Master in Biology: ***Structure and function of organisms*** LS.12.01 Explain the levels of organization of living systems, from molecules to cells, tissues, organ systems, whole organisms, populations, communities, and ecosystems.	• Using labeled diagrams of samples of cells, tissues, organs, and organ systems, describe the differences that distinguish one from the other.	Language Arts: Write about an analogy for organization of cellular levels (e.g., professions of people at your school). Religion: Describe and discuss the structure of a church or cathedral with its function in the community. Art: Design a poster that illustrates the organization of cellular levels. History: Study the times, advances, and drawings of Robert Hooke in biology.
LS.12.02 Use examples to show that in a cell, thousands of distinct molecules carry out vital functions such as energy production, cellular transport, waste disposal, biosynthesis, and storage of genetic material.	• Use an analogy to compare a cell and the molecules within the cell to a city and how the city functions. • Identify key molecules carrying out particular functions within the cell for the analogy above.	Language Arts: Choose and develop your own analogy that compares a cell and its functions with another object. Art: Use CAD to design a 3-D object that is analogous to a cell. Language Arts: Write a story about the structure and function of a cell in a tissue of your body.
LS.12.03 Describe the organelles in cells that underlie their basic cellular functions (e.g., energy production by cellular respiration and photosynthesis, cellular transport).	• Use an analogy to compare the departments within your high school that are involved in similar tasks to organelles that do work within a typical cell.	Language Arts: Use a Venn diagram or another appropriate graphic organizer to compare cell organelles to analogous, functioning parts of an organization or school. Technology: Diagram the parts of a combustion engine and describe the function of each part. Technology: Research images of cells on the internet (e.g., Cells Alive).

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
LS.12.04 Describe the process by which cells multiply (mitosis) and that cell differentiation leads from a single cell to organized arrangements of differentiated cells in the tissues of multicellular organisms.	• Using diagrams of different stages in the development and differentiation of cells, tissues, and organs, describe the importance of mitosis for the growth of multicellular organisms.	Math: Explore and graph the exponential growth of dividing cells (e.g., 1 to 2, 2 to 4, 4 to 8, etc.). Art: Create a cartoon strip illustrating the various stages of mitosis.
LS.12.05 Explain examples of cell functions that are regulated by proteins.	• Identify particular proteins that control specific functions within a cell.	Technology: Compare program commands and products with protein synthesis and function. Economics: Learn how banks or the Federal Reserve can regulate or control the flow of money and economic activity.
LS.12.06 Describe key characteristics of plant cells that underlie their morphology and functions (e.g., cell walls; chloroplasts for photosynthesis).	• Using a diagram of a typical plant cell with the cell structures labeled and a list of functions, match the labeled structure with its function within the cell.	Art: Create 3-D drawings of plant cells using CAD. Language Arts: Write and illustrate a story, like those in the *Magic School Bus* series, about the structures and functions of plant cells. Physical Education: Describe how iron in spinach can help you when you are active.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Behavior of organisms LS.12.07 Describe examples of behavior in organisms that is innate or learned.	• Hold a clear piece of plastic in front of your face and toss a wad of paper so it will strike the plastic. Observe and describe your innate response. Then spell a simple word or add up two or more numbers and observe and describe your learned response.	History: Examine classic experiments that differentiate between innate and learned behavior in a particular animal or humans. Social Studies: Discuss common driving situations (e.g., sliding on ice, abruptly needing to stop) and whether your innate reactions are appropriate or need to be retrained with a learned response (e.g., turning the wheels into the skid instead of overcorrecting in the opposite direction).
LS.12.08 Explain that organisms use sensory organs with specialized cells to detect stimuli, such as light, sound, or chemicals, to monitor their surroundings.	• Explain physiologically how you are able to detect odors (e.g., of extracts or other substances), distinguish sounds, or see colored lights.	Physics: Study the light spectrum, that it is only one part of the electromagnetic (EM) spectrum compared with many other wavelengths of EM radiation. Physics: Research and illustrate what dogs and bees see compared with what humans see. Language Arts: Write a story about a character with no sense of hearing (or taste, touch, sight, and so on).
LS.12.09 Diagram basic parts of neural networks consisting of specialized cells that generate responses to internal or external stimuli.	• Using diagrams of selected neural networks, identify the various specialized cells and indicate how they function in transmitting internal or external stimuli to the brain from the body part involved.	Art: Use common materials to build a model of neural networks that you can use to describe the nervous system to a younger audience. Math: Design and implement a domino chain that illustrates a particular neural network. Compare and contrast with other designs.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Reproduction and heredity of organisms LS.12.10 Explain how instructions for characteristics of organisms such as physiology, morphology, and reproduction are carried in the organic molecule DNA.	• Relate how DNA is interpreted within the cells in order for the cells to carry on their life process.	Language Arts: Read Francis Crick's and James Watson's account of the discovery of the double helix. Compare their account with Rosalind Franklin's initial findings. History: Trace how technology developed in order for humans to learn about DNA. Compare this to another historical event shaped by technology. History: Discuss the portrayal of the work of women in our textbook versions of history.
LS.12.11 Describe the role of DNA replication in the production of new cells (e.g., mitosis for growth, differentiation, and asexual reproduction; meiosis for germ cells in sexual reproduction).	• Using models of DNA, describe the structure of DNA and the role of the nucleotide bases (e.g., adenine, guanine, thymine, and cytosine) in the replication of DNA strands during the production of new cells. • Using models of DNA, describe the process of asexual reproduction and how asexual reproduction differs from sexual reproduction.	Language Arts: Write an essay about a biologic community where only asexual reproduction existed. Language Arts: Use a Venn diagram to compare and contrast mitosis and meiosis.

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LS.12.12 Describe how genetic information is transmitted from one generation to the next through gametes (egg and sperm) produced in meiosis.	• Using models of DNA, describe the structure of DNA and the role of the nucleotide bases (e.g., adenine, guanine, thymine, and cytosine) in the replication of DNA strands during meiosis (production of gametes). • Trace an inherited disease from an offspring back to its parents, grandparents, or both by looking at how the genetic information that codes for the trait is passed from one generation to the next.	Language Arts: Develop a cooperative game that illustrates meiosis. Language Arts: Write and illustrate a children's storybook explaining meiosis. History: Read about experiments in 1784 by Lazzaro Spallanzani that showed how frog eggs are fertilized.
Biologic evolution and change over time LS.12.13 Identify examples of organisms classified into groups and subgroups based on evolutionary relations, with species on Earth today related by descent from common ancestors.	• Compare and contrast the skulls of a wolf, a coyote, and a fox to determine how they are similar and how they are different. Then examine a diagram of a bear skull in light of the first 3.	Art: Create 3-D model overlays of skulls using CAD. Economics: Describe how people are classified into groups and subgroups based on their income, level of education, profession, or other demographics. History: Examine the development of phones or personal computers as an example of descent with modification.
LS.12.14 Explain how natural selection and evolutionary changes account for the fossil record of ancient life-forms, plus the molecular and morphological similarities among living organisms.	• Using a diagram of the fossil record of the horse from the Eocene to modern time, examine the changes in horses over time including the extinction of some of the ancestors of the horse. • Use diagrams of the bones of a whale flipper, a bat wing, and an opossum foot to find similarities to the bones in a human hand. Explain the significance of any similarities.	Earth Science: Explain how the fossil record, relative dating, and radioactive dating support the theory of evolution. Math: Learn how isotopes are used in radiometric age dating and about decay curves. Language Arts: Read one of several accounts of Darwin's voyage on the Beagle to South America and the Galapagos Islands. Art: Research and draw the types of fossils that have been found around your town.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
LS.12.15 Describe processes where biologic evolution can account for species extinctions, as well as diversity in species that can develop over many, many generations.	• Examine the changes that occurred in climate and vegetation during the evolution of horses that resulted in evolutionary changes in some horses and the extinction of others. • Review the history of the peppered moths in England from the beginning of the industrial age to date to reveal how the process of natural selection brought about changes in the coloration of this species.	Language Arts: Write a story about an organism whose difference (e.g., mutation) from others in the population made it easier for it to live in its environment than usual. Math: Research the extremes and means of the human body (e.g., tallest human vs. shortest human, largest shoe size vs. smallest shoe size) and make a visual that displays the diversity of human form.
LS.12.16 Describe the great diversity of organisms on Earth that have evolved from at least 3.5 million years of evolution in every ecological niche.	• Examine posters that illustrate the various plants and animals associated with two or more ecosystems to note the difference and similarities among the plants, animals and their environments; describe that in different ecosystems there are different organisms that occupy similar niches.	History/Geography: Create a travel brochure emphasizing the niches of flora and fauna of two ecosystems in the same country. Language Arts: Create a "home buying" brochure for an organism interested in moving into a new ecosystem. Describe its potential neighbors and "job openings" (i.e., new survival tasks).
Populations, interdependence, and ecosystems LS.12.17 Analyze factors that influence the size and stability of populations of organisms in ecosystems (e.g., birthrate, death rate, predation, migration patterns, changing ecosystems).	• Examine and discuss one or more of the following situations: 1. Wolf and moose population variations on Isle Royale, Michigan 2. Kaibab mule deer population fluctuations on the Kaibab Plateau in Arizona 3. Kirtland warbler and the jack pine relationships in Michigan 4. Passenger pigeon extinction	Math: Graph population changes over time for an organism. History: Read primary sources from different perspectives (such as lumber jacks and native people) about how the landscape changed. Civics: Have a class discussion about state versus federal law on species protection.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
LS.12.18 Compare physical, ecological and behavioral factors that influence interactions and interdependencies (e.g., cooperation and competition) of organisms in ecosystems.	• Describe examples of different kinds of interdependence such as mimicry (e.g., monarch and yellow swallowtail butterfly), parasitism (e.g., liver flukes and humans), mutualism (e.g., lichen), and predation (e.g., robin and earthworm). • Describe the role of each organism in each example of interdependence.	Language Arts: Create a story that illustrates the different kinds of interdependence. History: Using the different kinds of interdependent relationships, look for examples in history that would illustrate them. History: Study changes in fish populations and the fishing industry in Lake Michigan.
LS.12.19 Explain that populations reach limits to growth, with carrying capacity being the maximum number of individuals that can be supported in an environment.	• Identify the factors that determine carrying capacity in particular populations after reading an article or participating in a simulation (e.g., wolf and moose population variations over time on Isle Royale).	Mathematics: Select and use a specific type of graph (e.g., line, bar, pie) to plot population changes over time. Explain why that graphic best illustrates the cyclical nature of two populations. History: Read historical accounts of how the population changes of organisms directly or indirectly impact the human population.
Matter and energy in ecosystems LS.12.20 Describe the energy for life as being derived from the sun, as primary producers (plants) absorb sunlight to make covalent bonds between the atoms of carbon-containing (organic) molecules, which provide a source of energy when eaten as food.	• Use a diagram to show steps and relationships in a simple food chain or a food web. • Describe the chemical process of photosynthesis and the products produced.	Chemistry: Explore how and why elements bond together and learn the difference between ionic and covalent bonding. Look for examples in the photosynthetic process. Physics: Discuss the following: What is energy? What is the ultimate source of energy? What would the world be like without sunlight? Physical Education: Learn about the energy you consume, and how you expend energy by regular activity levels or in sports.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
LS.12.21 Explain that chemical elements (nutrients) are combined and cycled in different ways as matter and energy flow through living systems (e.g., cells, organs, organisms, communities) and the environment.	• Using diagrams of the carbon cycle, nitrogen cycle, or water cycle; show the steps by which nutrients are used and reused by living organisms.	Earth Science: Trace an element (C or N) or molecule (H_20) through a cycle. Economics/Business: Learn about fertilizers and their effect on increased food production. Earth Science: Explain how pollutants can affect many things even if they are introduced in only one area.
Diversity and adaptation of organisms LS.12.22 List several examples of species extinction that occur as the environment changes, or because the species cannot adapt quickly enough to external pressures for survival (e.g., the fossil record shows a history of extinctions).	• Describe 3 examples from the fossil record and the changes in the environment that caused both mass extinctions and extinction of individual species in the past.	Earth Science: Use plate tectonics to explain how volcanic disasters can occur, and change the atmosphere. Math: Plot population changes over time due a specific event. Language Arts: Read or discuss a science fiction piece that takes place in the future, and where the survival of humans is threatened.
LS.12.23 Describe organisms and their distinctive features that are specially adapted to their environment through biologic evolution (e.g., the shapes of bird beaks).	• Examine graphs of related organisms over time, consider their primary food and habitats, and identify adaptations that enabled the organisms to compete and survive. • Identify features (e.g., bird beaks) and food sources that are best suited to each other.	Art: Design and create a beak that eats a specific food source (e.g., pistachios). Math: Graph data such as beak size vs. food size and beak shape vs. food type. Language Arts: Read about and make a model of a fusiform body shape for swimming through water (e.g., ichthyosaur, dolphin, shark).

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Significant to Develop in Life Sciences: LS.12.24 Explain behaviors of organisms that promote survival and reproduction and can evolve by natural selection. (12A)	• Using examples such as the work with Darwin's finches by Peter and Rosemary Grant as described in *The Beak of the Finch* (Jonathan Weiner), describe how variations in climate and food conditions can result in evolution by natural selection. • Discuss costs and benefits of communal vs. solitary behavior and living such as with dogs (wolves, coyotes) versus cats (mountain lion, jaguar), respectively, and describe how these behaviors might relate to survival.	Language Arts: Write a storybook for elementary students that illustrates how evolution by natural selection occurs for an imaginary population. History: Compare and contrast Darwin's work with the work of Alfred Russel Wallace and Jean Baptiste Lamarck. Examine the political and religious climate during this time.
LS.12.25 Describe cell differentiation as a process regulated through the expression of different genes. (12A)	• Compare cell differentiation regulated through the expression of genes to cell differentiation influenced by the interaction between cells.	History: Examine the relationship between technology and scientific advances in understanding cell differentiation.
LS.12.26 Describe and diagram the flow of information through an organism by electrical impulses. (12A)	• Describe and trace how electrical impulses travel from the receptor through the nervous system.	Language Arts: Compare with a diagram or poster the flow of electrical impulses through an organism with an electricity grid in a city. Physics: Examine the nature of electricity. Chemistry: Explore the properties of materials that conduct electrical impulses.

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LS.12.27 Explain that most human cells contain 46 chromosomes (2 copies of each of 22 chromosomes, plus another pair for the gender of an individual). (12A)	• Identify the number of chromosomes in normal humans including the pair that determines gender and compare it with one other mammal and one other nonmammal. • Describe the role of chromosomes in humans.	Language Arts: Perform a skit that solves a genetic dilemma around chromosome mutations. Religion: Discuss whether or not genetic engineering should be a viable option for fetuses with chromosome mutations.
LS.12.28 Explain that genetic mutations (e.g., inserting, deleting, or substituting DNA segments in genes) may be beneficial, harmful, or have no effect in natural selection and biologic evolution. (12A)	• Describe how genetic mutations can occur and their potential effects on future generations of the organisms involved. • Indicate how a change might be beneficial, harmful, or have no effect on future generations. Provide an example of each.	Language Arts: Watch and critique the movie *GATTACA*. At what point should the genetic engineering of children be allowed? History: Research the current laws that govern genetic engineering for humans and other living organisms. Religion: Examine the perspectives that various religions have about genetic engineering.
LS.12.29 Identify disciplines in science that contribute to understanding biologic evolution and how species change over time, including comparative anatomy, physiology, nuclear chemistry, embryology, molecular biology, and paleontology (the fossil record). (12A)	• State a scientific field and a piece of evidence from that field that has contributed to our understanding of biologic evolution and how life has changed on Earth (e.g., paleontology and the fossil record; molecular biology and the Human Genome Project; comparative anatomy and classification).	Art: Describe how many disciplines contribute to an understanding of music (e.g., mathematics, language, art, geography). Language Arts: Debate the value of teaching science as an interdisciplinary course that includes in one year facets of biology, physics, chemistry, and earth science. Economics and Business: Discuss ways that a company in the high-tech industry has to be multidisciplinary.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
LS.12.30 Describe how energy flows through ecosystems from photosynthesizing organisms to consumers to decomposers, as these organisms build organic molecules (e.g., proteins, DNA, sugars, fats) and use the molecules for energy. (12B)	• When presented with an energy pyramid for an ecosystem, identify examples of organisms at each level and describe the transfer of energy through the pyramid. • Use the law of the conservation of energy to discuss why only part of the energy is transferred from one trophic level to the next.	Art: Develop a poster showing how a type of food is grown, produced, consumed, and then recycled back to Earth (e.g., bread, carrot). Physical Education: Select a good source of energy before exercising, and learn about the types of molecules in that food or drink. Chemistry: Determine the differences between organic molecules and how the number of bonds impacts their energy.
Useful to Work on in Life Sciences: LS.12.31 Identify features of human behavioral biology that link to fields such as psychology, sociology, and anthropology. (12A)	• Give examples of how anthropology and the study of the use of tools or musical instruments can help us understand human behavior.	History: Examine the history of tool using and making and note the most pivotal tools for promoting human culture. History: Examine and discuss the motives of different parties in World War II. Art: Discuss whether different forms of art reflect human behavioral biology.
LS.12.32 Describe that mutations occur regularly (but spontaneously) at low rates and that mutation may be affected by agents in the environment. (12A)	• Define mutation and identify some of the potential agents that cause mutations to occur. • Describe the potential effect of mutations on the somatic and sex cells.	Health: Explain why HIV is so difficult to treat. History: Research and discuss bacteria that lead to staph infections that have developed resistance to antibiotics.

State Goal 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Critical to Understand and Master in Chemistry: ***Structure and properties of matter*** C.12.01 Describe how matter consists of atoms, which are composed of even smaller particles that have measurable properties such as mass and charge.	• Select 2 elements to show how the mass number of an element relates to the protons and neutrons in a nucleus. • Compare and contrast a historical model of the atom (or particle models of matter) with modern models of the atom.	Language Arts: Write a script that describes an encounter between a scientist from the 1800s and a scientist from today as they discuss the building blocks of matter. Physical Education: Act out a live model of atoms combining to make molecules. Health: Use today's lunch as an example of how we get energy by breaking down molecules of food in our bodies.
C.12.02 Show with a simple diagram that atoms consist of a nucleus of protons and neutrons surrounded by electrons.	• Select a low-mass isotope in the periodic table (e.g., carbon-14, carbon-12) and use a diagram to represent the numbers of protons, neutrons, and electrons.	Art: Construct a model of an atom of helium and clearly show each part using a reference guide on atoms. Math: Using a periodic table, calculate the number of protons and neutrons in atoms and describe how an average mass of an atom is obtained (e.g,. mass of isotope for an element multiplied by isotope abundance).

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
C.12.03 Explain with sketches and words that characteristic properties of matter (solids, liquids, gases) result from the microscopic structure and interactions of atoms and molecules.	• Compare and contrast the relationships between water molecules in different phases (e.g., ice, water, and steam). • Compare and contrast the properties and structures of hydrogen and oxygen gas (H_2, O_2) and water (H_2O). • Describe differences between 2 inorganic compounds consisting of carbon: graphite and diamond.	Life Science: Discuss the uses of water on Earth and why it is essential to life and humans. Physical Education: Using students as molecules, show how molecules assimilate in liquids versus gas and solids, and how atoms are packed. Use the same space and add or subtract students from the location. Art: Consider and demonstrate how an artist might represent matter. History: Compare properties of earth, wind, fire, and water with properties of elements or compounds.
C.12.04 Explain the relationship between pressure, volume, temperature, and amount in the ideal gas law (PV = nRT).	• Use a simple graph to show the relationship between pressure and volume for a gas (e.g., a graph with axes of P, V). • Write a prediction for what will happen when a blown-up balloon is placed in a freezer (or heated), conduct the experiment, and then analyze the prediction and actual results.	Life Science: Explain internal and external forces that are exerted on the human body. How much space do you take up? What pulls on you? Math: Create a graph using the data from an experiment. Label the x-axis, y-axis and be able to find a slope of a line or trend of data.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Chemical reactions of matter C.12.05 Describe how in chemical reactions, atoms interact with one another by sharing or transferring outer electrons in different types of electron bonds (e.g., polar, covalent, ionic).	• Use a table of electronegativities to compare types of atomic bonds in salt (NaCl), water (H_2O), and methane (CH_4). • Use a table of electronegativities to compare types of bonds and polarities between water (H_2O), carbon dioxide (CO_2), and methanol (CH_3OH).	Language Arts: Write a brief summary or essay on the basic steps of the DNA replication process and polarity of the template strand. Religion: Discuss types of bonds within families, between friends, and within a parish. Geography: Name types of resources that neighboring countries need and share like atoms share electrons (e.g., atmosphere, marine fisheries, rivers between countries).
C.12.06 Use electronic structure (valence, electronegativity) of groups in the periodic table to predict chemical behavior and properties of elements.	• Describe the organization of the periodic table of elements and its use in predicting chemical behavior and properties of elements. • Use electron dot diagrams (i.e., Lewis structures) to represent molecules such as CH_4, CO_2, Cl_2, H_2O, C_2H_6, C_2H_4, or SiF_4.	Art: Use clay to show the positions of valence electrons in 5 of the assigned elements. Language Arts: Write limericks or haiku using words constructed with elements in the periodic table. Fine Arts: Create a performance about the periodic table for students age 8 to 14 that demonstrates how elements can be classified into families and groups based on similarities in electron structure and that once they are classified, you can predict the physical and chemical properties of these elements.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
C.12.07 Use balanced equations for common chemical reactions to show the conservation of mass (e.g., stoichiometry).	• Given reactants for photosynthesis and the production of glucose ($C_6H_{12}O_6$), use a balanced equation to predict or show other reaction products.	Physical Education: Write about what happens when muscles are fatigued (e.g., what happens to glucose stores?) using your own experiences as examples. Math: Balance several equations in algebra using division, multiplication, addition, and subtraction. Leave the formula in its simplest form.
C.12.08 Describe that many replacement reactions show a competition for electrons (oxidation/reduction) or hydrogen ions (acid/base) among reacting ions, molecules, or atoms.	• Perform lab experiments to observe a redox reaction (e.g., Al + $CuCl_2$ or Cu + $AgNO_3$). Write equations describing your observations, analyze the results, and identify the oxidizing and reducing agents. Relate your analyses of results to half-reactions. • Develop and share a new mnemonic device for redox reactions (e.g., OIL RIG: Oxidation Involves Loss, Reduction Involves Gain; LEO says GER!).	Art: Explain the technology used to make ancient Greek slipped pottery as an application of chemistry. Health: Research the acid base reactions that take place in your body. Construct a table of your results.
C.12.09 Use enthalpy diagrams to show that the overall energy change in a chemical reaction equals the sum of the steps (e.g., Hess's law; catalysts in biological or industrial reactions).	• Perform lab experiments and observe the reversibility of chemical reactions and the factors that cause the reverse (e.g., acid-base indicators; $N_2O_4(g)$ + energy $\rightleftharpoons$ $2N0_2(g)$) • Discuss enthalpy changes and demonstrate a spontaneous endothermic reaction (e.g., $Ba(OH)_2 \cdot 8H_2O$ + NH_4SCN, NH_4Cl + H_20, $NaCH_3COO$ + H_20).	Life Science: Brainstorm and discuss reversible reactions such as the reaction between hemoglobin and oxygen or formation and dissolution of calcium carbonate in oceans. Physical Education: Develop a model of dynamic equilibrium using two tanks of water. Simultaneously transfer water from one to the other at different rates and then at the same rate. Emphasize that dynamic equilibrium is a state in which the forward and reverse reactions are ongoing and occurring at the same rate.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
C.12.10 Describe factors that speed up or slow down a chemical reaction (e.g., chemical kinetics by catalysis).	• Describe an example from class of how factors such as temperature or concentration affect reaction rates.	Health: Discuss and summarize the chemical reactions that take place when you sleep. Physical Education: Describe in bowling the occurrences of kinetic energy and how kinetic energy is transferred to the pins.
Interactions of energy and matter C.12.11 Explain that chemical reactions may increase or decrease the temperature of the reaction environment by forming and breaking chemical bonds (e.g., change in enthalpy).	• Use the reaction for combustion to show how this changes the temperature of the environment of the reaction.	Math: Using a data table, create a graph of enthalpy and present it to the class. History: Learn about the development of steam engines, and how the generation of heat by combustion of coal can be converted to locomotion. History: Give an example of a system in disorder sometime in history.
C.12.12 Identify examples of changes in heat for a material and explain what this tells you about its properties (calorimetry).	• Compare differences in the rate of temperature change as heat moves down a copper rod and a glass rod.	History: Study the California gold rush (1849), and write about how gold miners determined if the mineral they found was gold. Health: Learn about how many calories you expend daily with regular activity, and compare this with how many calories you consume in a day.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
C.12.13 Describe with examples that factors (e.g., concentration, pressure, volume, temperature) can influence the position of a chemical equilibrium (Le Chatelier's principle).	• For the following reaction at chemical equilibrium, explain the effect of the following changes in the system by Le Chatelier's Principle and favoring reactants or products: $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g) + \text{heat}$ 1. increase in H_2, 2. increase in temperature, 3. decrease volume of the container, or decrease in temperature.	Language Arts: Write a detailed essay on Henri L. Le Chatelier. Describe his home life and compare it to yours. Life Science: Using a baggie as a gradient, test osmosis and diffusion across a semi-permeable membrane. Economics/Business: Discuss the idea of equilibrium (or not) with the flow of money in an economy.
C.12.14 Describe how to distinguish waves that gain or lose specific amounts of energy based on electron transitions at the atomic level (e.g., spectral lines for chemical identification).	• Use a diagram of the hydrogen atom to show how electron transition relates to distinctive spectral lines in the visible part of the spectrum.	History/Religion: Research the tsunami that occurred in December, 2004. What caused the tsunami? In what ways were waves involved? What relief efforts took place after the tsunami and how are the survivors doing today? Physics: Diagram an electromagnetic spectrum of light and label the frequencies at which colors can be seen by humans.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Significant to Develop in Chemistry: C.12.15 Give examples of how carbon is a unique element that makes chains, rings, and branching networks to form an array of carbon-based molecules in living and nonliving systems. (12C)	• Show with a molecular diagram and chemical formula an example of carbon structures in living and nonliving compounds of carbon.	Language Arts: Write an essay explaining what life is. What is considered a living thing? A nonliving thing? Why? Art: Using pipe-cleaners, construct a model of a carbon chain. Religion: Describe what constitutes life from a spiritual point of view and compare this view with the scientific definition of living things. Economics: Learn about diamond as an international commodity and estimates for the amount of available diamond.
C.12.16 Describe how some processes and interactions of matter occur at the level of the nucleus (e.g., fission in nuclear reactors, fusion in stars, radioactive decay of elements). (12C)	• Demonstrate the concept of half-lives for radioactive decay with a simple, labeled graph and give an example of a radioactive isotope. • In settings such as a high-mass star, use the periodic table to predict the product of fusion between atoms of oxygen and helium, or between an atom of carbon and atoms of helium.	Language Arts: Create a comic book about a fictional character that is radioactive. Describe the character's origin, chemical properties, special powers to help people on Earth, and danger to people on Earth. Health/Technology: Find out how radioactivity is used in the medical professions today.
C.12.17 Describe how energy can be stored in fossil fuels and released for human consumption when fuels are burned. (12C)	• Describe how the combustion of coal or natural gas (which consists of methane, ethane, and some propane) provides energy for human use and predict the reaction products.	Language Arts: Predict the future of Earth if nonrenewable energy stores continue to be depleted. Write about how you would remedy the problem. History: Examine the use of renewable and nonrenewable energy sources across time. Explain how our views are different from those of people during the early 1900s.

State Goal 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Critical to Understand and Master in the Earth and Space Sciences: ***History of processes on Earth*** ES.12.01 Describe how rock sequences and their fossils and environments are used to interpret and reconstruct changes that have occurred on Earth and its environments.	• Diagram and describe the Grand Canyon as a classic example of rock sequences and geologic history from the Precambrian to relatively recent volcanism. • Describe examples of fossils of ancient life-forms on Earth and their environments and compare them with the current diversity of life on the planet.	History: Research current archeological digs around the world. Discuss artifacts and remains archeologists are finding and the questions they are trying to answering. Literature: Read about exploration in the Grand Canyon by John Wesley Powell. Read *The Map That Changed the World: William Smith and the Birth of Modern Geology* by Simon Winchester. Math: Compare geologic strata with a ruler that measures time.
ES.12.02 Describe how some Earth processes occur quickly, while others require much more geologic time (e.g., earthquakes and volcanic eruptions versus ices ages, mountain building, or biologic evolution).	• Describe and diagram from Earth 2 examples of rapid geologic processes and 2 examples of processes that occur over millions of years (e.g., plate tectonic motions, sedimentation in ocean basins, evolution of life-forms). • Considering that many families of mammals first evolved on North America in the past 40 to 60 million years, describe why you would consider this a slow process, fast process, or both. • Given that recent ice ages have occurred about every 100,000 years, compare the duration of these cycles with the time back to the extinction of the dinosaurs at 65 million years ago (e.g., 650 times longer than the duration of ice age cycle).	Geography: Locate the tectonic plates on Earth's surface and label each plate with its speed and direction. Math: Use data on the speed and direction of tectonic plates to predict the positions of plates in 1,000 years, 10 million years, and 50 million years. History: Research a historic volcanic eruption or earthquake and its impact on humans (e.g., Krakatoa, Vesuvius, Mt. Saint Helens, 1906 San Francisco earthquake, etc.).

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Resources from Earth ES.12.03 Describe how natural resources help humans maintain and improve their quality of life, and describe Earth processes that result in resources used by humans.	• Describe 2 resources that you are using now and how these resources are gathered from Earth. • Give examples of how you use metals each day (e.g., steel in buildings, gold in electronic circuitry) and describe the continents where such resources are harvested. • Describe uses of wood in your school and how these uses are related to valuable geologic resources.	Economics: Identify the top 3 natural resources used for energy in the 5 highest gross national product (GNP) nations. Language Arts: Write a story that takes place in the future and describes the life of humans no longer dependent on fossil fuels. Art: Make a mural or sculpture consisting of natural resources from Earth (e.g., metals, glass, dry wall, cement, asphalt, plastics, aluminum, wood, etc.) Religion: Investigate and catalogue the natural resources used in construction and operation of your church.
ES.12.04 Study and identify different sources of energy for society and how all forms of energy relate to resources of Earth (e.g., coal, oil, natural gas, nuclear energy).	• Use a diagram to show how coal is produced and describe the past geologic environments that favored the formation of coal. • Given that 3 key producers of natural resources are Siberia, Canada, and Iran, compare and evaluate methods to transport natural gas, petroleum, and coal to other countries that use these resources.	Physics: Starting with the sun and ending with the lighting in your classroom, trace the transfer of energy from one form to another. Economics: Study the solar energy industry and describe the benefits and tradeoffs of using solar energy. Economics: Learn what countries produce the most petroleum and coal, which are the highest consumers, and which way money flows as a result.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Structure of solar systems and stars ES.12.05 Compare the processes involved in the life cycle of stars (e.g., gravitational collapses, thermonuclear fusion, novae) and evaluate the supporting evidence from scientific missions and astronomical observations.	• Depict on an H-R diagram the life cycle of a high-mass star from protostellar mass to main sequence, red supergiant, supernova, and black hole. • Describe recent astronomical images of a supernova and its pattern of luminosity (e.g., brightness over 1 to 2 months for Type Ia). • Using evidence from the recent missions, describe key findings related to the life cycles of stars (e.g., metallicity of stars, consumption of planets, interactions in binary systems).	Technology: Research the history and current condition of the Hubble Space Telescope. Debate with your class the pros and cons of continuing to support the telescope into the future. Language Arts: Consider the vastness of the universe and the dynamic life of distant stars, the light from which takes millions of years to reach our eyes. Describe how knowledge of these things makes you feel as you stand on a small spot on Earth's surface. History: Learn Greek stories about easily identifiable constellations, and key stars in them (e.g., Aldebaran, the red eye of Taurus). History: Study human accounts of the 1054 A.D. supernova (Chinese, Native American), and discuss seeing a new "star" during the day.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Significant to Develop in the Earth and Space Sciences ES.12.06 Use half-lives to describe radiometric dating for the ages of geologic and biologic processes on Earth and in our solar system (e.g., age of the solar system at about 4.5 billion years; evidence for first life at about 3.5 billion years; first humans at about 200,000 years). (12E)	• List and describe lines of evidence with radiometric dating that the solar system is about 4.5 billion years old (e.g., lunar samples, meteorites, oldest rocks on Earth). • Compare modern cyanobacteria (e.g., *Anabaena*) with some of the most primitive bacteria on Earth from about 3.5 billion years ago preserved in stromatolites.	Chemistry: List 4 elements with radioactive isotopes of which you have heard, and rank from shortest half-life to longest half-life. History: Research the length of recorded history and the types of writings that document the earliest time in recorded history. Math: Calculate or measure exponential decay curves, or the converse, exponential growth curves of increases in population for organisms.
ES.12.07 Explain how external and internal energy sources drive Earth processes (e.g., solar energy drives climate patterns in oceans and the atmosphere; internal heat and density of materials link to forces that drive plate tectonics). (12E)	• Use a diagram to show the steps by which a hurricane transports heat from equatorial regions to higher latitudes and then what happens to the heat at high latitudes. • Describe the 2 sources of internal heat as initial heat from formation of Earth and heat produced from the decay of radioactive elements. • Select a plate tectonic boundary and use a cross section with arrows to show the motion of at least 1 plate moving into Earth.	Geography: Use a global map to show areas of the world that have droughts or excessive rainfall during El Niño and La Niña years. Religion: Investigate the etymology (root) of “El Niño” as the name for climate phenomena (e.g., new child of December). Economics: Describe how people at some locations on Earth can use geothermal energy to heat their buildings or produce electricity.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
ES.12.08 Describe how some Earth processes are cyclical (e.g., rock cycle, water cycle), whereas other Earth processes evolve continuously with time (e.g., chemistry of oceans, chemistry of atmosphere, size and shape of continents, diversity of life). (12E)	• Select 1 process on Earth that recurs in cycles, and 1 process that does not recur in cycles, and describe ways that human society interfaces with or relies on that process.	Ecology: Compare the life span of one organism, with the cycling of organisms of a population in an ecosystem (e.g., one organism moves in a linear direction from young to old, yet population experiences continual recycling as reproduction produces new organisms to replace the aging ones). Religion: Discuss the role of God in the cyclical Earth processes that recycle earth materials.
ES.12.09 Explain that Earth is a system with elements and matter (e.g., carbon, nitrogen, oxygen) distributed and moving among the living and nonliving parts of the planet (e.g., hydrosphere, atmosphere, geosphere, biosphere) in geochemical cycles. (12E)	• Use a diagram to trace an example path for an atom of carbon as it cycles through the hydrosphere, atmosphere, geosphere, and biosphere. • List and describe the chemical forms a carbon atom can take as it cycles through living and nonliving parts of Earth and describe examples of some reactions that allow that carbon to change form. • Compare and contrast forms of carbon found on or in astronomical objects other than Earth (e.g., methane on Saturn's moon Titan; diamond, graphite, silicon carbide, amino acids in meteorites; carbon dioxide on Mars; carbon monoxide, carbon dioxide, methane, and methanol in nebulae).	Economics and Business: Explore a recycling plant to learn how materials are recycled. Make a flow chart of the process starting from an article (e.g., glass bottle, plastic container, newspaper, motor oil) through recycling, and to a new article made of recycled materials. Art: Represent an Earth cycle on a poster board, and describe it to the class (e.g., nitrogen, water, carbon, sulfur, calcium, etc.).

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
ES.12.10 Describe how nuclear fusion in stars (starting with 4 hydrogen fusing to form helium) begins the process to create all elements of the periodic table. (12F)	• Represent the synthesis of low-mass elements of the periodic table in fusion by combining helium atoms to make carbon and oxygen atoms.	Art: Use primary colors to create as many additional colors as possible. Technology: Explain why nuclear fusion is so difficult to create on Earth and harness as an energy source. History: Learn about and discuss the development of hydrogen bomb.
ES.12.11 Describe evidence for the size of the universe and the age of the universe of about 13.7 billion years (e.g., redshifts of elemental spectra for galaxies, Hubble's constant). (12F)	• Given the major emission spectral lines for elements at rest, identify spectra characterized by either redshifts or blueshifts and give the wavelengths of key shifted peaks. • Give examples of how viewing farther in the universe is analogous to looking "back in time" and describe how this relates to the speed of light.	Math: Calculate the redshift (z-value) of a galaxy using its velocity (recessional): redshift = galaxy velocity / speed of light Language Arts: Outline the evidence needed to convince a judge that you have the strongest argument in a debate. Religion: Compare geocentrism and heliocentrism, and discuss implications for our understandings of the geometry, size, and age of the universe.
Useful to Work on in the Earth and Space Sciences ES.12.12 Explain evidence that the early Earth was very different from the Earth today. (12E)	• Use summary maps of Precambrian geology for the continents as evidence that continents were a different size at that time determine the difference in area at that time. • Describe and compare the geologic record of Precambrian fossils with modern fossils and compare how their environment was similar or different (e.g., stromatolite mounds in shallow seas).	History/Language Arts: Choose an object that was commonly used 100 years ago and not in use today. Write a short story that describes the use of the object and makes reference to how different life was then from today. Religion: Discuss scientific views of early Earth and compare it to the Bible's account of God creating Earth.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
ES.12.13 Explain that Earth, the Sun, and the rest of the solar system formed from a nebular cloud of gas and rock particles 4.6 billion years ago. (12F)	• Explain why it would be difficult to find preserved on Earth rocks that are 4.6 billion years old. • List that 3 key lines of evidence for the age of the solar system come from the oldest rocks on Earth, the age of primitive lunar samples, and the ages of hundreds of meteorite samples. • Use orbital radii for the inner 5 planets to suggest how the asteroid belt might represent parts of the evolving solar system that were not incorporated into growing planets or the Sun.	Religion: Form literature circles and read passages from Genesis. Compare and contrast the literal and interpretive readings of Genesis with passages from a text of how stars and planets formed. Math: Describe how you would help younger students understand the magnitude of the number 4.6 billion.
ES.12.14 Diagram several types of stars and their life cycles on H-R diagrams of star surface temperature (K) versus luminosity (L_{star}/L_{Sun}). (12F)	• Use an H-R diagram to explain why or why not red giants are hotter and brighter than main sequence stars. • Use an H-R diagram to explain why white dwarves are less luminous but sometimes the same temperature as supergiants. • Represent with an H-R diagram an example of the evolutionary history and path over about 10 billion years for a star the mass of the Sun.	Math: Create your own H-R diagram by plotting the temperature of a number of stars vs. the luminosity of the stars. Math: Write a sentence that describes in words what a graph depicts. Find and describe as many different types of graphs as you can. History: Study the story of Orion, the hunter, and view the red giant (Betelgeuse) and blue supergiant (Rigel) in Orion.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
ES.12.15 Describe and compare the chemical and physical characteristics of galaxies and objects within galaxies (e.g., stars, globular clusters, nebulae, pulsars, black holes, dark matter). (12F)	• Select 2 astronomical objects found in galaxies and use a T-table to show how they are similar and different (e.g., composition, temperature, mass, density). • Research the cause for supernovae and describe 2 reasons why they are significant to astronomers.	Technology: Describe the tools that astronomers use to observe and explore objects in the universe (e.g., Hubble or Spitzer Space Telescopes). Compare the accuracy of various kinds of observations based on the sophistication of the tools used to make the observations. Language Arts: Write a science fiction story about our solar system being drawn into a black hole or a globular cluster like M13.

State Goal 12: Understand fundamental concepts, principles, and interconnections of the life, physical, and earth and space sciences.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Critical to Understand and Master in Physics: ***Interactions of energy and matter*** P.12.01 Describe how all waves transfer energy when they interact with matter (e.g., seismic, electromagnetic, sound waves, tsunamis).	• Use examples to demonstrate an understanding of energy transfer by waves (e.g., plucked string of a guitar sending sound to ears, earthquakes creating movement in water that creates tsunamis).	Physical Education: Create motions among people in a group that demonstrates the transfer of energy. Language Arts: Describe and diagram the effect of throwing a rock in a pond of still water, and what happens when the waves hit the shore. Health: Learn about the risks of overexposing skin to ultraviolet radiation, or how X-rays are used in medical sciences. Technology: Investigate websites showing near instant results from global seismology.
Force and Motion P.12.02 Describe examples of how work is done when a force is applied over a distance ($W = F \times d$) and how power indicates the expenditure of work per unit time ($P = W/t$).	• Diagram and calculate the work done when a cart is pulled by a string attached at a 45-degree angle.	Math: Measure angles and then apply to the formula of work. Physical Education: Use critical thinking skills to measure the amount of work that you do in a game of basketball. Language Arts: Read and discuss the Greek myth of Sisyphus in Hades and a large rock in the context of work and power.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
P.12.03 Demonstrate how objects change their motion only when a net force is applied, with the magnitude of force related to mass and acceleration ($F = ma$), or to the rate of change of momentum ($F = \Delta p/\Delta t$).	• Use a diagram or experiments with a fan cart to show net force on the cart and describe how the motion of the cart is affected by changing the mass of the cart. • Calculate applied force and changes in momentum in weight training, and calculate how much you could bench press on Mars or Jupiter.	Language Arts: In your journal, write about three simple machines you used in one week. Describe where the force was applied and the type of machine (e.g., can opener, elevator, car). Technology: Prepare a six slide Power Point presentation of a simple machine including a picture and several transitions. Physical Education: Analyze and diagram the parts of a football contest in terms of magnitudes of forces, and compare with impacts in car accidents. History: Investigate how Sir Isaac Newton interacted with an apple.
P.12.04 Analyze and diagram with vectors the factors that influence the relative motion of an object in different settings (e.g., friction, wind shear, crosscurrents, potential differences).	• Use a simple vector diagram to show the velocity and direction that a plane should fly to maintain a straight course if the plane encounters a sustained crosswind (or oblique wind) of given velocity. • Use simple vector diagrams to determine relative motions of tectonic plates.	Language Arts: Write about how successes are often built from mistakes. Write a journal logging mistakes you have made and how you learned from them. History: Chart the failures and successes of creating airplanes. Make a timeline showing who did each attempt and how modern day airlines are related to these designs.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
P.12.05 Demonstrate factors that govern types of motion (e.g., projectile, harmonic, circular, free fall), such as distance, velocity, time, and acceleration in projectile motion (e.g., $d = V_o t + 1/2 at^2$).	• Given adequate information, use the equations for constant and accelerated motion to determine the time for a struck baseball to pass over a center-field fence that is 450 feet from home base. • Describe the types of motion to consider in a safe mission to Mars and back to Earth.	Physical Education: Relate the types of motion to a baseball game by explaining and demonstrating the types of motion during an inning of baseball. Math: Calculate several velocity problems after learning about velocity. History: Study Apollo lunar missions, and the understandings needed for the types of motion used in the missions.
Conservation of Energy P.12.06 Distinguish between energy described as kinetic energy (motion), potential energy (position), and field energy (electromagnetic waves).	• Use a diagram to show and labels to denote the energy types present and the energy transformations that occur when a mass falls freely onto a vertically oriented spring and compresses that spring.	Physical Education: Demonstrate types of motion present in volleyball and clearly show when potential energy is at its greatest point. Earth Science: Construct a 3-D model of Earth displaying energy sources. Where is the energy stored on Earth? Language Arts: Write a story about the music group "Totally Kinetic" that actually uses all kinds of energy in a concert.
P.12.07 Describe the conversions or transfer of energy between physical processes in a closed system (harmonic motion).	• Considering Earth's atmosphere as a closed system, use principles of physics to describe the steps by which a hurricane in the Northern Hemisphere transports heat from equatorial to higher latitudes, and what happens to the heat at high latitudes.	History: Research two instances of deadly catastrophes due to changes the Earth's atmosphere. Briefly describe the causes and effects of each occurrence. Technology: Learn about the status of rechargeable batteries. History: Learn about the discovery and mechanics of the steam engine in the industrial revolution in England and America.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
P.12.08 Show that temperature is a measure of random motions and vibrations of atoms, molecules, and ions (i.e., average kinetic energy).	• Diagram with labels and describe the motion of water molecules in 3 separate containers of water, each of which is at a different temperature. • Predict temperatures on the Moon, where there is no atmosphere.	Drama: Role-play kinetic energies of molecules by walking slowly, walking fast, and running. Describe the temperature changes that developed in your body as a result of movement and draw an analogy to an object at a different temperature. Art: Make an abstract painting that illustrates the molecular structure and motion of an object that is hot or cold.
Significant to Develop in Physics: P.12.09 Show that gravitation is a universal force between any masses and that gravitation depends on the masses and distances between the masses. (12D)	• Describe how the gravitational fields of the moon and Earth interact to produce tides. • Describe the role of gravitation in the shape and motion of planets around the Sun.	Language Arts: Write a poem or haiku about the gravitational attraction among all objects at ranges of distances (e.g., solar system, galaxy, universe). Math: Calculate the gravitational attraction between you and your desk, and between you and Earth.
P.12.10 Show that between charged particles or masses, electromagnetic forces are much greater than gravitational forces, with the electromagnetic forces proportional to charge and inversely proportional to distance squared. (12D)	• Calculate and compare the gravitational attraction and electromagnetic repulsion that 2 electrons will experience at a given distance apart. • Using magnitudes of forces, describe why a suspended pith ball will be displaced by a charged ebonite rod, yet will be unaffected by an uncharged ebonite rod.	Language Arts: Describe a world in which gravitational forces are stronger than electromagnetic forces between charged particles. Technology: Find out where electromagnets are used and why they are useful to us.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
P.12.11 Describe that acceleration results from a change in velocity of a moving object ($a = \Delta V/\Delta t$). (12D)	• Use a diagram and arrows to characterize the motion of a fan cart, and show individual and net forces on the cart. • Consider a basketball in a basketball game, and analyze the record of acceleration it would experience	Math: Create a game of math problems on acceleration. Present the game in class to see how many correct answers your classmates can generate. Language Arts: After reading a book on aerodynamics, summarize how velocity and acceleration relate to flying a plane.
P.12.12 Describe how waves such as electromagnetic waves (radio, microwave, visible, ultraviolet, X-ray, gamma ray) have a wavelength that is inversely proportional to frequency. (12D)	• When creating waves with a stretched Slinky or spring, describe how a faster motion of the hand produces more waves that are closer together (and vice versa) as well as the relationship between frequency, wavelength, and wave velocity.	Music: Perform an experiment with tuning forks to generate waves of different frequencies and pitches. What is A-440? Earth Science: Write a report on how earthquakes produce waves that can be detected around the world. Technology: List and describe the ways that we communicate with satellites using EM waves, and their wavelengths. History: Research the discovery and initial use of AM and FM radio signals. Art: Develop a poster or sculpture titled "Speed of Light" and represent different EM waves in the piece.
Useful to Work on in Physics: P.12.13 Describe with an example how electricity and magnetism are 2 aspects of a single electromagnetic force. (12D)	• Demonstrate in an experiment the reasons why a magnet needle can be displaced by a nearby electrical current and why a current can be induced in a wire by bringing a magnet nearby (creating flux).	Earth Science: Explain how two magnetic fields combine and predict the location of areas where two fields can cancel each other to leave no resultant field. Geography: Locate the Bermuda Triangle, describe its apparent effects, and investigate evidence for its causes.

State Goal 13: Understand the relationships among science, technology, and society in historical and contemporary contexts.

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Critical to Understand and Master in High School: ***Safety in science*** H.13.01 Estimate and suggest ways to reduce the degree of risk involved in science activities.	**B:** Review as a class and list safety protocols for working with bacterial or potentially harmful biologic samples. **ESS:** Review safety procedures for using dilute acid in calcium carbonate tests; treating acid spills on people, clothes, or surfaces; or using geologic hammers on rock samples. **C:** Describe where in your lab you can find safety equipment such as safety goggles, gloves, aprons, and showers. **P:** Review possible flammable or electric hazards that may be a part of your lab activities.	Language Arts: Make a poster illustrating safety protocols or safety measures for a school-wide event (e.g., fire escape routes for the auditorium; ambulance access for a football game). Technology: Research materials and design for protective clothing used by firefighters, toxic cleanup specialists, or other public safety personnel. Physical Education: Review safety procedures for sports (e.g., stretching, sufficient water, proper protective head and mouth gear).
H.13.02 Design procedures and policies to eliminate or reduce risk in potentially hazardous science activities.	**C:** Review as a class the protocols for acid spills on people, clothes, lab counters, or floors. **AD:** Design protocols for the safe disposal of different types of potentially hazardous waste, considering laboratory by-products from industry, hospitals, or nuclear power plants.	Health: Study a diagram of a sample factory, identify the hazardous situations or potentially hazardous situations, and suggest safer alternatives. Language Arts/History: Consider safety and work environments in excerpts from *The Jungle* by Upton Sinclair.

B: Biology **ESS:** Earth and Space Sciences **C:** Chemistry **P:** Physics **AD:** All Disciplines

LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Understanding science and technology H.13.03 Explain that questions of science drive technology, and technology provides new methods for scientific analysis that enhance measuring variables, such as quantity, distance, location, size, mass, or speed.	**B:** Describe an advance in medical sciences that was made possible by prior advances in technology (e.g., artificial hearts, orthoprosthetics, organ transplants). **ESS:** Describe how technology to place telescopes in orbit helps astronomers make scientific discoveries (e.g., Hubble, Spitzer Space Telescopes). **ESS:** Make a diagram showing how technological communications among components enables monitoring of volcanic and seismic activity. **P:** Describe how the discovery of superconductivity has applications in technology and industry. **C:** List ways that the discovery of Teflon and other plastics are part of products that you purchase. **P:** Analyze costs and benefits of nuclear power and how they relate to the discovery of nuclear fission. **AD**: Write about a historic scientific discovery that led to an important change in manufacturing.	Language Arts: Read and prepare an outline of an article describing new technologies used in a recent discovery (e.g., Hubble or Spitzer Space Telescopes; seismic networks). Civics: Study the process by which the public funds projects in government labs to develop new technologies. Physical Education: Study the technology for analyzing false starts and close finishes in the 100-meter dash or the 100-meter freestyle of butterfly. Technology: Learn how GPS measurements of tectonic plate motions are used to estimate seismic hazards.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Science as a human endeavor H.13.04 Identify procedures used by scientists to substantiate results, including peer review, citation of prior findings, accurate reporting of methods and measurements, and publishing results in journals.	**AD:** Analyze a report by a newspaper journalist to determine if the findings were substantiated and corroborated before publication. **AD:** Describe the importance of different groups of scientists doing the same experiment a 2nd or 3rd time. **AD:** List the series of steps that must occur before the results of a scientific experiment or project can be published in a professional journal.	Language Arts: Examine a tabloid article about science, and write a peer review and analysis as would a scientist completing a review. Physical Education: Contrast an athlete who makes a significant achievement once (e.g., bats over 500, runs mile under 4 minutes), with an athlete who regularly achieves that same benchmark. Physical Education: Review the protocols by which certain "records" in sports are documented and substantiated. Language Arts: Demonstrate the distinction between proper citation of references and plagiarism.
H.13.05 Give examples that science is accomplished by teams working on projects (e.g., space missions), as well as by individual scientists doing work in settings ranging from the field to the laboratory.	**AD:** Identify 2 examples each of scientists working individually and in teams to complete new research. **AD:** Recall and write about experiences where you worked in a team, with a partner, and by yourself to solve a problem or fix something. Discuss how the experiences compared with one another.	Physics: In team of 5 students, design and build a 30-second marble roller coaster that stands four feet high. Assign specific duties to each team member (e.g., 1 person makes the supports, 1 person makes the rails, 1 person makes the tricks, and so on). History: Examine how writers collaborated and conflicted in developing the Constitution of the United States or the Declaration of Independence. Compare these with historic addresses written and given by individuals.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.13.06 Give examples of a scientific discovery that relies on creativity, imagination, solid skills, and a firm knowledge base.	**AD:** Give an example of how you used your imagination plus some basic skills to fix or improve something in your home. **AD:** Summarize why procedures in science should not always proceed cookbook-style, like a recipe.	Math: Describe how forensic scientists need to use their skills in math, as well as creativity to imagine an array of crime scenarios. Art: Compare modern art with classical art and discuss how each form displays creativity and imagination and a solid foundation of artistic skills. Home Economics: Research a recent recipe-contest winner and describe what made the recipe original and creative.
Nature of science H.13.07 Explain that science is one way of knowing, but not the only way of knowing, and that science may not be an appropriate means to investigate some matters of personal beliefs.	**AD:** List examples of ideas not necessarily related to the natural or physical world that could be very difficult to test (or could not be tested) in a scientific manner. **AD:** Discuss in your class whether a scientific test could be developed to determine how and when a person obtains a "soul" or a "spirit."	Religion: Reenact the 1925 Scopes Monkey Trial, in which the teaching of evolution was criticized as unlawful. Discuss how the trial might have been different if other religious points of view were represented. History: Compare successful medical practices from different cultures (e.g., eastern, western) with the different backgrounds for their use. Art: Consider and discuss whether "knowledge" by an artist (e.g., painter, musician, stage performer) has elements of "science," technology, or not.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.13.08 Detail how core ideas in science have been tested repeatedly (e.g., conservation of energy, laws of motion, biologic evolution, plate tectonics), while in other areas understandings may still be improving (e.g., human evolution, global warming, origin of life, virus transmission, origin of the universe).	**AD:** Give simple examples of how math helps to frame and be a part of core ideas in science (e.g., $F = ma$; $E = mc^2$). **ESS:** Compare and contrast differences in understanding for science related to the causes of temperature changes in seasons, versus the causes for global warming. **B:** Research and compare the total number of hominid fossils found with estimates for the total number of horse fossils found.	History: Research the growth of a new idea in science and how the public and other scientists reacted to it (e.g., Albert Einstein and relativity; Alfred Wegener and plate tectonics; Charles Darwin and natural selection; William Smith and stratigraphy). Psychology: Test students' reaction to change in policy that affects them (e.g., new start time for school, stricter dress code, cancellation of a school event). Social Studies: Discuss and debate current issues such as influenza outbreaks, or measures to address possible global warming.
History of science H.13.09 Give examples of how historical perspectives of scientific explanations by an array of persons show that knowledge of the natural world changes over time and builds on prior knowledge (e.g., medical sciences, computer capabilities).	**AD:** Discuss and describe in class how communications have changed over time and how some communications have been replaced by others (e.g., Pony Express, Internet). **AD:** Discuss and describe recent changes in personal computer capabilities and phone communications. Predict future changes based on these recent ones. **B:** Discuss how our understanding of how disease spreads has changed over the last 200 years. Include examples of remedies from the past that no longer make sense with what we know today about disease.	Technology: Create a 20-slide PowerPoint presentation describing the evolution of the Internet, personal computers, or cell phones to what they are like today. Personal Health: Read about and discuss the discovery in the mid 1800s by Dr. Ignaz Semmelweiss that antiseptic techniques slowed the spread of disease. History: Read about the discovery of vaccination, and current key applications.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Science, technology, and society H.13.10 Describe situations where science and technology only indicate what can happen (or what are the odds of it happening), while human decisions are needed to evaluate what should happen.	**AD:** Distinguish or contrast between science calculating the odds that a suspect committed a crime versus a detective claiming with 100 percent certainty that the suspect committed the crime. **B:** Compare possible scientific results from experiments with genetically modified agriculture or aquaculture versus decisions that weigh costs and benefits of such technologies. **ESS:** Compare decisions to drill for oil on the Arctic National Wildlife Refuge with the scientific findings about the presence of oil reserves there. **P/C:** Contrast scientific knowledge and findings about the first atomic bomb with the decisions that had to be made whether to use atomic weapons in World War II.	Technology/History: Read about the decision to build the Glen Canyon Dam, the effect of the dam on the Colorado River, and the situation of Lake Powell. Language Arts: Discuss a line from the movie *Jurassic Park* regarding cloning dinosaurs for a theme park, "Just because we can doesn't mean we should." How does this apply to science (e.g., cryogenics, cloning humans, infertility treatments)? Religion/Language Arts: Discuss current issues in biotechnology and genetic engineering, considering excerpts from the moment of "life" in *Frankenstein* by Mary Shelley (1818).
Personal Health H.13.11 List ways that families are an important support structure that serves many physical, mental, and social needs of individuals, particularly young children.	**AD:** Discuss or write about families and communities and how these structures relate to the well-being and education of individuals. **B:** Give examples of animals that rely on a family system or distinctive social structure for their survival and well-being.	Language Arts: Write a memoir-style essay about an event in your life with family members that had an important impact on your life today. Physical Education: Compare and contrast the functions of families, with the functions of teams in sports.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.13.12 Write ways that sexuality is basic to the physical, personal, and social development of humans and involves understandings of physiological functions, cultural influences, and ethical values of families and communities.	**B:** Discuss how sexuality is part of evolutionary change. **AD:** Describe and discuss positive and negative ways that culture can influence human sexuality.	Language Arts: Create a succinct brochure or poster to promote important views on sexuality for teenagers. Religion: Discuss church teachings on human sexuality, the role of family, and compare with other positions on such topics.
H.13.13 Describe examples of substances that modify an individual's physiology or behavior in detrimental or beneficial ways (e.g., cholesterol-lowering drugs), yet can also lead to physical dependency and increased health risks.	**B:** Describe a drug, or family of drugs, that can be used in beneficial as well as detrimental ways. **B:** Discuss the toxic effects of alcohol on the human body with respect to behavior (e.g., binge drinking, alcohol poisoning).	Health: Research and discuss as a class 5 medications commonly taken by Americans that may have harmful side effects. Life Science/Careers: Find out what a toxicologist or a forensic scientist does and the training one needs for this field. History: Research the Prohibition, and discuss use of alcohol and advertising today.
H.13.14 Describe how diseases depend on many factors (e.g., influenza) and while many diseases can be prevented (HIV, STDs), controlled (asthma), or cured (tuberculosis), other diseases may result from body dysfunctions or personal habits and cannot be transmitted (cancer, heart disease).	**B:** Compare and contrast diseases that are communicable and those that are not. **B:** List and discuss various social, geographic, or economic factors that may relate to the transmission of certain diseases. **B:** Explain how bacterial resistance to antibiotics occurs and its significance to the treatment of some diseases.	History: Read an account of Ryan White's life and discuss how the public's understanding of AIDS has changed since he lived. Economics: Research insurance cost estimates, and how the health system covers individuals with heart disease. Medical Sciences: Describe the difference between a bacterium and a virus, and why both cannot be treated with an antibiotic.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Natural resources and humans in the environment H.13.15 Describe examples of factors that influence ecosystems and the environment, such as organism populations and distribution, resource use, consumption patterns, socioeconomic needs, and political or religious views.	**B:** List 3 examples of invasive species in the Midwest or other parts of North America, describe their effect on ecosystems, and devise possible new solutions (e.g., zebra muscles, carp, snakehead fish, nonnative grasses, kudzu). **ESS:** Describe steps that reduce erosion and maintain the health of soils for agriculture. **ESS:** Compare and contrast different ways that political or religious views could influence the use of natural resources.	Language Arts: Read *The Grapes of Wrath* by John Steinbeck to learn about people affected by the Dust Bowl of the 1930s. History: Research the agricultural practices and natural occurrences (e.g., drought) that led to the Dust Bowl, and compare with demographic, economic, and climate patterns in important agricultural regions today. Economics: Research and discuss domestic oil needs for our country, and petroleum production from the Arctic National Wildlife Refuge.
Natural hazards and level of risk H.13.16 Describe with examples both natural and human-related hazards that present a need to assess potential danger and levels of risk.	**AD:** List and suggest solutions for 2 natural and 2 human-made hazards in your community. **AD:** Describe key health risks in your family or community, distinguish which can be affected by personal decisions, and identify possible solutions. **ESS:** Compare maps of seismic risk with locations of active faults, plate tectonic boundaries, and volcanoes. Critically evaluate the types of warning systems required. **ESS:** Evaluate regions in your state or community prone to flooding and analyze economic loss versus personal hazard for flooding in those regions.	Economics: Discuss causes of global warming and possible affects of an average increase in temperature. Health: Discuss behaviors that teens commonly engage in that are hazardous to their health (e.g., smoking, drinking alcohol, fast driving). History: Research the size and origins of the tobacco industry in the United States.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
Significant to Develop at High School: H.13.17 Describe with examples that scientists in different disciplines ask different types of questions, and new disciplines in science such as biochemistry or geophysics emerge at the interface of scientific fields. (13A)	**AD:** Discuss the difference in public health issues associated with cigarette smoking versus a disease like diabetes or cancer. **AD:** Describe the very different types of questions public health personnel, physicians, or medical researchers ask to solve the problems of disease (e.g., public health personnel deal with populations, physicians deal with individuals). **AD:** Describe the expertise in different fields of science that would be required to understand industrial pollution in a public waterway.	Student Government: For a school-wide event, note who has the expertise to participate (e.g., a talent show might rely on the computer lab for a slide show, the maintenance staff for stage setup, the tech crew for lights and sound, the English class for the script, and the newspaper staff for publicity). Health: List the people involved in performing a common surgery (e.g., knee surgery) and their roles (e.g., surgeon, anesthesiologist, nurse, X-ray technician). Geography: Note on a global map regions of seismic and volcanic hazard, and describe how fields of geology, physics, and math are key to understanding such hazards.
H.13.18 Describe that understandings of science may be influenced by societal, cultural, and personal beliefs. (13A)	**AD:** Compare different types of treatment for a disease or a condition such as chronic lower back pain, based on different cultures (e.g., drugs, surgery, acupuncture, herbs, crystals).	Language Arts: Write an essay depicting how science has changed your own personal beliefs and experiences of the world. Civics: Describe a current issue in your community or the country related to understandings of science and ethics.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.13.19 Describe that science seeks to explain the natural world by using empirical standards, logic, analysis, skepticism, and revision. (13A)	**AD:** Use simple examples of logic and probability to understand a scientific explanation for an issue (e.g., elevated risks for heart disease, probability for earthquake risk in different parts of a continent). **AD:** Explore and describe a significant scientific finding that was revised or modified based upon additional measurements and analysis (e.g., drug recalls).	Religion: Compare a current, scientific view of the natural world, with views on a similar topic presented in the Bible. Discuss how the depictions are not the same, yet perhaps still overall compatible. Do views of the Bible change?
H.13.20 Compare different experimental designs in the sciences (direct observation, controlled or random-assigned experiments, computer modeling, statistical comparison). (13A)	**AD:** Design a simple experiment using a control (e.g., plants with different levels of nutrients or water) and identify weaknesses of the same experiment when not using a control. **AD:** Compare and contrast laboratory measurements of a phenomenon with similar observations in a natural setting (e.g., how light interacts with matter in a lab vs. astronomical observations of nebulae chemistry). **AD:** Explore and report on the different environments in which scientists of various disciplines work (e.g., in laboratories, outdoors, underwater, at universities, locally vs. globally).	History: Compare and contrast how scientists and historians study events, and how they substantiate their predictions. Psychology: Compare various ways of learning new information (e.g., visual, auditory, kinesthetic), and discuss how you learn best. Business/Technology: Study the professional settings of various scientists and decide which might suit you (e.g., outdoor field work, laboratory research, computer modeling using mathematics).

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.13.21 Give examples of how science typically occurs as small changes to existing knowledge in all fields, while at other times advances have a long-lasting impact on science and society (e.g., Copernican revolution, relativity, geologic and astronomical time, DNA, biologic evolution, plate tectonics, germ theory). (13A)	**AD:** Discuss and compare changes in understanding of the common cold that have occurred in the last few decades with changes in our understanding of the genomes of several organisms. **AD:** Compare progressive changes in the technology of cell phones or personal computers with the changes in thought that accompanied ideas such as heliocentrism, plate tectonics, or determining the genomes of organisms.	History: Research and describe the work and applications of work on the human genome. Psychology: Take a personality or aptitude test that helps you understand the kind of career that you would be good at and enjoy (e.g., detail-oriented vs. big-picture work; solitary work vs. collaborative). History: Devise as a class a term for the revolution associated with the use of the internet and personal computers.
H.13.22 Give examples of policies regarding science and technology that are important at local, state, national, and global levels and require analysis of costs, benefits, and effects (e.g., genetic engineering, greenhouse gas production, agriculture and aquaculture). (13B)	**AD:** Compare the costs and benefits of using fossil fuels on a global scale with the possible link to global warming and its ramifications. **AD:** Discuss the use of genetically engineered agriculture and aquaculture as a food resource for humans.	Economics/Business: Study ways that car manufacturers could lower exhaust emissions in new models of autos. Technology: Discuss and list ways that science and technology have been important in understanding issues of national security. Economics/Business: Find out why detergent manufacturers stopped using phosphates and how that affected the industry.

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LEARNING STANDARD/OUTCOME	SAMPLE ASSESSMENT	CONNECTIONS
H.13.23 Show how many types of hazards (natural or human-induced) can lead to injury, illness, or death, but that such hazards can often be reduced using science and technology. (13B)	**AD:** Describe a technological solution in your community or state that reduces the health risk from a natural or human-induced hazard. **AD:** Write about and list safety features in modern cars compared with cars in the past (e.g., air bags, seat belts, high-impact materials).	Geography: Use a map and poster to outline current advances for a tsunami warning system in the Pacific and Indian oceans, and Caribbean region. Language Arts: Research and write about recent advances in seismic and volcanic warning systems on the West Coast. Physical Education: Study improvements in football equipment from the early 1900s to today, and research whether such changes have reduced the incidence of long-term injuries in ex-professional players.

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