Correlations to Next Generation Science Standards (NGSS)

AccessScience can help students fulfill performance expectations in the Next Generation Science Standards for High School (**Grades 9–12**). View content correlations in Disciplinary Core Idea (DCI) arrangements below.

PHYSICAL SCIENCES

PS1A: Structure and Properties of Matter

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, "How can one explain the structure, properties, and interactions of matter?" Students are expected to develop understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Using this expanded knowledge of chemical reactions, students are able to explain important biological and geophysical phenomena. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars, and the generation of nuclear power. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas.

Matter and its Interactions

HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

- Actinide elements [Article]
- Alkali metals [Article]
- Alkaline-earth metals [Article]
- Atomic Structure and the Periodic Law [Book chapter]
- Chemical bonding [Article]
- Chemical element [Article]
- Electron affinity [Article]
- Electron configuration [Article]
- Mendeleyev, Dmitri Ivanovich (1834–1907) [Biography]
- Metal hydrides [Article]
- Noble gases [Article]
- Periodic table [Article]
- Transition elements [Article]
- Valence [Article]
- Women in Chemistry: Heroes of the Periodic Table [Video]

HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Chemical Bonding and Molecular Structure [Book chapter]
Coldest chemical reaction reveals the moment new molecules form [Briefing]

HS-PS1-3: Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

Charged particle optics [Article]
Electric field [Article]
Electric Fields [Book chapter]
Electricity [Book chapter]
Faraday, Michael (1791–1867) [Biography]
Ion [Article]

HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Chemical bond [Article]
Chemical Bonding and Molecular Structure [Book chapter]
Chemical energy [Article]

HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Chemical kinetics [Article]
Kinetic methods of analysis [Article]
Physical chemistry [Article]
Rates of Reactions [Book chapter]

HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Chemical equilibrium [Article]
Chemical thermodynamics [Article]
Le Châtelier's principle [Article]
Phase equilibrium [Article]
Thermodynamics and Chemical Equilibrium [Book chapter]

HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Atomic mass [Article]
Calculations from Chemical Equations [Book chapter]
Conservation of mass [Article]
Mole (chemistry) [Article]

HS-PS1-8: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Alpha, Beta, and Gamma Rays [Video]
Atomic nucleus [Article]
First detection of a radioactive molecule in space [Briefing]
Half-life [Article]
New insights into alpha particle formation [Briefing]
Nuclear fission [Article]
Nuclear fusion [Article]
Nuclear Physics [Book chapter]
Nuclear reaction [Article]
Radioactivity [Article]

PS1B: Chemical Reactions

HS-PS1-2: Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Chemical Bonding and Molecular Structure [Book chapter]
Chemical kinetics [Article]
Chlorine [Article]
Electron configuration [Article]
Periodic table [Article]
Valence [Article]

HS-PS1-4: Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Chemical bond [Article]
Chemical Bonding and Molecular Structure [Book chapter]
Chemical energy [Article]
Chemistry [Article]
Hydrogen bond [Article]
Organic reaction mechanism [Article]

HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Chemical thermodynamics [Article]
Collision (physics) [Article]
Kinetic methods of analysis [Article]
Rates of Reactions [Book chapter]

HS-PS1-6: Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Chemical equilibrium [Article]

Chemical thermodynamics [Article]
Le Châtelier's principle [Article]
Phase equilibrium [Article]
Thermodynamic processes [Article]
Thermodynamics and Chemical Equilibrium [Book chapter]

HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Atomic mass [Article]
Calculations from Chemical Equations [Book chapter]
Conservation of mass [Article]
Mole (chemistry) [Article]
Stoichiometry [Article]

PS2: Motion and Stability

The performance expectations associated with this disciplinary core idea support students' understanding of ideas related to why some objects will keep moving, why objects fall to the ground and why some materials are attracted to each other while others are not. Students should be able to answer the question, "How can one explain and predict interactions between objects and within systems of objects?" The performance expectations in PS2 focus on students building understanding of forces and interactions and Newton's Second Law. Students also develop understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are able to use Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. Students are able to apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, systems and system models, and structure and function are called out as organizing concepts for these disciplinary core ideas.

Forces and Interactions

HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Acceleration [Article]
Dynamics [Article]
Force [Article]
Laws of Motion [Book chapter]
Mass [Article]
Motion [Article]
Newton, Isaac [Biography]
Newton's laws of motion [Article]
Newton's Laws of Motion [Book chapter]

HS-PS2-2: Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Angular momentum [Article]
Conservation of momentum [Article]
Conservation of Momentum [Video]

Linear momentum [Article]
Linear Momentum and Collisions [Book chapter]
Momentum [Article]
Momentum [Book chapter]

HS-PS2-3: Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

Atmospheric entry [Article]
Collision (physics) [Article]
Collision (physics) [Video]
Impact [Article]
Impulse (mechanics) [Article]
Linear Momentum and Collisions [Book chapter]
Momentum [Book chapter]
Parachute [Article]

HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Coulomb, Charles Augustin de [Biography]
Coulomb's law [Article]
Earth's gravity field [Article]
Electric charge [Article]
Electric field [Article]
Electricity [Book chapter]
Electrostatics [Article]
Gravity [Article]
Gravity [Book chapter]
Gravity [Video]
Laws of Motion [Book chapter]
Newton, Isaac [Biography]
Newton's laws of motion [Article]

HS-PS2-5: Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Electric current [Article]
Electromagnet [Article]
Electromagnetic field [Article]
Electromagnetic induction [Article]
Electromagnetism [Article]
Magnetic Fields [Book chapter]
Magnetism [Article]
Magnetism [Book chapter]
The Subject of Electromagnetics [Book chapter]

HS-PS2-6: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Bonding and Molecular Structure [Book chapter]
Chemical Bonding and Molecular Structure [Book chapter]

Drug delivery systems [Article]
Electrical conductor [Article]
Electrical insulation [Article]
Electric insulator [Article]
Materials science and engineering [Article]
Polymer [Article]

PS3: Energy

The Performance Expectations associated with this DCI help students formulate an answer to the question, "How is energy transferred and conserved?" Energy is understood as a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy associated with the configuration (relative positions) of particles. In some cases, the energy associated with the configuration of particles can be thought of as stored in fields. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of cause and effect; systems and system models; energy and matter; and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations associated with PS3.

HS-PS3-1: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Conservation of energy [Article]
Conservation of energy [Video]
Energy [Article]
Energy [Book chapter]
Heat balance [Article]
Potential Energy and Conservation of Energy [Book chapter]

HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

Electrostatics [Article]
Energy [Article]
Energy [Book chapter]
Energy conversion [Article]
Harmonic motion [Article]

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Efficiency [Article]
Electric power generation [Article]
Energy conversion [Article]
Energy source [Article]
Engine [Article]
Generator [Article]

Motor [Video]
Potential Energy and Conservation of Energy [Book chapter]
Power plant [Article]
Solar cell [Article]
Solar energy [Article]
Turbine [Article]
Waste-to-energy [Article]
Wind power [Article]
Work and Energy [Book chapter]

HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Efficiency [Article]
Chemical thermodynamics [Article]
Heat conduction [Article]
Heat convection [Article]
Heat transfer [Article]
The First and Second Laws of Thermodynamics [Book chapter]
Thermodynamic principles [Article]
Thermodynamics [Book chapter]

HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Electric field [Article]
Electric Fields [Book chapter]
Electromagnetism [Article]
Forces and Torques in Magnetic Fields [Book chapter]
High magnetic fields [Article]
Intermolecular force [Article]
Magnet [Article]

PS4: Waves and their Applications in Technologies for Information Transfer

The Performance Expectations associated with this disciplinary core idea are critical to understand how many new technologies work. As such, this core idea helps students answer the question, “How are waves used to transfer energy and send and store information?” Students are able to apply understanding of how wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. Models of electromagnetic radiation as either a wave of changing electric and magnetic fields or as particles are developed and used. Students understand that combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of cause and effect; systems and system models; stability and change; interdependence of science, engineering, and technology; and the influence of engineering, technology, and science on society and the natural world are highlighted as organizing concepts for these disciplinary core ideas.

HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

- Electromagnetic radiation [Article]
- Electromagnetic Waves [Book chapter]
- Seismology [Article]
- Sound [Article]
- Sound Waves [Video]
- Underwater sound [Article]
- Wavelength [Article]
- Wave motion [Article]
- Wave (physics) [Article]
- Waves and Sounds [Book chapter]

HS-PS4-2: Evaluate questions about the advantages of using digital transmission and storage of information.

- Computer security [Article]
- Computer storage technology [Article]
- Data communications and networks [Article]
- Information management [Article]
- Information technology [Article]
- Integrated services digital network (ISDN) [Article]

HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

- Atomic Structure and the Periodic Law [Book chapter]
- Diffraction [Article]
- Electrical interference [Article]
- Electromagnetic compatibility [Article]
- Electromagnetic radiation [Article]
- Electromagnetic wave [Article]
- Electromagnetic Waves [Book chapter]
- Electromagnetic wave transmission [Article]
- Photochemistry [Article]
- Photoemission [Article]
- Photon [Article]
- Resonance (alternating-circuit currents) [Article]

HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

- Absorption of electromagnetic radiation [Article]
- Absorption of light [Video]
- Bioelectromagnetics [Article]
- Electromagnetic radiation [Article]
- Photon [Article]
- Radiation biology [Article]

Radiation injury to plants and animals [Article]
Toxic Effects of Radiation and Radioactive Materials [Book chapter]

HS-PS4-5: Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

Communications satellite [Article]
Holography [Article]
Laser [Article]
Laser [Video]
Laser spectroscopy [Article]
Medical imaging [Article]
Propagation of Electromagnetic Waves in the Atmosphere [Book chapter]
Radio receiver [Article]
Solar cell [Article]
Submillimeter-wave technology [Article]
WiMAX broadband wireless communications [Article]
X-ray [Article]

LIFE SCIENCES

LS1: From Molecules to Organisms: Structures and Processes

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, "How do organisms live and grow?" In the performance expectations, students demonstrate that they can use investigations and gather evidence to support explanations of cell function and reproduction. They understand the role of proteins as essential to the work of the cell and living systems. Students can use models to explain photosynthesis, respiration, and the cycling of matter and flow of energy in living organisms. The cellular processes can be used as a model for understanding of the hierarchical organization of organism. Crosscutting concepts of matter and energy, structure and function, and systems and system models provide students with insights to the structures and processes of organisms.

HS-LS1-1: Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

- Crick, Francis Harry Compton [Biography]
- Deoxyribonucleic acid (DNA) [Animation]
- Deoxyribonucleic acid (DNA) [Article]
- Franklin, Rosalind Elsie [Biography]
- Genetic code [Article]
- The genetic code [Animation]
- How translation works [Animation]
- Nucleic acid [Article]
- Protein [Article]
- Proteins: Determination of Primary Structure [Book chapter]
- Proteins: Higher Orders of Structure [Book chapter]
- Ribonucleic acid (RNA) [Article]
- RNA and DNA structure compared [Animation]
- Transcription and Translation [Book chapter]
- Watson, James Dewey [Biography]

HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

- Cardiovascular system [Article]
- Digestive system [Article]
- Endocrine system (invertebrate) [Article]
- Endocrine system (vertebrate) [Article]
- Excretion [Article]
- Motor systems (neuroscience) [Article]
- Muscular system [Article]
- Nervous system (invertebrate) [Article]
- Nervous system (vertebrate) [Article]
- Organization & Cells of the Nervous System [Book chapter]
- Organs of digestion [Animation]
- Reproductive system [Article]
- Respiratory system [Article]
- Respiratory system overview [Animation]
- Skeletal system [Article]
- The Circulatory System [Book chapter]

The Respiratory System [Book chapter]
Urinary system [Article]

HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Autonomic nervous system [Article]
Autonomic Nervous System: Sympathetic, Parasympathetic, & Enteric [Book chapter]
Carotid body [Article]
Endocrine system (invertebrate) [Article]
Endocrine system (vertebrate) [Article]
Homeostasis [Article]
Plant-water relations [Article]
Tree growth [Article]

HS-LS1-4: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

Cell cycle [Article]
Cell differentiation [Article]
Cell division [Article]
Embryonic differentiation [Article]
How the Cell Cycle Works [Animation]
Mitosis [Article]
Mitosis [Animation]
Mitosis and Cytokinesis [Animation]
The Nucleus [Book chapter]

HS-LS1-5: Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

Chlorophyll [Article]
Photochemistry [Article]
Photosynthesis [Article]]
Photosynthetic Electron Transport and ATP Synthesis [Animation]
Progress in developing an "artificial leaf" for hydrogen fuel generation [Briefing]
What if Humans Could Photosynthesize? [Animation]

HS-LS1-6: Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Amino acids [Article]
Amino Acids and Peptides [Book chapter]
Amino Acids, Peptides, and Proteins [Animation]
Biochemistry [Article]
Biopolymer [Article]
Building Blocks of Life [Book chapter]
Carbohydrate [Article]
Carbohydrates of Physiological Significance [Book chapter]

Glucose [Article]
Peptide [Article]
Protein [Article]
Protein Synthesis [Animation]

HS-LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy.

Cellular respiration [Article]
Citric acid cycle [Article]
Glucose [Article]
How the NAD+ Works [Animation]
Mitochondria [Article]
Plant metabolism [Article]
Plant respiration [Article]

LS2: Ecosystems: Interactions, Energy, and Dynamics

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, “How and why do organisms interact with their environment, and what are the effects of these interactions?” The LS2 DCI includes four sub-ideas: Interdependent Relationships in Ecosystems, Cycles of Matter and Energy Transfer in Ecosystems, Ecosystem Dynamics, Functioning, and Resilience, and Social Interactions and Group Behavior. High school students can use mathematical reasoning to demonstrate understanding of fundamental concepts of carrying capacity, factors affecting biodiversity and populations, and the cycling of matter and flow of energy among organisms in an ecosystem. These mathematical models provide support of students’ conceptual understanding of systems and their ability to develop design solutions for reducing the impact of human activities on the environment and maintaining biodiversity. Crosscutting concepts of systems and system models play a central role in students’ understanding of science and engineering practices and core ideas of ecosystems.

HS-LS2-1: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

Ecological competition [Article]
Economic entomology [Article]
Ecosystem [Article]
Mathematical ecology [Article]
Plant vulnerability to climate change [Article]
Population ecology [Article]
Theoretical ecology [Article]

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Alpine vegetation [Article]
Biodiversity [Article]
Biome [Article]
Biomes [Animation]
Conservation of resources [Article]

Disease ecology [Article]
Ecological methods [Article]
Ecosystem [Article]
Fisheries ecology [Article]
Forest ecosystem [Article]
Mathematical ecology [Article]
Paleobiodiversity [Article]
Plant-animal interactions [Article]
Plant vulnerability to climate change [Article]
Population ecology [Article]
Population viability [Article]

HS-LS2-3: Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

Freshwater ecosystem [Article]
Gas exchange during respiration [Animation]
Hydrosphere [Article]
Marine microbiology [Article]
Marine sediments [Article]
Methanogenesis [Article]
Plant respiration [Article]
Respiration [Article]
Terrestrial ecosystem [Article]
Yeast [Article]

HS-LS2-4: Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Biogeochemistry [Article]
Biological productivity [Article]
Ecological community [Article]
Ecological energetics [Article]
Ecosystem [Article]
Food web [Article]
Forest ecosystem [Article]
Forest soil [Article]
Freshwater ecosystem [Article]
Hydrology [Article]
Marine ecology [Article]
Marine sediment [Article]
Nitrogen cycle [Article]
Phosphorus cycle [Article]
Soil microbiology [Article]
Trophic ecology [Article]

HS-LS2-5: Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Atmospheric chemistry [Article]

Biogeochemistry [Article]
Dissolved organic carbon in the deep ocean biodegrades after all [Briefing]
Ecosystem [Article]
Forest soil [Article]
Fungal ecology [Article]
Marine sediment [Article]
Potential of soils for carbon sequestration [Briefing]
Rhizosphere [Article]
Rhizosphere ecology [Article]

HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

Coral reef structural complexity [Article]
Drought [Article]
Ecological succession [Article]
Ecotoxicology [Book chapter]
Erosion [Article]
Forest ecosystem [Article]
Global climate change [Article]
Invasion ecology [Article]
Ocean acidification [Article]
Plant vulnerability to climate change [Article]
Wetland [Article]

HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

Anthropocene extinction [Article]
Conservation of species [Article]
Desertification [Article]
Environmental engineering [Article]
Environmental management [Article]
Erosion [Article]
Insects threatened by biodiversity crisis [Briefing]
Introduction to Toxicology: Occupational & Environmental [Book chapter]
Land reclamation [Article]
Urban climatology [Article]
Invasive species [Article]
Marine conservation [Article]
Nanoparticle Toxicology [Book chapter]
North American birds are disappearing [Briefing]
Reservoir [Article]
Restoration ecology [Article]
River engineering [Article]
Soil conservation [Article]
Water conservation [Article]

HS-LS2-8: Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.

Bee dance language [Briefing]
Behavioral ecology [Article]
Inheritance of social organization among spotted hyenas [Briefing]
Migratory behavior [Article]
Social hierarchy [Article]
Social insects [Article]
Social mammals [Article]
Sociobiology [Article]
Territoriality [Article]
Why Do Wasps Attack? [Video]

LS3: Heredity: Inheritance and Variation of Traits

The performance expectations in this Disciplinary Core Idea help students formulate answers to the questions: "How are characteristics of one generation passed to the next? How can individuals of the same species and even siblings have different characteristics?" The LS3 Disciplinary Core Idea includes two sub-ideas: Inheritance of Traits, and Variation of Traits. Students are able to ask questions, make and defend a claim, and use concepts of probability to explain the genetic variation in a population. Students demonstrate understanding of why individuals of the same species vary in how they look, function, and behave. Students can explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expression. Crosscutting concepts of patterns and cause and effect are called out as organizing concepts for these core ideas

HS-LS3-1: Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Cell nucleus [Article]
Chromosome [Article]
Deoxyribonucleic acid (DNA) [Article]
Gene [Article]
Genetic code [Article]
Genetics [Article]
Meiosis [Animation]
Meiosis [Article]
The Flow of Genetic Information [Book chapter]

HS-LS3-2: Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Chromosome aberration [Article]
Crossing over (genetics) [Article]
DNA Organization, Replication, & Repair [Book chapter]
DNA Replication and Repair [Book chapter]
Genetic Toxicology [Book chapter]
Human genetics [Article]
Meiosis [Article]

Meiosis with crossing over [Animation]
Mutagens and carcinogens [Article]
Mutation [Article]
Recombination (genetics) [Article]

HS-LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Biometrics [Article]
Elementary Probability Theory [Book chapter]
Human genetics [Article]
Population genetics [Article]
Probability [Article]
Probability distribution [Article]
Statistics [Article]

LS4: Biological Evolution: Unity and Diversity

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, "What evidence shows that different species are related? The LS4 Disciplinary Core Idea involves four sub-ideas: Evidence of Common Ancestry and Diversity, Natural Selection, Adaptation, and Biodiversity and Humans. Students can construct explanations for the processes of natural selection and evolution and communicate how multiple lines of evidence support these explanations. Students can evaluate evidence of the conditions that may result in new species and understand the role of genetic variation in natural selection. Additionally, students can apply concepts of probability to explain trends in populations as those trends relate to advantageous heritable traits in a specific environment. The crosscutting concepts of cause and effect and systems and system models play an important role in students' understanding of the evolution of life on Earth.

HS-LS4-1: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

Animal evolution [Article]
Convergent evolution [Article]
Developmental genetics [Article]
Evolution [Article]
Evolutionary developmental biology [Article]
Heterochrony [Article]
Macroevolution [Article]
Molecular anthropology [Article]
Phylogenetic trees [Animation]
Phylogeny [Article]
Plant evolution [Article]
Speciation [Article]

HS-LS4-2: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

[Adaptation (biology)] [Article]
Charles Darwin and his theory of evolution [Briefing]
Darwin, Charles Robert [Biography]
Ecological competition [Article]
Evolution [Article]
Macroevolution [Article]
Meiosis [Animation]
Mutagens and carcinogens [Article]
Mutation [Article]
Population genetics [Article]
Speciation [Article]

HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

Distribution (probability) [Article]
Evolution [Article]
Population genetics [Article]
Sociobiology [Article]
The Flow of Genetic Information [Book chapter]

HS-LS4-4: Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Adaptations of the Joshua tree (*Yucca brevifolia*) [Briefing]
Evolution [Article]
Evolutionary epidemiology [Briefing]
Forest genetics [Article]
Human biological variation [Article]
Physiological ecology (animal) [Article]
Population genetics [Article]
Quorum sensing in bacteria [Briefing]

HS-LS4-5: Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Australian wildfires threaten koalas [Briefing]
Climate change likely drove African megaherbivores to extinction [Briefing]
Declining insect populations in Puerto Rico [Briefing]
Deforestation [Article]
Dramatic reductions in the Bornean orangutan population [Briefing]
Drought [Article]
Eastern lowland gorilla is critically endangered [Briefing]
Ecological succession [Article]
Ecotoxicology [Book chapter]
Extinction (paleontology) [Article]
Fire and disturbance ecology [Article]
Fisheries ecology [Article]

Global climate change affects Arctic treeline [Briefing]
Insects threatened by biodiversity crisis [Briefing]
Massive die-off of saiga antelopes [Briefing]
Massive seabird die-off attributed to ocean warming [Briefing]
North American birds are disappearing [Briefing]
Plant vulnerability to climate change [Article]
Recovery of the Iberian lynx [Briefing]
Speciation [Article]

HS-LS4-6: Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Anthropocene extinction [Article]
Biodiversity [Article]
Human ecology [Article]
Simulation [Article]

EARTH AND SPACE SCIENCES

ES1: Earth's Place in the Universe

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, "What is the universe, and what is Earth's place in it?" This DCI is broken down into three sub-ideas: the universe and its stars, Earth and the solar system and the history of planet Earth. Students examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Other concepts are practical, such as understanding how short-term changes in the behavior of our Sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support theories of the formation of the solar system and universe. The crosscutting concepts of patterns, scale, proportion, and quantity, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas.

HS-ESS1-1: Develop a model based on evidence to illustrate the life span of the Sun and the role of nuclear fusion in the Sun's core to release energy that eventually reaches Earth in the form of radiation.

Mild space weather forecast for 2020s predicts fewer solar storms [Briefing]
Nuclear fusion [Article]
Revised sunspot cycle predicts highly active solar period [Briefing]
Solar radiation [Article]
Star [Article]
Stellar evolution [Article]
Sun [Article]

HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

Accelerating universe [Article]
Astronomical spectroscopy [Article]
Big bang theory [Article]
Cosmic background radiation [Article]
Cosmology [Article]
Electromagnetic radiation [Article]
Galaxy formation and evolution [Article]
Henrietta Leavitt: The Woman Who Measured the Universe [Video]
How the First Stars Transformed the Universe [Video]
Inflationary universe cosmology [Article]
Line spectrum [Article]
Redshift [Article]
The Achievements of Edwin Hubble [Video]
Universe [Article]

HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements.

Big bang theory [Article]
Cosmic abundance of elements [Article]
Dying stars called collapsars may forge much of the universe's gold [News]

Nucleosynthesis [Article]
Strontium is the first heavy element detected from a neutron star merger [News]
Why We Are Made of “Star Stuff” [Video]

HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Celestial mechanics [Article]
Circular Motion and Gravitation [Book chapter]
Gravity [Article]
Kepler’s laws [Article]
Kepler’s First Law [Video]
Kepler’s Second Law [Video]
Kepler’s Third Law [Video]
Laws of Motion [Book chapter]
Newton, Isaac [Biography]
Newton’s Laws of Motion [Book chapter]
Orbital motion [Article]
Planet [Article]
Satellite (astronomy) [Article]

HS-ESS1-5: Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

Continental drift [Article]
Continental Drift [Video]
Convection in the Earth [Article]
Earth’s crust [Article]
Evolution of the continents [Article]
Mid-Oceanic Ridge [Article]
Paleomagnetism [Article]
Plate tectonics [Article]
Plate Tectonics [Video]

HS-ESS1-6: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history.

Archean [Article]
Chicxulub collision put Earth’s crust in hot water for over a million years [News]
Chicxulub impact crater [Article]
Earth’s age [Article]
Earth’s core may have hardened just in time to save its magnetic field [News]
Evolution of the continents [Article]
Fluid in superdeep diamonds may be from some of Earth’s oldest unchanged material [News]
Formation of the Solar System [Video]
Hadean [Article]
Meteorite [Article]
Solar system [Article]
Space rocks may have bounced off baby Earth, but slammed into Venus [News]

ES2: Earth's Systems

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, "How and why is Earth constantly changing?" This DCI is broken down into five sub-ideas: Earth materials and systems, plate tectonics and large-scale system interactions, the roles of water in Earth's surface processes, weather and climate, and biogeology. For the purpose of the NGSS, biogeology has been addressed within the life science standards. Students develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface, and the Sun-driven surface systems that tear down the land through weathering and erosion. Students begin to examine the ways that human activities cause feedbacks that create changes to other systems. Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students model the flow of energy between different components of the weather system and how this affects chemical cycles such as the carbon cycle. The crosscutting concepts of cause and effect, energy and matter, structure and function and stability and change are called out as organizing concepts for these disciplinary core ideas.

HS-ESS2-1: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

Atoll [Article]
Coastal landform [Article]
Convection in the Earth [Article]
Earth's crust [Article]
Erosion [Article]
Escarpment [Article]
Evolution of the continents [Article]
Formation of Islands Over Hot Spots [Video]
Hill and mountain terrain [Article]
Hot spots (geology) [Article]
Karst topography [Article]
Marine geology [Article]
Mass wasting [Article]
Mid-Oceanic Ridge [Article]
Orogeny [Article]
Plains [Article]
Rift valley [Article]
Seamount and guyot [Article]
Subduction zone [Article]
Weathering processes [Article]
Volcano [Article]
Volcano [Video]

HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

Climate modeling [Article]
Drought [Article]
Glaciers in the Himalayas are melting fast, study shows [Briefing]
Greenhouse effect [Article]
Heat balance of the Earth [Article]
Hydrological consequences of global warming [Article]

Ocean warming [Article]
Soil eroded by glaciers may have kick-started plate tectonics [News]
Systems ecology [Article]
The Arctic is burning and Greenland is melting, thanks to record heat [News]
Warm Atlantic water is melting Arctic sea ice [Briefing]

HS-ESS2-3: Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

Asthenosphere [Article]
Convection in the Earth [Article]
Earth's core [Article]
Earth's heat flow [Article]
Earth's interior [Article]
Geodynamo [Article]
High-pressure mineral synthesis [Article]
Lithosphere [Article]
Magnetic reversal [Article]
Moho (Mohorovičić discontinuity) [Article]
Plate tectonics [Article]
Plate Tectonics [Video]
Seismology [Article]

HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

A volcano-induced rainy period made Earth's climate dinosaur-friendly [News]
Climate history [Article]
Climate modeling [Article]
Climatology [Article]
Effect of volcanic SO_2 emissions on cloud albedo [Briefing]
Global climate change [Article]
Paleoclimatology [Article]

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

Fluvial erosion landforms [Article]
Hydrology [Article]
Hydrosphere [Article]
Sedimentary rock [Article]
Sedimentology [Article]
Soil [Article]
Streamgaging [Article]
Stream transport and deposition [Article]
Water [Article]
Weathering processes [Article]

HS-ESS2-6: Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Atmospheric chemistry [Article]
Biogeochemistry [Article]
Carbon [Article]
Dissolved organic carbon in the deep ocean biodegrades after all [Briefing]
Ecosystem [Article]
Marine sediment [Article]
Organic geochemistry [Article]
Potential of soils for carbon sequestration [Briefing]
Rhizosphere ecology [Article]
Why Carbon is the Key to Life [Video]

HS-ESS2-7: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Animal evolution [Article]
Biosphere [Article]
Evolution of the atmosphere [Article]
Flooding Earth's atmosphere with oxygen may not have needed a triggering event [News]
How ancient oceans of magma may have boosted Earth's oxygen levels [News]
Paleontology [Article]
Plant evolution [Article]
Prebiotic organic synthesis [Article]
Precambrian [Article]
Proterozoic [Article]
Stromatolite [Article]
Tentative fossilized evidence of oldest animal life [Briefing]
The dinosaur-killing asteroid impact radically altered Earth's tropical forests [News]

ES3: Earth and Human Activity

The performance expectations in this Disciplinary Core Idea help students formulate an answer to the question, "How do Earth's surface processes and human activities affect each other?" This DCI is broken down into four sub-ideas: natural resources, natural hazards, human impact on Earth systems, and global climate change. Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the significant environmental impacts of human activities. Engineering and technology figure prominently here, as students use mathematical thinking and the analysis of geoscience data to examine and construct solutions to the many challenges facing long-term human sustainability on Earth. The crosscutting concepts of cause and effect, systems and system models, and stability and change are called out as organizing concepts for these disciplinary core ideas.

HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Desertification [Article]
Early modern humans [Article]
Environmental geology [Article]
Erosion [Article]
Forest timber resources [Article]
Human ecology [Article]
Landslide detection by modeling seismic data [Briefing]
Technology and natural hazards clash to create 'natech' disasters [News]

Water conservation [Article]
Water resource [Article]

HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Agricultural soil and crop practices [Article]
Conservation of resources [Article]
Environmental engineering [Article]
Environmental management [Article]
Forest engineering [Article]
Green engineering [Article]
Hazardous waste engineering [Article]
Mining [Article]
Recycling technology [Article]
Soil conservation [Article]

HS-ESS3-3: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

Aquaculture [Article]
Conservation of resources [Article]
Environmental management [Article]
Fisheries ecology [Article]
Forest [Article]
Forest fire [Article]
Hazardous waste engineering [Article]
Industrial ecology [Article]
Landfill mining risks and rewards [Briefing]
Land-use planning [Article]
Salmon farming [Article]
Soil [Article]
Sustainability [Article]
Urban forestry [Article]
Water conservation [Article]

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Chemical recycling of plastic waste [Briefing]
Environmental engineering [Article]
Environmental impact of food waste [Briefing]
First recyclable polyester bioplastic [Briefing]
Forest engineering [Article]
Green computing [Article]
Green water scarcity and sustainability [Briefing]
Hydrological consequences of global warming [Article]
Industrial ecology [Article]
Landfill mining risks and rewards [Briefing]
Land reclamation [Article]
Nanoparticle Toxicology [Book chapter]
Recycling carbon fiber [Briefing]

Single-use plastic-bag alternatives [Briefing]
Solar panel recycling concerns [Briefing]
Solutions for reducing climate and health effects of concrete production [Briefing]
Waste-to-energy [Article]
Waterless dyeing of textiles [Briefing]

HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

Australia's wildfires have now been linked to climate change [News]
Climate change is bringing earlier springs, which may trigger drier summers [News]
Climate change made Europe's flash floods in July more likely [News]
Climate change may be speeding up ocean circulation [News]
Climate change may make El Niño and La Niña less predictable [News]
Climate change predicted to increase areas affected by stalled weather patterns [News]
Climate modeling [Article]
Climatology [Article]
Deadly heat in an era of global climate change [Briefing]
Earth's lower atmosphere is rising due to climate change [News]
Environmental sex determination of green sea turtles affected by climate change [Briefing]
Global climate change [Article]
Global climate change affects Arctic treeline [Briefing]
Hydrological consequences of global warming [Article]
In the past 15 years, climate change has transformed the Arctic [News]
Tornado activity and climate change [Briefing]

HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Acid rain [Article]
Air pollution [Article]
Air Pollution [Book chapter]
Anthropocene extinction [Article]
Are Human Burial Practices Disturbing Earth's Ecosystems? [Video]
Clearing land to feed a growing human population will threaten thousands of species [News]
Desertification [Article]
Ecotoxicology [Book chapter]
Fed by human-caused erosion, many river deltas are growing [News]
Global climate change [Article]
Green water scarcity and sustainability [Briefing]
Human ecology [Article]
Humans are overloading the world's freshwater bodies with phosphorus [News]
Hydrological consequences of global warming [Article]
Ocean acidification [Article]
Ocean warming [Article]
Plant vulnerability to climate change [Article]
Soil degradation [Article]
Urban climatology [Article]
Water pollution [Article]
Water resource [Article]
Weather modification [Article]

ENGINEERING DESIGN

ETS1: Engineering Design

By the end of 12th grade, students are expected to achieve all four HS-ETS1 performance expectations related to a single problem in order to understand the interrelated processes of engineering design. These include analyzing major global challenges, quantifying criteria and constraints for solutions; breaking down a complex problem into smaller, more manageable problems, evaluating alternative solutions based on prioritized criteria and trade-offs, and using a computer simulation to model the impact of proposed solutions.

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

- Applied ecology [Article]
- Biofuels may provide climate benefits after all [Briefing]
- Decision theory [Article]
- Engineering, social implications of [Article]
- Environmental engineering [Article]
- Environmental management [Article]
- Green engineering [Article]
- Planting trees could buy more time to fight climate change than thought [News]
- Resilient building design [Briefing]
- Sustainability [Article]

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

- Algorithm [Article]
- Engineering design [Article]
- Green engineering [Article]
- PERT [Article]
- Problem solving (psychology) [Article]

HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

- Decision theory [Article]
- Demand for and environmental impacts of sand mining [Briefing]
- Environmental engineering [Article]
- Environmental impact of food waste [Briefing]
- Environmental management [Article]
- Environmental test [Article]
- Food Toxicology: Fundamental and Regulatory Aspects [Book chapter]
- Gantt chart [Article]
- Green engineering [Article]
- Industrial ecology [Article]
- Landfill mining risks and rewards [Article]
- PERT [Article]
- Reliability, availability, and maintainability [Article]
- Systems engineering [Article]

HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

- Automated decision making [Article]
- Computer-aided engineering [Article]
- Decision support system [Article]
- Optimization [Article]
- Simulation [Article]
- Systems analysis [Article]
- Systems engineering [Article]