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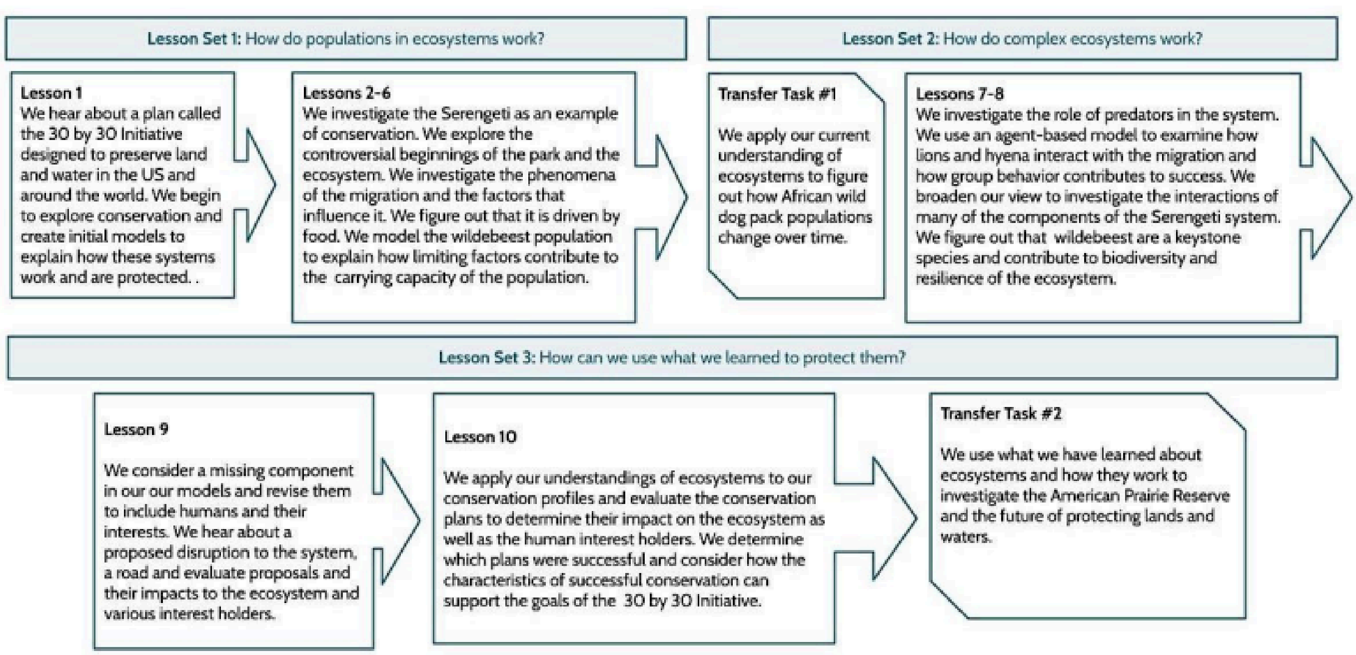
OpenSciEd Biology Scope and Sequence

Unit B.1 In this unit, students figure out big ideas about ecosystem energy flow, carrying capacity, and interactions. They investigate the importance of biodiversity and how humans interact with natural systems. Students explore conservation in the context of the 30-40 Initiative, which aims to conserve 30 percent of US lands and waters by 2030. They investigate four different conservation profiles in the US.

This 5-6 week unit gives students a real-world context for thinking about ecosystems and their protection while at the same time helping them recognize that often what we learn about one ecosystem can be applied to another. Most of the unit is spent as a class investigating a single case together, the Serengeti. The Serengeti National Park was created to protect the great animal migration route and has a history of complicated human interactions. The Serengeti has been studied extensively for over 70 years, and many long-term, comprehensive data sets are available for students to investigate.



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Unit B.2 This six-week unit is designed to help students build a deeper understanding of the flow of matter and energy within ecosystems and the cycling of carbon on a global scale due to increased fires. Students read about mysterious arctic fires popping up near the burn scars of old fires and do a visual inquiry to obtain more information about what is happening with matter and energy in these arctic fire systems.

To figure out how these fires can burn under ice and release so much carbon dioxide, students explore the interactions between peat, permafrost, decomposers, the sun, and other system components by investigating burning fuels and measuring the rate of decomposition and photosynthesis under different conditions. Students are motivated to see if they can generalize this phenomenon to other systems and the effect of increased carbon dioxide on the atmosphere. Students quantitatively model how matter and energy flow through different earth systems and levels within an ecosystem.

Lesson Set 1: What causes zombie fires to burn under the ice and what are the consequences?

Lesson 1

We observe a puzzling phenomenon: fires are burning in the arctic under ice and emerging in the spring to cause new fires. We begin to explore what is happening to the matter and energy in zombie fire systems.

Lessons 2-5

We investigate by burning peat and other fuels and explore the relationship between peat and permafrost. We figure out that peat is many layers of partially decomposed plants and that conditions such as cold temperatures and low oxygen can affect the rate of decomposition. We wonder how there got to be so many plants in the cold Arctic and figure out that the Earth's tilt has changed and that differences in available solar energy impact how much carbon dioxide is captured and stored as chemical energy in plants.

Lesson 6: Embedded Summative Explanation

We put the pieces together from Lesson Set 1 by building a class consensus model based on evidence that we collected to construct an explanation for what is happening to the matter and energy in zombie fires.

Lesson Set 2: How is global carbon cycling affected by fires?

Lessons 7-9

We figure out from case studies that carbon sinks around the world are burning due to human actions and putting lots of carbon dioxide into the atmosphere. We figure out that increases in carbon dioxide are causing warmer temperatures. We quantitatively model how these increases in carbon dioxide (matter) and temperature (energy) are shifting the balance in Earth systems. We wonder how we can interrupt positive feedback loops in fire systems.

Electronic Exit Ticket

We use the model we developed of Earth's systems to predict what would happen to global atmospheric carbon dioxide if human activity were to cause a mass die-off of plants and to explain how increases in human-caused fires in carbon sinks lead to increases in global temperatures.

Lesson Set 3: How do we design solutions to manage the impacts of fires?

Lessons 10-11

We investigate how prescribed burning, cultural burning, restoring grazer populations, and replanting forests help manage the amount of available carbon and energy that burn in wildfires. We put the pieces together from the unit to develop fire management systems for communities we care about.

Lesson 12: Transfer Task

We use what we have figured out about the flow of matter and energy in fire systems to investigate the Dead Zone in the Gulf of Mexico where massive fish kills are happening.

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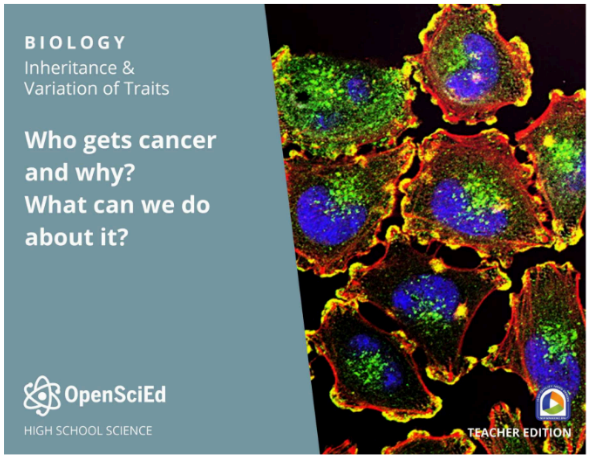
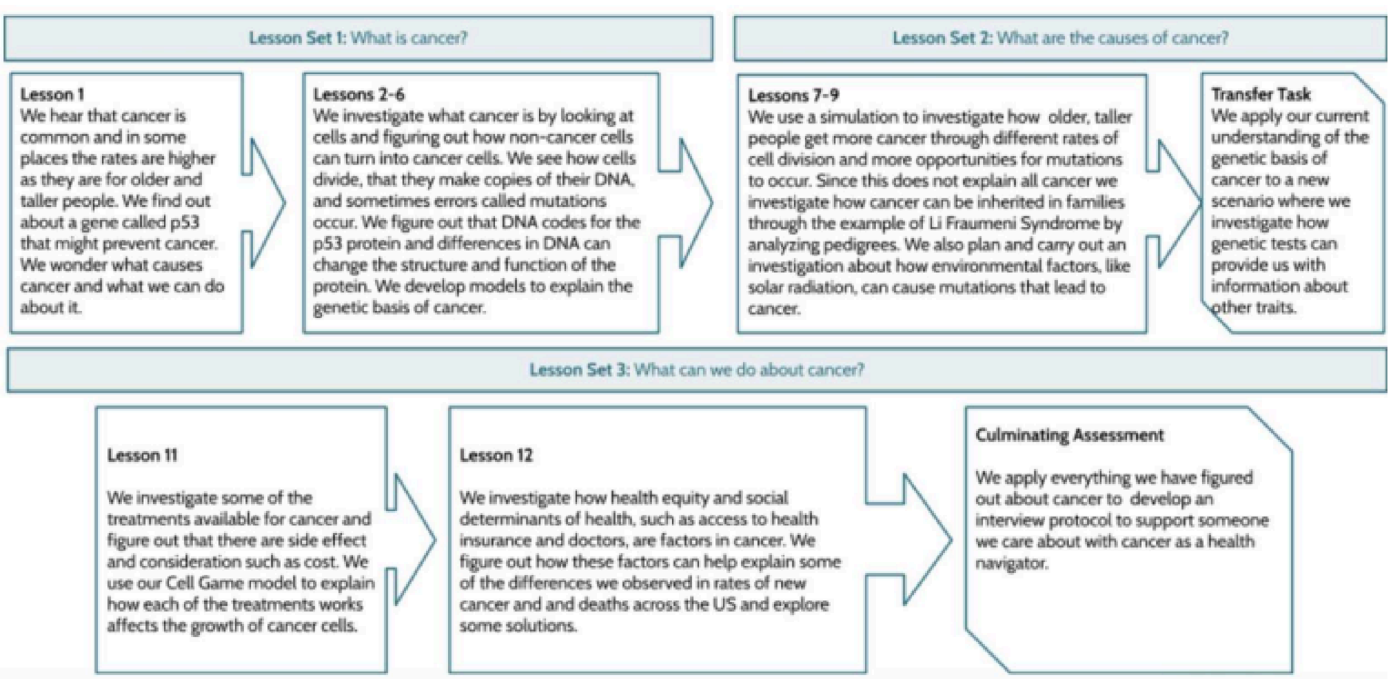


Unit B.3 This five-week unit is designed to deepen student's understanding of inheritance and trait variation by exploring cancer as a phenomenon. Students explore the genetic basis of cancer by investigating what cancer is and how mutations that can increase cancer risk occur. While many genes are implicated in cancer, the unit focuses on p53, a tumor suppressor gene involved in many cancers.

Students investigate cancer caused by mutations that occur throughout our lifetimes, inherited mutations, and how the environment can cause mutations. Students investigate additional factors that explain differences across the US in cancer and mortality, access, and feasibility of treatment options.



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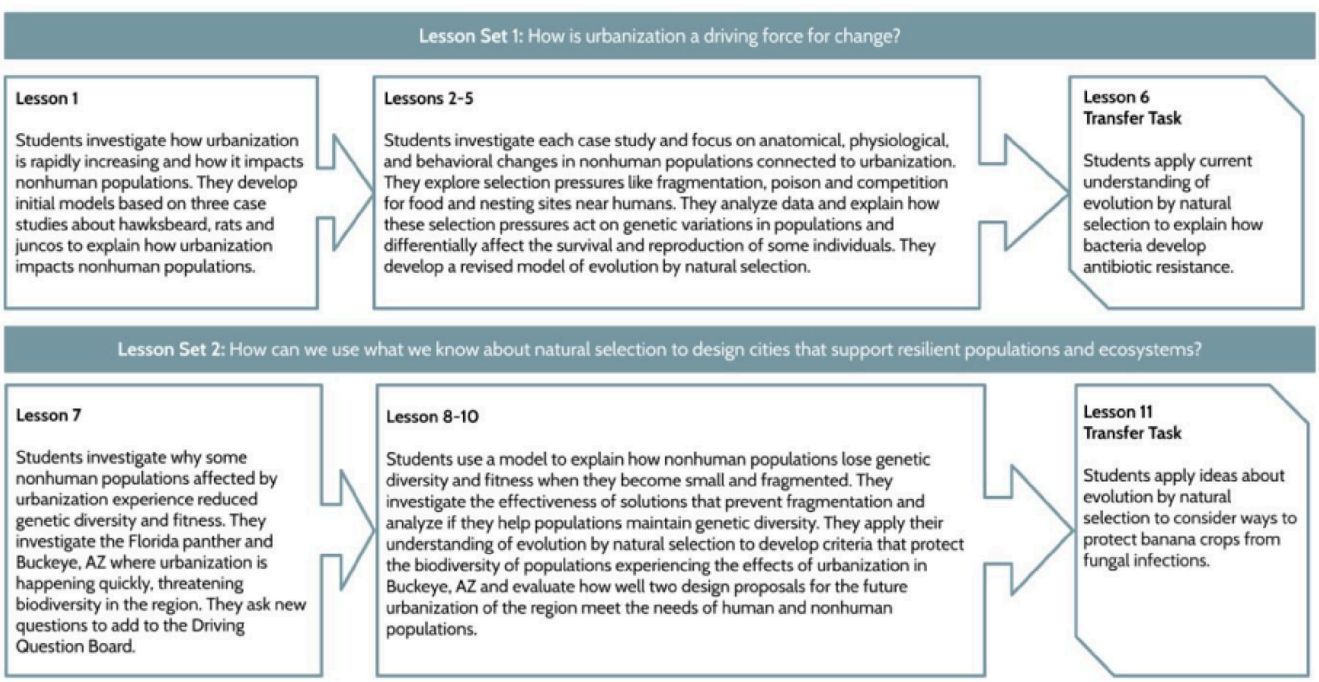
Unit B.4 This five-week unit on natural selection and the evolution of populations focuses on the phenomenon of increasing urbanization worldwide and the impact of that change on nonhuman populations. Students observe nonhuman populations affected by urbanization in their community and read about three case studies of nonhuman populations that differ in urban and nonurban environments. These initial investigations prompt students to ask what is causing the differences they see in these populations.

Students create an initial model of how and why nonhuman populations could change because of urbanization and investigate each case study in more detail to uncover the mechanisms for change. They conduct an investigation of the impact of habitat fragmentation on seed dispersal strategies in hawksbeard plants. Students then investigate how rats in Tokyo could have become resistant to poison, gathering information from various studies to learn how genetic variations affect their physiology and survival rates. Students also investigate studies of juncos to see if bold behavior is advantageous for living close to people in urban environments.



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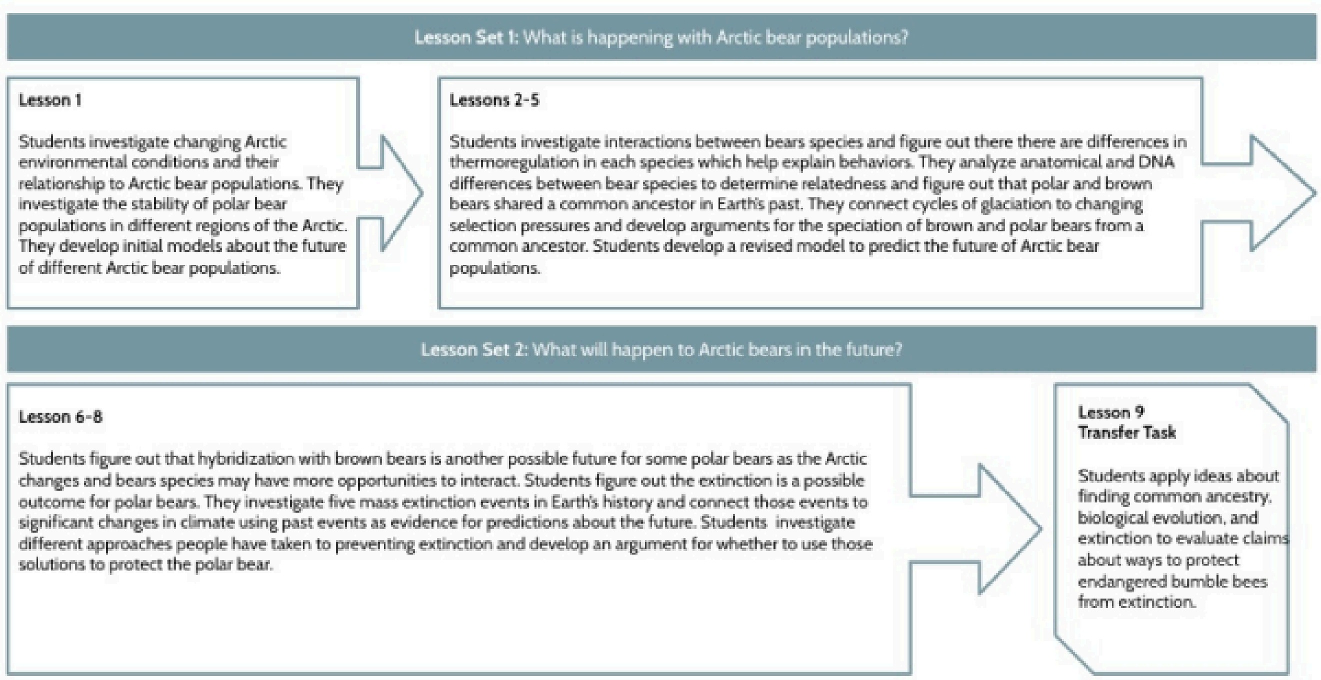
Unit B.5 This four-week unit is anchored by the unusual sightings of polar, brown, and black bears in Wapusk National Park. Students investigate why scientists find this so unusual and consider what this means for the future of the bears as the Arctic warms. Lessons 1-5 focus on figuring out how and why the Arctic bears interact in particular ways. Students figure out how past relationships between the species and conditions on Earth over geologic time can help them predict the future.

In lessons 6-9, students investigate the speed at which extinction and speciation events occurred in the past compared with changes in bears living in the modern-day Arctic experience. They figured out that hybridization is a possibility for Arctic bears. Students investigate ways humans have helped protect other species from extinction and debate what role humans should play in safeguarding Arctic bears and species in danger of extinction. This unit culminates with a Transfer Task where they apply all of their understanding of how to figure out why the bumble bee is threatened with extinction and to evaluate claims about ways to prevent extinction from occurring.



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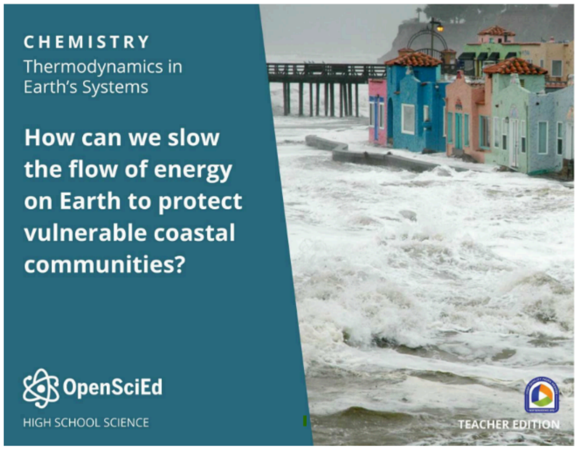
OpenSciEd Chemistry Scope and Sequence



Unit C.1 Students explore coastal communities affected by rising sea levels, forcing some communities to move. Students analyze data that show how sea level rise is historically connected to polar ice melt and temperature increases, and thorough data and investigation determine that the temperature increase is caused by humans releasing excess carbon dioxide into the atmosphere. Students develop energy transfer models based on evidence to illustrate how atmospheric carbon dioxide, more than any other factor, causes global temperature increases, polar ice melt, and sea level rise.

In this 6 week unit, students are introduced to two possible solutions and figure out how these solutions, along with decreasing carbon dioxide emissions, could help slow sea level rise. Since sea level rise is driven significantly by polar ice melt, it provides a meaningful context for students to consider anthropogenic climate change, its impacts, and physical science ideas around energy transfer. Students figure out how energy transfers on the molecular and Earth-systems levels through radiation, convection, and conduction.

Lesson Set 1: Why and how is the sea level rising?

Lesson 1

We observe a puzzling phenomenon: the sea level is rising in communities around the world, causing many people to migrate or take steps to protect their communities.

Lessons 2-4

We figure out that the sea level is rising because increased global temperatures are causing polar ice melt. We attribute increased temperatures to CO_2 released by people and determine the potential impact if Earth's land ice was to all or partially melt. We brainstorm potential solutions to the problem of polar ice melt and sea level rise.

Lesson Set 2: What solutions could help slow polar ice melt?

Lessons 5-7

We are introduced to microbeads and a berm as possible solutions to slow polar ice melt. We figure out that the microbeads solution would prevent energy from eventually being absorbed by carbon dioxide, thus disrupting a harmful feedback loop. We examine other feedback loops in the Earth system, describing positive and negative feedback loops involving different Earth spheres.

Transfer Task #1

We apply our ideas about feedback loops to think about how permafrost interacts with Earth systems.

Lesson Set 3: How well would the berm solution work in the context of Earth systems?

Lessons 8-9

We figure out from Inuit and scientific knowledge that the berm solution would work by stopping warm water from reaching the base of the glacier. We wonder why the warm water is at the bottom of the bay, investigate, and figure out that warm water is at the base due to density differences.

Lessons 10-11

We investigate how energy transfers between different-temperature liquids, then generalize these findings with simulations to quantify how energy transfers between different substances. We then investigate and quantify how much ice melts when energy is transferred to it.

Lessons 12-13

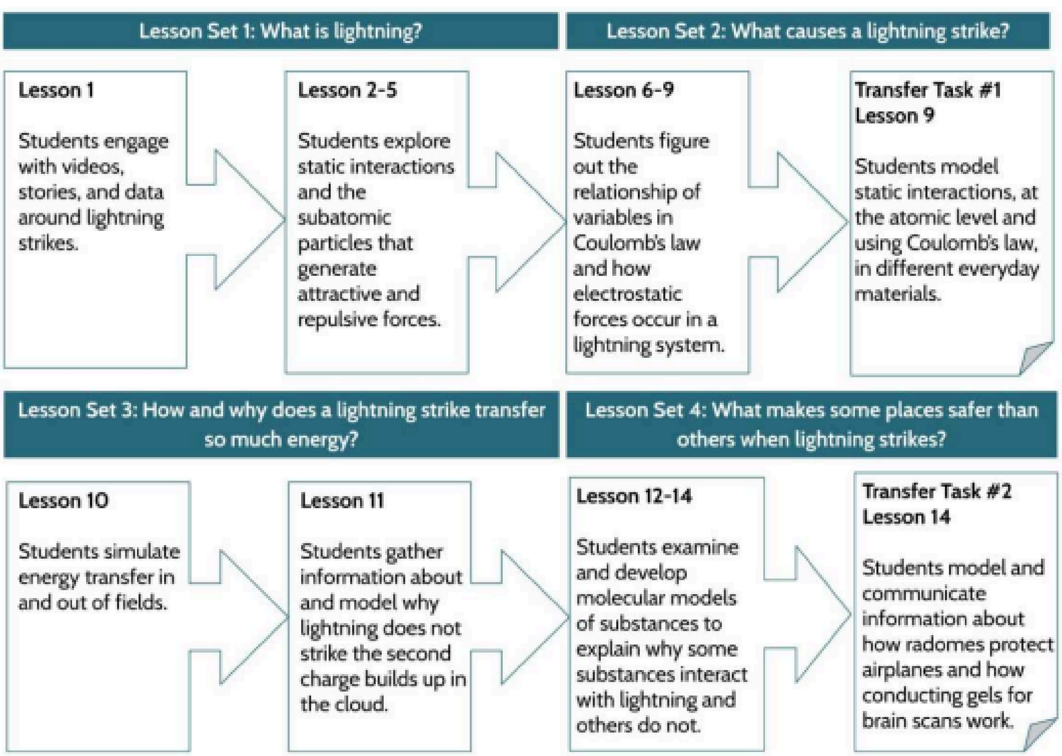
We put the pieces together from Lesson Set 3 by building a class consensus model of how a berm prevents glacier melting. We calculate the impact that the glacier could have, generate ideas for a computational model that could help us capture other ideas from the human about impacts on Earth systems, and use this model to answer questions about the impact of different changes on Earth's climate.

Transfer Task #2

We examine heat pumps and plan an investigation to troubleshoot a heat pump that is malfunctioning.

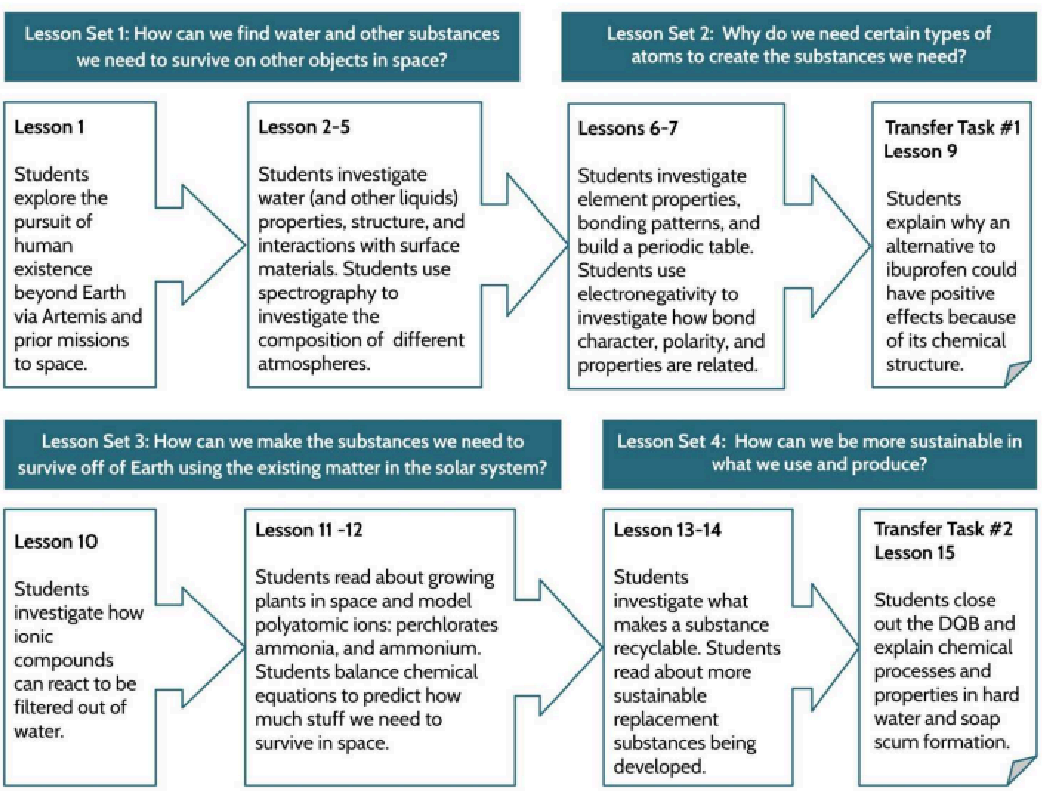
Unit C.2 This six-week unit is designed to help students build a deeper understanding of atomic structure and atomic-scale force interactions by exploring phenomena surrounding lightning and other static interactions. Students engage with stories and data about lightning and investigate a similar phenomenon in water droppers. They further investigate static interactions with various materials, including sticky tape, digging to the subatomic level.

Students apply these ideas back to lightning and further investigate force interactions, developing Coulomb's law and ideas about polarization that can be applied to other phenomena. They identify electric fields as the source of the large energy transfers in lightning and explain lightning's sudden behavior using ionization. Students consider why structures made of certain materials protect from lightning and investigate why bodies of water, most of which contain dissolved salts, are hazardous during storms. Finally, students develop a consensus model and transfer their understanding to the phenomena of airplane radomes and conducting gels used to simulate brains.



Unit C.3 This six-week unit is anchored by examining plans to live and work for more extended periods on the Moon (NASA Artemis mission). Students consider the constraints associated with this problem, which leads them to develop questions about how to find, recycle, and make the substances needed to live off Earth and on it. In lessons 1-5, students investigate planetary surface features (Earth's and Mars') to investigate water and its unique structure and function in erosion.

Students develop an understanding of physical science concepts of light and matter and Earth and space science concepts of spectroscopy to identify substances off Earth. They also learn about the structure of atoms, the patterns in their bonds, and the organization of the periodic table. Additionally, they develop the idea of conservation of matter through chemical equations in the context of various substances, including those that form ionic compounds and polyatomic ions. Finally, students consider applications of these ideas to issues related to recycling and sustainability.



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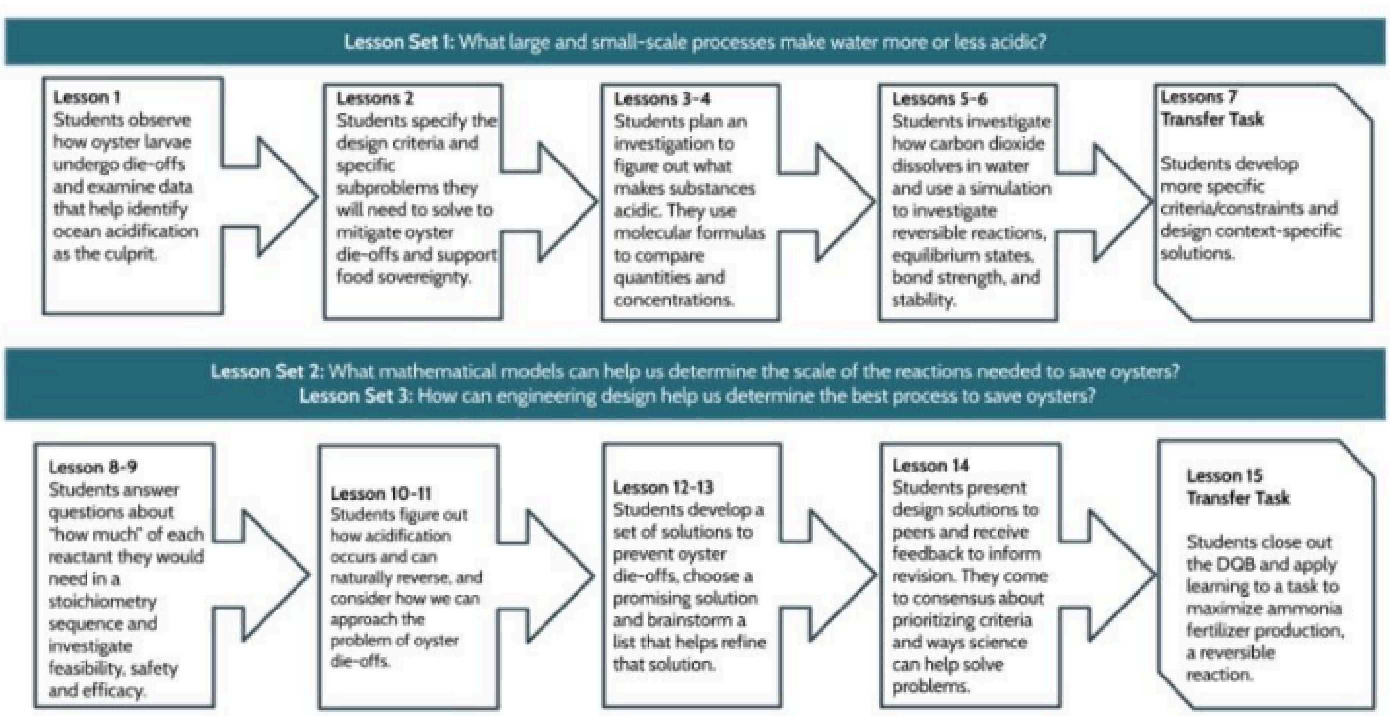
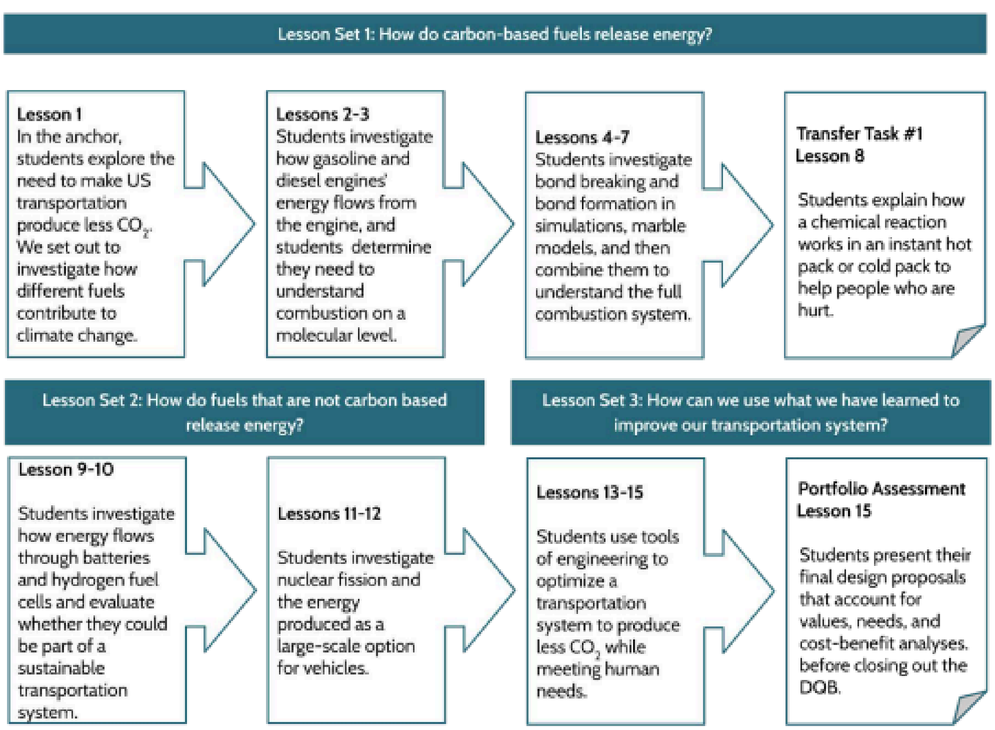
Unit C.4 This six-week unit is anchored by the phenomenon of oyster larvae die-offs. These overnight events became widespread in the Pacific Northwest in the mid-2000s as ocean pH reached a new low. Students learn that oyster die-offs occur in the Pacific Northwest due to ocean acidification. They decided to design solutions to help oysters and break the problem of oyster die-offs due to ocean acidification into smaller sub-problems.

Students investigate acids and bases, how carbon dioxide enters the ocean, and how carbon moves through some of Earth's systems. They use a computational model to figure out how acidification and other processes can naturally reverse due to shifts in chemical equilibrium. Students consider different groups of people's interest in solving the problem of oyster die-offs and engage in a mid-unit transfer task. Students begin by developing a mathematical model (of stoichiometry) that will allow them to determine how much of a base is needed to neutralize an acid. They apply this mo del to adding bases to oyster tanks to restore a healthy pH.

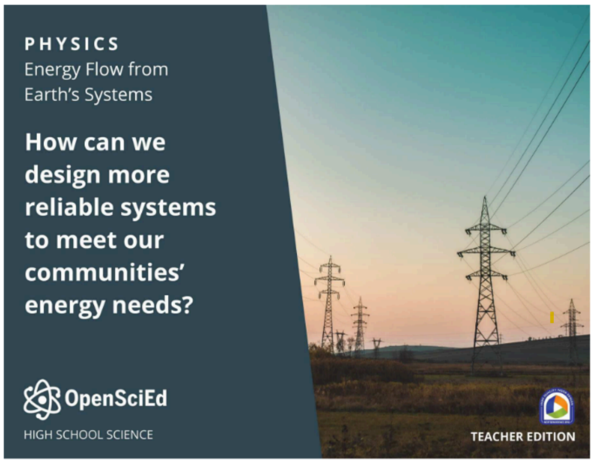


Unit C.5 This six-week unit is anchored by the problem of continuing carbon dioxide emissions from transportation, despite the harm it causes established throughout the rest of the course. Students explore fifteen fuels used for transportation, ranging from "human power" to fossil fuels, biofuels, batteries, hydrogen, and uranium. In Lessons 1-8, students leverage physical and computational model data to develop scientific ideas about how carbon-based fuels get energy from breaking and forming bonds, as energy transfers between particles and fields.

In Lessons 9-12, students explore the origins of energy in non-carbon-based fuels and consider the energy implications of different fuels. In Lessons 13-15, they examine transportation systems and use engineering thinking to evaluate the social impact of various fuels, including costs, availability, safety, and environmental effects. Throughout the unit, students use concepts of matter, energy, and forces to explain how different fuels power vehicles and evaluate potential future fuels using science concepts from the unit and new engineering tools developed from previous lessons.

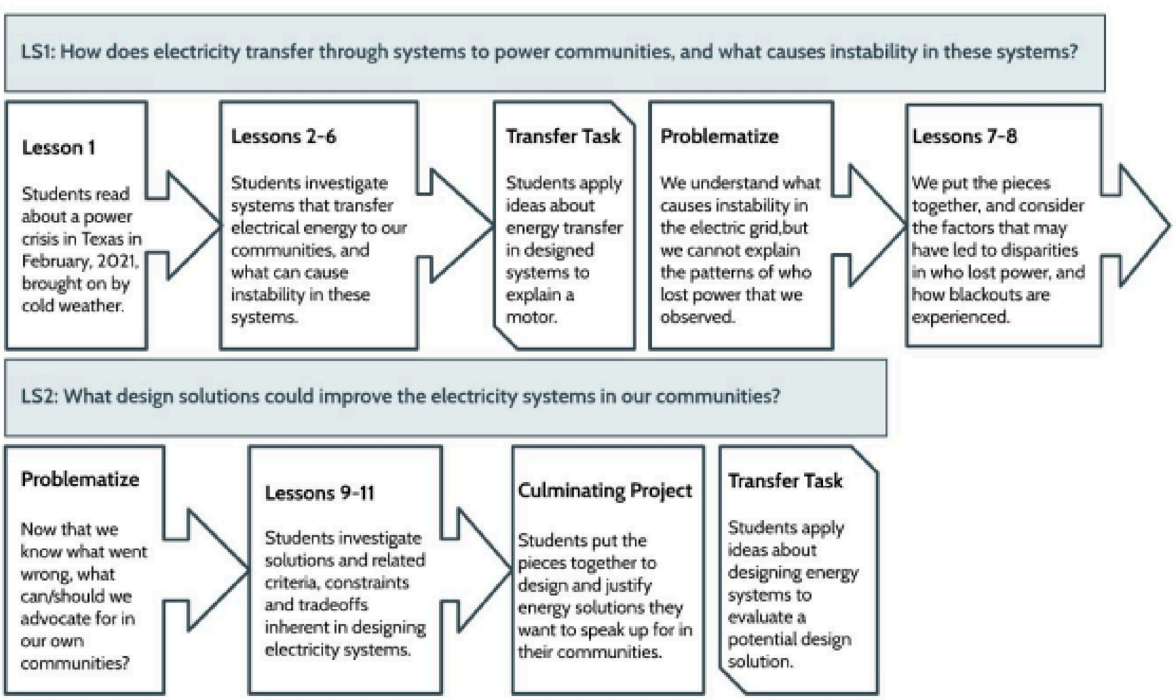


OpenSciEd Physics Scope and Sequence



Unit P.1 Students investigate the Texas power crisis of February 2021. Students read articles and wonder about the complex social, environmental, and physical realities that led to such a crisis. Students develop models for energy flow through our electrical infrastructure systems, from a generator to our communities. Students develop explanations regarding what happened in Texas at multiple scales, from the electrons in the wires to the power companies making difficult decisions.

In this 6 week students consider engineering trade-offs, criteria, and constraints inherent in making decisions about our energy systems, and apply them in a culminating task: design a reliable energy solution that meets our communities' needs, as articulated by interviews with friends and family members. The task is designed to support students in taking agency and to give students the tools to speak up in their local and global community for a better energy future, one that aligns with their own values, and those of their families.



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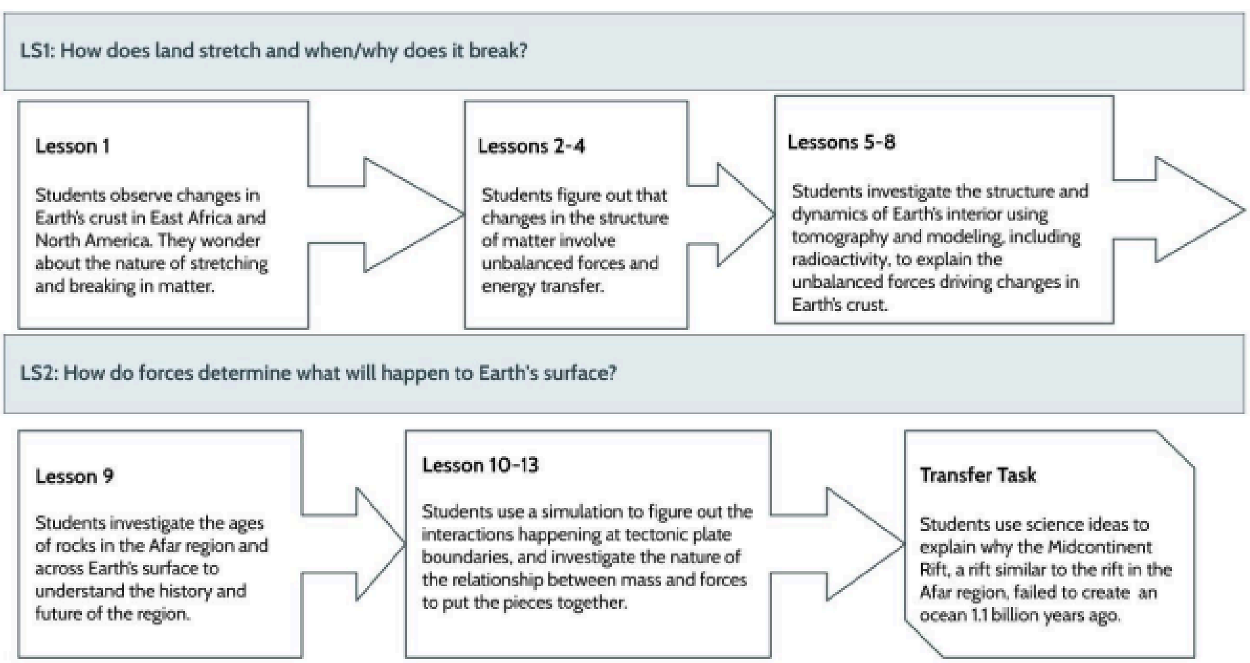
Unit P.2 This 6-week unit is anchored by a crack in Earth's crust that appeared in the Afar region in 2005. Earthquakes and volcanic eruptions also occurred around this time. Students read about the Afar event and other earthquakes in North America. Students look for similarities and differences in these earthquake events, prompting students to model the events before, during, and after the crack was discovered. Students figure out that changes in the structure of matter involve unbalanced forces and energy transfer, using this idea to explain earthquakes and volcanoes at plate boundaries.

Students then investigate the structure and dynamics of Earth's interior using tomography and modeling, including radioactivity, to explain the unbalanced forces driving changes in Earth's crust. Students investigate the ages of rocks to understand the history and future of the Afar region. Students use a simulation to figure out the interactions happening at tectonic plate boundaries and investigate the nature of the relationship between mass and forces on the movement of tectonic plates to explain the past, present, and potential future of the Afar region.



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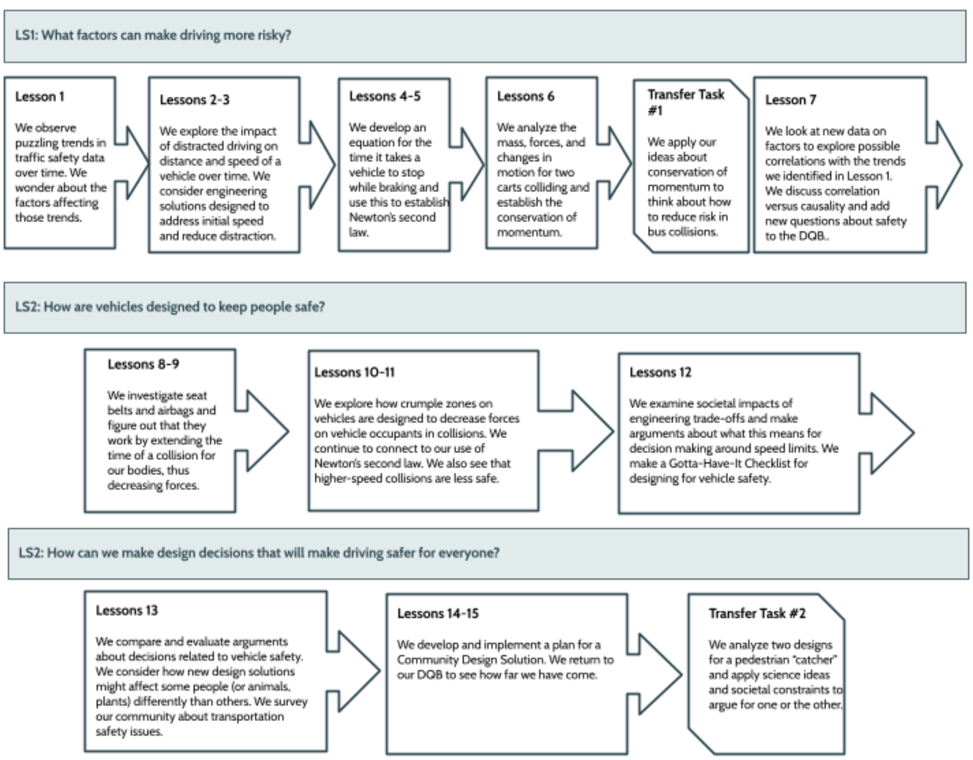
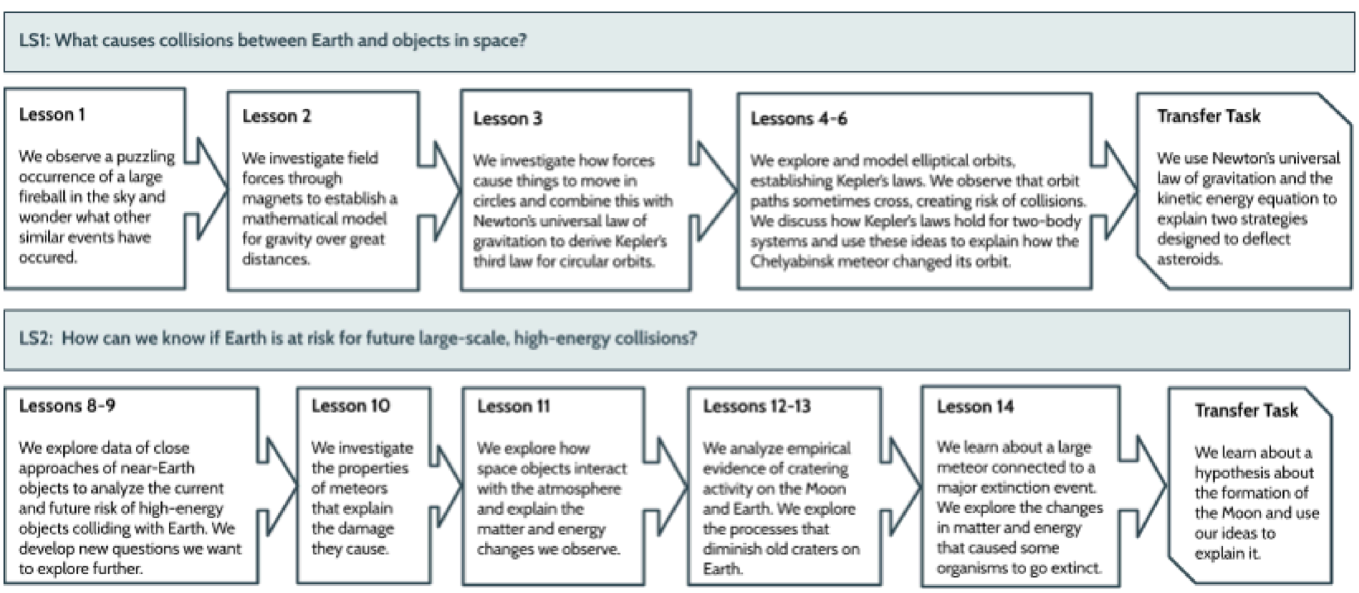
Unit P.3 This six-week unit is designed to introduce students to the concept of momentum and Newton's second law in an intuitive and grounded context. A puzzling set of patterns in traffic collision data over time anchors the learning. While overall vehicle fatalities have been decreasing steadily for decades, the trend appears to have reversed, with both collisions and fatalities increasing.

This phenomenon provides the context for investigating the physical relationships among mass, velocity, momentum, force, time, and acceleration, basic physical quantities that provide the foundation for the study of mechanics. Students will analyze statistics on vehicle collisions, analyze the motion of vehicles stopping short, and model vehicle collisions as part of an engineering task to reduce the chances of injury in a collision by testing and evaluating solutions that could change force interactions in the system.



Unit P.4 This six-week unit is anchored by a montage of video clips showing a fireball over Chelyabinsk in Siberia in 2013 that caused millions of dollars in damage and thousands of minor injuries, although no fatalities. This phenomenon provides the context for investigating forces at a distance, energy transfer, and the mechanics of orbits, including Kepler's laws and Newton's universal law of gravitation. By the end of Lesson 7, students will be able to explain how different strategies of meteor deflection to protect Earth from meteor impacts work.

In Lessons 8-15, students study Earth's history and future by analyzing data on near-Earth objects and predicting the likelihood of a high-energy collision. They investigate whether a meteor's mass or velocity affects the damage it can cause and examine how small objects burn up in Earth's atmosphere. By analyzing cratering on objects without atmospheres and evidence on Earth, they identify patterns in meteor impacts over time. They explore the Chicxulub crater and its connection to a mass extinction event, explaining how the impact caused both short-term and long-term effects. They evaluate their progress and complete a task on the Moon's formation.



Unit P.5 This five-week unit begins with a short news article explaining that some people use microwave ovens to store electronics, followed by a series of in-class demonstrations using a microwave oven, including playing music on a Bluetooth speaker from a device inside the oven and heating a plate of food.Students investigate wave properties and their relationships and learn about the production of electromagnetic radiation from electricity using a magnetron.

Students use a simulation to understand how moving a charged particle back and forth will create ripples in the electric field surrounding it that propagate through space as electromagnetic waves. They design investigations to understand better how microwaves, a type of electromagnetic wave, are contained in the oven and find evidence to build an explanation of wave reflection. Students use simulations to investigate how particles of different materials (water, plastic, metal) interact with changing electric fields and connect this particle-scale evidence to macroscopic evidence about materials heating up in the microwave oven.

Lesson Set 1: How does a microwave oven heat food?

Lesson 1
Students see that wireless signals change when they pass through the microwave oven walls/door and that food inside cooks without an obvious heat source.

Lessons 2-3
Students identify a relationship between moving electrons and changing electric fields. They develop a model of how physical waves transfer energy.

Lessons 4-5
Students figure out how moving charges create EM waves that transfer energy that can be absorbed, reflected, or transmitted by matter.

Lessons 6
Transfer Task
Students explain how an increase in greenhouse gases could contribute to the overall increase in global temperatures.

Lessons 7-8
Students investigate how the structure of the microwave oven and the polarity of matter explain patterns of energy transfer.

Lesson Set 2: How do we use EM radiation safely in our lives?

Lesson 9
Students construct the EM spectrum using wavelength and frequency of various types of EM radiation. They construct an argument that includes the uses of EM radiation.

Lesson 10
Students question whether higher frequency or amplitude leads to an increase in skin cancer and use multiple sources of evidence to identify patterns.

Lesson 11
Students investigate how interactions of x-rays with matter can be harnessed to create images as well as how EM radiation is used in wireless communication.

Lesson 12
Students develop ways to send messages with EM waves, use a simulation, and develop a model for how this system works and compares to digital communication.

Lesson 13
Transfer Task
Students evaluate claims about 5G radiation and use the model for EM radiation to argue about whether this technology is safe.

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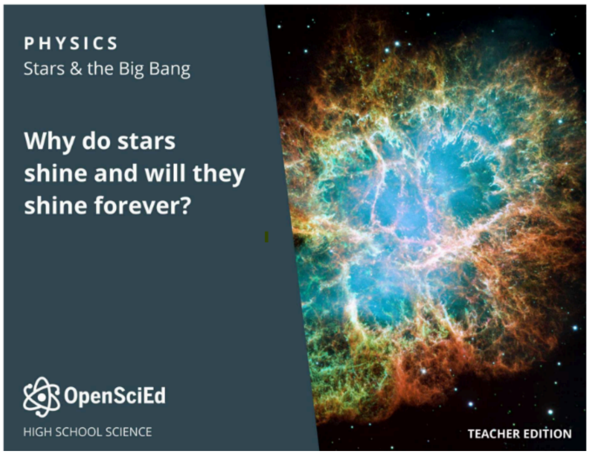

Unit P.6 This three-week unit is anchored by historical accounts of stars that suddenly appear and then disappear a short time later. Students wonder how some stars appear unchanging while these stars change so drastically within a short time. That gets students wondering why stars shine and what could cause stars to change. They organize their questions regarding matter, energy, and forces and decide to look more closely at the places in the sky where these historical events took place using modern technology.

In Lessons 2-5, students investigate photos and spectra of stellar remnants, develop research questions, and reach a consensus on fusion and the lifecycle of stars. Their research is guided by tools for planning, obtaining, and evaluating information. They learn that stars convert lighter elements like hydrogen and helium into heavier elements over millions or billions of years, prompting curiosity about the origins of these lighter elements. In Lessons 6-7, students use spectra clues and research tools to explore the Big Bang theory, concluding that the Universe expanded from a hot, dense state 14 billion years ago. They also reflect on the nature of scientific theories.