Fairfield Public Schools Curriculum

Grade(s):	10
Discipline/Course:	Science/Environmental Chemistry
Course Title:	Environmental Chemistry (Honors/College Prep)
Prerequisite(s):	Successful completion of 9th grade Biology
Course Description: *Program of Studies*	Environmental Chemistry is a year-long, laboratory-based, college preparatory course that integrates Chemistry with Earth Science concepts and meets the expectations of the Next Generation Science Standards. Students will explore the central role chemistry plays in addressing global challenges and opportunities of modern society to ensure we can achieve a sustainable future. Students will be asked to use evidence, evaluate claims, and develop models to interpret the unseen. Students begin with phenomena and use them to enhance their conceptual understandings of the following core ideas: The Origins and Structure of Matter; Chemical Reactions and Interactions in the Environment; Heat and Energy in the Earth System; The Chemistry of Living Systems; The Chemistry of Climate Change; and The Chemistry of Sustainability. This course lays the foundation for further study in the sciences and also serves as an AP Chemistry and AP Environmental Science preparedness course.
Course Essential Questions:	How can one explain the structure and properties of matter that make up our natural and human designed Earth system? How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them? How is energy transferred and conserved in natural and human designed systems? How can we sustainably meet the world's energy needs and other global challenges?

Course Enduring Understandings:	Energy cannot be created or destroyed-it only moves between one place and another place, between objects and/or fields, or between systems. Resource availability has guided the development of human society. The opportunities of modern society to address global challenges and ensure a sustainable future rely on the effective management of natural resources.
Duration:	Full year/1.0 credit
Course Materials/ Resources:	N/A There is no textbook associated with this course. Student and teacher materials will be compiled using a variety of primary scientific resources including but not limited to: National Oceanic and Atmospheric Administration, (NOAA), United States Geologic Society (USGS), American Association for the Advancement of Science (AAAS), Scientific American, American Chemical Society (ACS), American Association of Chemistry Teachers (AACT), National Association of Geoscience Teachers (NAGT)
FPS Course Academic Expectation(s):	Synthesizing and Evaluating Creating and Constructing

Unit Number and Title:	Unit 1: Nuclear Energy: The Atom, Radioactivity, and Human Energy Needs
Unit Overview:	In this unit, students investigate how a milk-gallon-sized amount of uranium could destroy a city, and explore how this energy might be used for good and whether it should be used at all. The unit begins with investigations into the basic structure or matter, the atom, and an exploration of the concepts of conservation of matter and energy. Students explore how geologic processes have resulted in naturally occurring radioactive minerals and how we can use geologic evidence to learn about Earth's past. Students investigate fission within a nuclear chain reaction, stable and unstable isotopes, and the role of the strong force within the nucleus in binding protons and neutrons together. The unit turns to how

	nuclear chain reactions are controlled in nuclear power plants and explores radiation associated with both enrichment of uranium and waste from nuclear reactors.
Learning Goals	
Standard(s):	**Scientific and Engineering Practices: (Highlighted Practices are Priority)** Asking Questions, **Engaging in Argument from Evidence**, **Construction Explanations & Designing Solutions**, **Developing & Using Models**, **Obtaining, Evaluating & Communicating Information**, Analyzing & Interpreting Data, Using Mathematics and Computational Thinking **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) **PS1.C: Nuclear Processes** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total

	energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) The availability of energy limits what can occur in any system. (HS-PS3-1) **ESS2.A: Earth Materials and Systems** Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3) The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **ESS3.A: Natural Resources** Resource availability has guided the development of human society. (HS-ESS3-1) All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be

	viewed as the surface expression of mantle convection. (HS-ESS2-3) Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1) **CCCs: Energy and Matter, Systems and System Models, Stability and Change, Scale, Proportion, and Quantity**
Essential Question(s):	How can nuclear material power our cities but also destroy them? How can one explain the structure and properties of matter that make up our Earth system?
Enduring Understanding(s):	In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved The total amount of energy and matter in closed systems is conserved. Energy cannot be created or destroyed-it only moves between one place and another place, between objects and/or fields, or between systems. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. Much of science deals with constructing explanations of how things change and how they remain

	stable.
Learning Goal(s): *Students will be able to use their learning to:*	**During this unit, students will meet the following NGSS Performance Expectations:** 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. **During this unit, students will be working towards the following NGSS Performance Expectations:** 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. 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. HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

Unit Number and Title:	Unit 2: Batteries: Elements, The Periodic Table, and Sustainable Design
Unit Overview:	Why are some elements so reactive and others are not? Why are some common and some rare? Can we predict the properties of elements using the periodic table? How can we leverage the properties of different elements to help us live more sustainably? In this unit, students will learn about the structure and properties of matter, periodic trends, and how humans use that knowledge to design and create new technologies that might help us live more sustainably in the future.
Learning Goals	
Standard(s):	**Scientific and Engineering Practices: (Highlighted Practices are Priority)**

	Asking Questions, **Planning and Carrying Out Investigations**, **Engaging in Argument from Evidence**, **Construction Explanations & Designing Solutions**, **Developing & Using Models**, **Obtaining, Evaluating & Communicating Information**, Analyzing & Interpreting Data **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1) The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3) **PS1.B Chemical Reactions** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-1),(HS-PS1-3),(HS-PS2-6) **PS3.B: Conservation of Energy and Energy Transfer** Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its

	configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) **ETS1.B Developing Possible Solutions** When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. **ESS3.A Natural Resources** Resource availability has guided the development of human society. (HS-ESS3-1) All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) **CCCs: Patterns; Structure and Function; Scale, Proportion, and Quantity**
Essential Question(s):	How can we sustainably meet the world's energy needs? How do the structure and interactions of matter guide the development of human society?
Enduring Understanding(s):	Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

	The significance of a phenomenon is dependent upon the scale, proportion, and quantity at which it occurs.
Learning Goal(s): *Students will be able to use their learning to:*	**During this unit, students will meet the following NGSS Performance Expectations:** 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. [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. HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. **During this unit, students will be working towards the following NGSS Performance Expectations:** 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. 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.

Unit Number and Title:	Unit 3: Water Resources: Chemical Interactions and Human Impact

Unit Overview:	How do human activities impact our water resources? Why are some of Earth's water resources becoming degraded? Water is essential to life, yet millions of people in the world - 1 in 9 (in 2021) - lack access to a reliable source of clean water. Water is characterized by its unique combination of physical and chemical properties that are central to our planet's dynamic system. Students will investigate water shortages and water pollution through the lenses of the interactions of matter at the bulk scale as well as the importance of responsible management of natural resources to sustain human societies and biodiversity.
Learning Goals	
Standard(s):	**Scientific and Engineering Practices:** **Asking Questions, Planning and Carrying out Investigations** **Construction Explanations & Designing Solutions**, **Developing & Using Models**, **Obtaining, Evaluating & Communicating Information**, Analyzing & Interpreting Data **Disciplinary Core Ideas:** **PS1.A Structure and Properties of Matter** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3) **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS1-1),(HS-PS1-3),(HS-PS2-6) **ESS2.C: The Roles of Water in Earth's Surface Processes** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5)

	ESS3.A: Natural Resources Resource availability has guided the development of human society. (HS-ESS3-1) **ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4) **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. **CCCs: Patterns, Cause and Effect,** Systems and System Models, **Stability and Change**
Essential Question(s):	How are water resources degraded through human activities? How can we sustainably manage our water resources?
Enduring Understanding(s):	Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

	Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Change and rates of change can be quantified and modeled over very short periods of time. Some system changes are irreversible.
Learning Goal(s): *Students will be able to use their learning to:*	**During this unit, students will meet the following NGSS Performance Expectations:** 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. 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. HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. **During this unit, students will be working towards the following NGSS Performance Expectations:** 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.

Unit Number and Title:	Unit 4: Chemistry of Human Impact on Ecosystems
Unit Overview:	How can animal behavior be traced to human caused changes? Why are populations of some organisms changing? Students will investigate how living systems are impacted by human designed chemical reactions that have been developed to meet human needs. Through studying these reactions, students

	will learn scientific principles regarding reaction rates and equilibrium in chemical systems. This unit highlights the central role of chemistry in understanding matter and energy relationships in the biosphere.
Learning Goals	
Standard(s):	**Scientific and Engineering Practices: (Highlighted Practices are Priority)** Asking Questions, Engaging in Argument from Evidence, **Construction Explanations & Designing Solutions**, **Developing & Using Models**, **Obtaining, Evaluating & Communicating Information**, Analyzing & Interpreting Data, **Using Mathematics and Computational Thinking** **Disciplinary Core Ideas:** **PS1.B: Chemical Reactions** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes **LS1.C: Organization for Matter and Energy Flow in Organisms** As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)

	LS2.B: Cycles of Matter and Energy Transfer in Ecosystems The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4) **ESS2.D Weather and Climate** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) **ESS2.E: Biogeology** The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. **ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) **CCCs: Cause and Effect, Energy and Matter, Systems and System Models, Stability and Change**
Essential Question(s):	How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them? How do human developed technologies and resource use impact natural systems?
Enduring Understanding(s):	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. The total amount of energy and matter in closed systems is conserved

	Feedback (negative or positive) can destabilize a system. Much of science deals with constructing explanations of how things change and how they remain stable.
Learning Goal(s): *Students will be able to use their learning to:*	**During this unit, students will meet the following NGSS Performance Expectations:** 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. 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. HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. **During this unit, students will be working towards the following NGSS Performance Expectations:** HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. 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.

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

Unit Number and Title:	Unit 5: Fuels: Chemical Reactions and Energy
Unit Overview:	What is a sustainable energy source for our transportation needs? Through investigating the answer to this question, students first look to chemical reactions and energy to really figure out *why* rearranging matter sometimes seems to result in a net increase or decrease in energy of the surroundings. They then zoom in to the atomic scale to build and refine models of bonding that help explain these changes in energy at the bulk scale. After linking atomic structure, attractive and repulsive forces, and bonding to endothermic and exothermic processes, students will look to questions of measurement. How do we quantify what is happening in a chemical reaction? How can we use this information to determine costs and benefits of different fuels?
Learning Goals	
Standard(s):	**Scientific and Engineering Practices: (Highlighted Practices are Priority)** Asking Questions, Engaging in Argument from Evidence, **Construction Explanations & Designing Solutions**, **Developing & Using Models**, **Obtaining, Evaluating & Communicating Information**, Analyzing & Interpreting Data, **Using Mathematics and Computational Thinking** **Disciplinary Core Ideas:** **PS1.A: Structure and Properties of Matter** A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

	PS1.B: Chemical Reactions Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5) The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7) **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)

	Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) **ESS3.A: Natural Resources** Resource availability has guided the development of human society. (HS-ESS3-1) All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) **CrossCutting Concepts:** **Energy and Matter, Systems and System Models, Stability and Change**
Essential Question(s):	How does our reliance on fossil fuels impact Earth? How is energy transferred and conserved in natural and human designed systems?
Enduring Understanding(s):	Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. The total amount of energy and matter in closed systems is conserved. When investigating or describing a system, the boundaries and initial conditions of the system need to

	be defined.
Learning Goal(s): *Students will be able to use their learning to:*	**During this unit, students will meet the following NGSS Performance Expectations:** 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. 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. HS-PS1-7: Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. 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. HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials **During this unit, students will be working towards the following NGSS Performance Expectations:** 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.

Unit Number and Title:	Unit 6: Addressing Global Climate Change: Matter and Energy in the Earth System
Unit Overview:	Why is the Earth's average temperature rising? What's happening to the Earth's polar ice sheets? Why are we seeing more extreme weather events? What are the solutions to our greatest global challenge? Students will apply their understanding about matter and energy within the Earth system from previous units to investigate global climate change as well as it's impact on local communities.
Learning Goals	
Standard(s):	**Scientific and Engineering Practices:** Asking Questions, **Engaging in Argument from Evidence**, **Construction Explanations & Designing Solutions**, **Developing & Using Models**, **Obtaining, Evaluating & Communicating Information**, **Analyzing & Interpreting Data, Using Mathematical and Computational Thinking** **Disciplinary Core Ideas:** **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) The availability of energy limits what can occur in any system. (HS-PS3-1)

	Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-4) **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HSESS2-1),(HS-ESS2-2) **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-2),(HS-ESS2-4) Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7) Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS26),(HS-ESS2-4) Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. **ESS3.D: Global Climate Change** Though the magnitudes of human impacts are greater than they have ever been, so too are human

	abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6 **ETS1.A Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them **CCCs: Energy and Matter, Systems and System Models, Stability and Change, Cause and Effect**
Essential Question(s):	How can we sustainably meet the challenge of global climate change?
Enduring Understanding(s):	Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Feedback (negative or positive) can destabilize a system. Models can be used to predict the behaviour of a system, but these predictions have limited precision or reliability due to the assumptions and approximations inherent in the model.
Learning Goal(s): *Students will be able to use their learning to:*	**During this unit, students will meet the following NGSS Performance Expectations:** 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. HS-PS3-4: Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). 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. HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* 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's systems. 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.