NGSS Standards: Which Relate To Climate Change Or It's Effects?

It can be a real puzzle to identify standards that you can use to teach climate change lessons. Some standards mention the term "climate change" and some just include the phrases like "human impact." Others refer to engineering challenges that might apply to any regeneration or resilience efforts that communities can use to deal with climate change, but the language is generic, the standard does not mention climate change itself. This first table describes how standards might address climate change in very different ways, note that the last half of the types below (6-9) do not mention CC explicitly.

Types of Possible Links to CC in Standards	**How Do These Standards Mention Or "Hint At" Their Relationship To Climate Change?**
1. Direct references to climate	Refers to climate system or weather dynamics
2. Direct references to climate change	Mentions that climate changes, either naturally or through anthropogenic forcing
3. Direct or indirect (negative) human impacts on climate	Encompasses direct anthropogenic influences on climate or that exacerbate existing climate change risks
4. How humans will be affected by climate change	Describes present or future climate-related risks for humans or for the more-than-human world
5. Engineering for mitigation or adaptation of climate risks	Engineering standards that directly reference challenges with lowering or adapting to specific climate risks.
6. Foundational geophysical knowledge, potentially applicable to climate change	Expresses a fundamental idea from the domains of chemistry, physics, or earth sciences more broadly that students could use to understand or incorporate into an explanation for a variety of climate change phenomena
7. Foundational biological knowledge	Expresses a fundamental idea from the domain of biology that students could use to understand or incorporate into an explanation for a variety of climate change phenomena
8. Downstream biological effects	Describes a scientific principle that could be used to understand or explain biological systems phenomena that is part of a cascade of climate change effects
9. Foundational engineering applications	Engineering standards that refer to broad principles which could be used to study, mitigate, or adapt to climate change risks, but do not mention climate change.

The remaining tables below use the categories above to identify all climate-relevant disciplinary core ideas (DCIs) and performance expectations (PEs) in the NGSS. Many states have adopted these standards for their own use. In doing so, many have modified some of the standards or have used descriptors other than DCIs or PEs. Remember, most of the engineering standards in the NGSS are not specific to any context with regard to their approaches to problem-solving or design, so only those that reference some aspect of climate science are included below, labeled as *engineering mitigation or adaptation to climate change*.

Grade level K	
Energy (K-PS3)	
DCI: Sunlight warms the Earth's surface (PS3.B)	Foundational geophysical knowledge
PE: Make observations to determine the effect of sunlight on Earth's surface. (K-PS3-1)	Foundational geophysical knowledge
PE: Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area. (K-PS3-2)	Engineering mitigation or adaptation to CC
Earth's Systems (K-ESS2)	
DCI: Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (ESS2.D)	Direct references to climate or weather
DCI: Plants and animals can change their environment. (ESS2.E)	Foundational biological knowledge
PE: Use and share observations of local weather conditions to describe patterns over time. (K-ESS2-1)	Direct references to climate or weather
PE: Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. (K-ESS2-1)	Foundational biological knowledge
Earth and Human Activity (K-ESS3)	
DCI: Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (ESS3.A)	Foundational knowledge biological
DCI: Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (ESS3.B)	Direct references to climate or weather
DCI: Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (ESS3.C)	Direct or indirect human impacts on climate
PE: Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. (K-ESS3-1)	Foundational biological knowledge
PE: Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. (K-ESS3-2)	Direct references to climate or weather
PE: Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. (K-ESS3-3)	Engineering mitigation or adaptation to CC

Grade level 1: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
Waves and their Applications (1-PS4)	
DCI: Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. (PS4.B)	Foundational geophysical knowledge
PE: Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. (1-PS4-3)	Foundational geophysical knowledge
Heredity: Inheritance and Variation of Traits (1-LS3)	
DCI: Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly, like their parents. (LS3.A)	Foundational biological knowledge
DCI: Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (LS3.B)	Foundational biological knowledge
PE: Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. (1-LS3-1)	Foundational biological knowledge
Earth's Place in the Universe (1-ESS1)	
DCI: Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (ESS1.A)	Foundational geophysical knowledge
PE: Use observations of the sun, moon, and stars to describe patterns that can be predicted. (1-ESS1-1)	Foundational geophysical knowledge
PE: Make observations at different times of year to relate the amount of daylight to the time of year. (1-ESS1-2)	Foundational geophysical knowledge

Grade level 2: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
Matter and its Interactions (2-PS1)	
DCI: Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (PS1.B)	Foundational geophysical knowledge
Ecosystems: Interactions, Energy, and Dynamics (2-LS2)	
PE: Plan and conduct an investigation to determine if plants need sunlight and water to grow. (2-LS2-1)	Foundational biological knowledge
Biological Evolution: Unity and Diversity (2-LS4)	
DCI: There are many different kinds of living things in any area, and they exist in different places on land and in water. (LS4.D)	Foundational biological knowledge
PE: Make observations of plants and animals to compare the diversity of life in different habitats. (2-LS4-1)	Downstream biological effects of CC
Earth's Place in the Universe (2-ESS1)	
DCI: Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (ESS1.C)	Foundational geophysical knowledge
PE: Use information from several sources to provide evidence that Earth events can occur quickly or slowly. (2-ESS1-1)	Foundational geophysical knowledge
Earth's Systems (2-ESS2)	
DCI: Maps show where things are located. One can map the shapes and kinds of land and water in any area. (ESS2.B)	Foundational geophysical knowledge
DCI: Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (ESS2.C)	Foundational geophysical knowledge

Grade level 3: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
From Molecules to Organisms: Structures and Processes (3-LS1)	
DCI: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (LS1.B)	Foundational biological knowledge
PE: Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. (3-LS1-1)	Foundational biological knowledge
Heredity: Inheritance and Variation of Traits (3-LS3)	
DCI: Many characteristics of organisms are inherited from their parents. (LS3.A)	Foundational biological knowledge
DCI: Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (LS3.A)	Foundational biological knowledge
DCI: Different organisms vary in how they look and function because they have different inherited information. (LS3.B)	Foundational biological knowledge
DCI: The environment also affects the traits that an organism develops. (LS3.B)	Foundational biological knowledge
PE: Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. (3-LS3-1)	Foundational biological knowledge
PE: Use evidence to support the explanation that traits can be influenced by the environment. (3-LS3-2)	Foundational biological knowledge
Biological Evolution: Unity and Diversity (3-LS4)	
DCI: When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (LS2.C)	Downstream biological effects of CC
DCI: Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. (LS4.A)	Foundational biological knowledge
DCI: Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (LS4.B)	Foundational biological knowledge
DCI: For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (LS4.C)	Foundational biological knowledge
DCI: Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (LS4.D)	Foundational biological knowledge
PE: Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. (3-LS4-1)	Foundational biological knowledge
PE: Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. (3-LS4-2)	Foundational biological knowledge
PE: Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. (3-LS4-3)	Foundational biological knowledge
Earth's Systems (3-ESS2)	
DCI: Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (ESS2.D)	Direct references to climate or weather
DCI: Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (ESS2.D)	Direct references to climate or weather
PE: Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. (3-ESS2-1)	Direct references to climate or weather

PE: Obtain and combine information to describe climates in different regions of the world. (3-ESS2-2)	Direct references to climate or weather
Earth and Human Activity (3-ESS3)	
DCI: A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (ESS3.B)	Engineering mitigation or adaptation to CC
PE: Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard. (3-ESS3-1)	Engineering mitigation or adaptation to CC

Grade level 4: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
Energy 4-PS3)	
DCI: Light transfers energy from place to place. (PS3.B)	Foundational geophysical knowledge
DCI: The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (PS3.D)	Foundational geophysical knowledge
PE: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (4-PS3-2)	Foundational geophysical knowledge
Waves and their Applications in Technologies (4-PS4)	
DCI: Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (PS4.A)	Foundational geophysical knowledge
PE: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. (4-PS4-1)	Foundational geophysical knowledge
Earth's Systems (4-ESS2)	
DCI: Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (ESS2.A)	Foundational geophysical knowledge
PE: Analyze and interpret data from maps to describe patterns of Earth's features. (4-ESS2-2.)	Foundational geophysical knowledge
Earth and Human Activity (4-ESS3)	
DCI: Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (ESS3.A)	Direct or indirect human impacts on climate
DCI: A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (ESS3.B)	Engineering mitigation or adaptation to CC
PE: Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment. (4-ESS3-1)	Direct or indirect human impacts on climate
PE: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* (4-ESS3-2)	Engineering mitigation or adaptation to CC

Grade level 5: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
Energy (5-PS3)	
DCI: The energy released [from] food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (PS3.D)	Foundational biological knowledge
PE: Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. (5-PS3-1)	Foundational biological knowledge
From Molecules to Organisms: Structures and Processes (5-LS1)	
DCI: Plants acquire their material for growth chiefly from air and water. (LS1.C)	Foundational biological knowledge
PE: Support an argument that plants get the materials they need for growth chiefly from air and water. (5-LS1-1)	Foundational biological knowledge
Ecosystems: Interactions, Energy, and Dynamics (5-LS2)	
DCI: The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem. (LS2.A)	Foundational biological knowledge
DCI: Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (LS2.B)	Foundational biological knowledge
PE: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (5-LS2-1)	Foundational biological knowledge
Earth's Systems (5-ESS2)	
DCI: Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (ESS2.A)	Direct references to climate or weather
DCI: Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (ESS2.C)	Foundational geophysical knowledge
PE: Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. (5-ESS2-1)	Direct references to climate or weather
Earth and Human Activity (5-ESS3)	
DCI: Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (ESS3.C)	Direct or indirect human impacts on climate

Grade level Middle School: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
Matter and Its Interactions (MS-PS1)	
DCI: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (PS1.A)	Foundational geophysical knowledge
DCI: Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (PS1.A)	Foundational geophysical knowledge
DCI: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from the reactants. (PS1.B)	Foundational geophysical knowledge
DCI: Some chemical reactions release energy, others store energy. (PS1.B)	Foundational geophysical knowledge
DCI: The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (PS3.A)	Foundational geophysical knowledge
DCI: The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule. The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (PS3.A)	Foundational geophysical knowledge
PE: Develop models to describe the atomic composition of simple molecules and extended structures. (MS-PS1-1)	Foundational geophysical knowledge
PE: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (MS-PS1-2)	Foundational geophysical knowledge
PE: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (MS-PS1-3)	Engineering mitigation or adaptation to CC
Energy (MS-PS3)	
DCI: Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (PS3.A)	Foundational geophysical knowledge
DCI: The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (PS3.B)	Foundational geophysical knowledge
DCI: Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (PS3.B)	Foundational geophysical knowledge
Waves and Their Applications (MS-PS4)	
DCI: A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (PS4.A)	Foundational geophysical knowledge
DCI: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on its material and the frequency (color) of the light. (PS4.B)	Foundational geophysical knowledge
PE: Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. (MS-PS4-1)	Foundational geophysical knowledge
PE: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. (MS-PS4-2)	Foundational geophysical knowledge
From Molecules to Organisms: Structures and Processes (MS-LS1)	
DCI: Genetic factors as well as local conditions affect the growth of the adult plant. (LS1.B)	Foundational biological knowledge

DCI: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (LS1.C)	Foundational biological knowledge
DCI: Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (LS1.C)	Foundational biological knowledge
DCI: The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. (PS3.D)	Foundational biological knowledge
DCI: Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (PS3.D)	Foundational biological knowledge
Ecosystems: Interactions, Energy, and Dynamics (MS-LS2)	
DCI: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (LS2.A:)	Foundational biological knowledge
DCI: In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (LS2.A)	Foundational biological knowledge
DCI: Growth of organisms and population increases are limited by access to resources. (LS2.A)	Foundational biological knowledge
DCI: Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (LS2.B)	Foundational biological knowledge
DCI: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (LS2.C)	Downstream biological effects of CC
DCI: Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (LS2.C)	Downstream biological effects of CC
DCI: Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (LS4.D)	Downstream biological effects of CC
PE" Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. (MS-LS2-1)	Foundational biological knowledge
PE: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (MS-LS2-2)	Foundational biological knowledge
PE: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (MS-LS2-3)	Foundational biological knowledge
Heredity: Inheritance and Variation of Traits (MS-LS3)	
DCI: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (LS1.B)	Foundational biological knowledge
Biological Evolution: Unity and Diversity (MS-LS4)	
DCI: The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (S4.A)	Foundational biological knowledge

DCI: Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (LS4.B)	Foundational biological knowledge
DCI: In artificial selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (LS4.B)	Engineering mitigation or adaptation to CC
DCI: Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (S4.C)	Downstream biological effects of CC
PE: Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. (MS-LS4-1)	Foundational biological knowledge
Earth's Place in the Universe (MS-ESS2)	
DCI: This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (ESS1.B)	Foundational geophysical knowledge
DCI: The geologic time scale interpreted from rock strata provides a way to organize Earth's history .Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.(ESS1.C)	Foundational geophysical knowledge
Earth's Systems (MS-ESS2)	
DCI: All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (ESS2.A)	Foundational geophysical knowledge
DCI: The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (ESS2.A)	Foundational geophysical knowledge
DCI: Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (ESS2.C)	Direct references to climate or weather
DCI: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (ESS2.C)	Direct references to climate or weather
DCI: Global movements of water and its changes in form are propelled by sunlight and gravity. (ESS2.C)	Direct references to climate or weather
DCI: Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (ESS2.D)	Direct references to climate or weather
DCI: Because these patterns are so complex, weather can only be predicted probabilistically. (ESS2.D)	Direct references to climate or weather
DCI: The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (ESS2.D)	Direct references to climate or weather
Earth and Human Activity (MS-ESS3)	
DCI: Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and	Direct or indirect human impacts on climate

many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (ESS3.A)	
DCI: Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (ESS3.C)	Direct or indirect human impacts on climate
DCI: Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (ESS3.C)	Direct or indirect human impacts on climate
DCI: Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (ESS3.D)	Direct or indirect human impacts on climate
PE: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (MS-ESS3-2)	Engineering mitigation or adaptation to CC
PE: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. (MS-ESS3-3)	Direct or indirect human impacts on climate
Engineering Design (MS-ETS1)	
PE: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS-ETS1-1)	Engineering mitigation or adaptation to CC

Grade level High School: Climate-relevant Disciplinary Core Ideas (DCIs) and Performance Expectations (PEs)	
Matter and Its Interactions (HS-PS1)	
DCI: 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. (PS1.B)	Foundational geophysical knowledge
Motion and Stability: Forces and Interactions (HS-PS2)	
DCI: Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (PS3.A)	Foundational geophysical knowledge
Energy (HS-PS3)	
DCI: 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. (PS3.A)	Foundational geophysical knowledge
DCI: At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (PS3.A)	Foundational geophysical knowledge
DCI: 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. (PS3.A)	Foundational geophysical knowledge
DCI: 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. (PS3.B)	Foundational geophysical knowledge
DCI: Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (PS3.B)	Foundational geophysical knowledge
PE: 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-PS3-1)	Foundational geophysical knowledge
PE: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (HS-PS3-3)	Engineering mitigation or adaptation to CC
Waves and Their Applications (HS-PS4)	
DCI: Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (PS3.D)	Engineering mitigation or adaptation to CC
DCI: The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (PS4.A)	Foundational geophysical knowledge
DCI: When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (PS4.B)	Foundational geophysical knowledge
DCI: Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (PS4.B)	Engineering mitigation or adaptation to CC
PE: Use mathematical representations to support a claim about relationships among the frequency, wavelength, and speed of waves traveling in various media. (HS-PS4-1)	Foundational geophysical knowledge
From Molecules to Organisms: Structures and Processes (HS-LS1)	
DCI: The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (LS1.C)	Foundational biological knowledge

DCI: The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells. (LS1.C)	Foundational biological knowledge
DCI: As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (LS1.C)	Foundational biological knowledge
Ecosystems: Interactions, Energy, and Dynamics (HS-LS2)	
DCI: Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (LS2.A)	Foundational biological knowledge
DCI: Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (LS2.B)	Foundational biological knowledge
DCI: Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. 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. (LS2.B)	Foundational biological knowledge
DCI: Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (LS2.B)	Foundational biological knowledge
DCI: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (LS2.C)	Foundational biological knowledge
DCI: Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (LS2.C)	Direct or indirect human impacts on climate
DCI: Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (LS4.D)	Foundational biological knowledge
DCI: Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (LS4.D)	Direct or indirect human impacts on climate
PE: Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. (HS-LS2-1)	Foundational biological knowledge

PE: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. (HS-LS2-2)	Foundational biological knowledge
Heredity: Inheritance and Variation of Traits (HS-LS3)	
DCI: Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (LS3.B)	Foundational biological knowledge
Biological Evolution: Unity and Diversity (HS-LS4)	
DCI: The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (LS4.B)	Foundational biological knowledge
DCI: Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (LS4.C)	Foundational biological knowledge
DCI: Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (LS4.C)	Foundational biological knowledge
DCI: Adaptation also means that the distribution of traits in a population can change when conditions change. (LS4.C)	Foundational biological knowledge
DCI: Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (LS4.D)	Direct or indirect human impacts on climate
PE: 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. (HS-LS4-3).	Foundational biological knowledge
Earth's Systems (HS-ESS2)	
DCI: Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (ESS1.B)	Direct references to climate change
DCI: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (ESS2.A)	Foundational geophysical knowledge
DCI: 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. (ESS2.A)	Direct references to climate change
DCI: 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	Foundational geophysical knowledge

amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (ESS2.C)	
DCI: 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. (ESS2.D)	Foundational geophysical knowledge
DCI: Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (ESS2.D)	Foundational biological knowledge
DCI: Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (ESS2.D)	Direct or indirect human impacts on climate
DCI: 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. (ESS2.E)	Foundational biological knowledge
PE: 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-ESS2-2)	Foundational geophysical knowledge
Earth and Human Activity (HS-ESS3)	
DCI: 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. (ESS2.D)	Direct or indirect human impacts on climate
DCI: 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. (ESS3.A)	Engineering mitigation or adaptation to CC
DCI: The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (ESS3.C)	Direct or indirect human impacts on climate
DCI: Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (ESS3.C)	Engineering mitigation or adaptation to CC
DCI: 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. (ESS3.D)	Direct or indirect human impacts on climate
DCI: 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. (ESS3.D)	Direct or indirect human impacts on climate
PE: 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-ESS3-5)	Direct references to climate change
PE: 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-ESS3-1)	How humans will be affected by climate change
PE: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. (HS-ESS3-2)	Engineering mitigation or adaptation to CC