Seventh Grade Performance Targets

for the
South Carolina College- and Career-Ready Science Standards 2021

For use 2025-2026

July 2025

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Contents

Purpose and Use

Science is a way of understanding the physical universe using observation and experimentation to explain natural phenomena. Science also refers to an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines. As science educators we must take a 3-dimensional approach in facilitating student learning. By addressing content, science and engineering practices and crosscutting concepts, students can have relevant and evidence-based instruction that can help solve current and future problems.

This document is intended as a guide for discerning and describing features of students and their work who have met the stated Performance Expectation (PE). This document is not intended to be read from cover to cover, but to be used, when needed, to support teacher professional learning and curriculum decisions. This is not intended for student use, and thus is not written in student-friendly language. This is not a curriculum or a means to limit instruction in the classroom. Although each PE states a dedicated Science and Engineering Practice (SEP) and Crosscutting Concept (CCC), students will need to use the whole range of SEPs and CCCs to achieve success by the end of instruction.

Three-dimensional science learning requires discipline specific communication skills. This means that effective science learning occurs when students are expected to speak, listen, read, and write in ways that are appropriate to science. With each Performance Target, there are question/sentence stems and terminology to support student discourse about phenomena to help teachers facilitate the acquisition of science discourse. Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding. The terms and stems in this section are intended to provide a baseline for teachers, neither list is exhaustive nor complete.

In addition to the doing (SEP), thinking (CCC), and learning of science knowledge (Disciplinary Core Ideas) outlined here, students will also require a working knowledge of grade-level appropriate tools and techniques of science. Students should know and recognize how scientists and engineers use these tools and techniques, not just identify them. Students should be able to use these tools to gather data, describe how these tools gather data, and/or interpret data sampled from them. These tools and techniques for Grade 7 include all those previously identified and add or emphasize:

- beaker
- digital balance
- graduated cylinder
- graduated syringe
- heat lamp
- hot plate
- meter stick/ruler
- microscope
- thermometer
- timing device
- triple beam balance

Document Updates

July 2025

- All Performance Expectation statements have been reformatted to call out each of the dimensions as follows:
  - Science and Engineering Practice – **bold**
  - Crosscutting Concept – *italicize*
  - Disciplinary Core Idea - regular
- The watermark from previous versions of this resource has been replaced with the wording "For use 2025-2026" on the title page and in the footer. This change was made to improve accessibility of this resource.
- Because scientific notation is no longer an expectation of the math standards, the following PEs have a new statement related to the use and application of scientific notation.
  - 7-PS1-1
  - 7-PS3-2
  - 7-LS2-1
  - 7-ESS3-4
- Additional Terminology
  - 7-LS2-2
    - autotroph
    - consumer
    - decomposer
    - heterotroph
    - producer
  - 7-LS2-3
    - autotroph
    - heterotroph
  - 7-LS2-4
    - abiotic
    - autotroph
    - biotic
    - heterotroph
  - 7-ESS3-3
    - trade-off

June 2024

- Updated watermark to 2024-2025.
- Adjusted formatting and grammar.

PS1 – Matter and Its Interactions

7-PS1-1. Develop *models to describe the atomic* composition of simple molecules and extended structures.

> ***Clarification Statement:*** Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended atomic structures will assist students in making sense of different phenomena such as how diamonds and graphite can both be made of pure carbon. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.
> ***State Assessment Boundary:*** Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and **Using Models** Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to predict and/or describe phenomena.	**PS1.A: Structure and Properties of Matter** Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).	**Scale, Proportion,** **and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

*Although beyond the SAB, an understanding of the ionic nature of subunits helps to clarify why extended structures form the way they do.

*Because atomic masses and molecular quantities are very small, students may need to understand and apply the conventions of scientific notation when working with measured quantities.

Observable features of student performance by the end of the course:

1. **Components of the model**
   a. Students develop/use a model (for example: chemical formulae, periodic table, etc.) to represent the atomic composition of simple molecules (for example: ammonia, carbon dioxide, oxygen, methane, sodium chloride, water, etc.) and extended structures. Students identify the relevant components, including:
      i. individual atoms,
      ii. molecules,
      iii. extended structures with repeating subunits, and
      iv. state of matter (limited to gases, liquids, solids).
2. **Relationships**
   a. Students describe relevant relationships between components of a model, including:
      i. Individual atoms—two or more—combine to form molecules, which can be made up of the atoms of the same element (for example: oxygen- O_2, ozone- O_3, etc.) or atoms of different elements (for example: NaCl—table salt, $C_6H_{12}O_6$—glucose, etc.).
      ii. Some molecules can bond to each other.
      iii. In some molecules:
         1. atoms of the same element repeat forming monatomic molecules (for example: noble gases), and/or
         2. molecules composed of the atoms of two or more different elements repeat (for example: crystals).

3. **Connections**
    a. Students develop/use a model to describe and/or predict that:
        i. Pure substances are made up of a bulk quantity of individual atoms or molecules.
        ii. Each pure substance is made up of the following:
            1. individual atoms of the same element connected to form extended structures (for example: diamond/graphite, gold, silver, etc.);
            2. individual atoms of different elements (limited to: molecules) that repeat to form extended structures (for example: sodium chloride, water, etc.);
            3. individual atoms that are not attracted to each other (for example: noble gases—helium, neon, etc.);
            4. molecules composed of the atoms of different elements that are not attracted to each other (for example: carbon dioxide, etc.);
            5. molecules composed of the atoms of different elements that are attracted to each other (for example: sugar, sodium chloride, etc.); and/or
            6. molecules of the same type of atom that are not attracted to each other (for example: oxygen, etc.).
    b. Students develop/use models to describe how the behavior of bulk substances depends on the structures of the substances at atomic and molecular levels.

7-PS1-1 Academic Language

Question/Sentence Stems

- The quantity of ________ and ________ can be compared.
- The proportion of ________that is ________ is ________.
- The scale of the model of ________ is ________compared to the actual objects.
- To understand the phenomenon of ________, I can use a scale of ________in my model.
- I need to use a scaled model because ________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- atom
- bond
- chemical formula
- chemical symbol
- combination
- compound
- crystal
- diatomic molecule
- element
- gas
- heterogeneous
- homogeneous
- isomer
- liquid
- matter
- mixture
- molecular structure
- molecule
- monatomic molecule
- noble gas
- periodic table
- phase change
- product
- properties
- pure substance
- reactant
- solid
- solute
- solution
- solvent
- state of matter

7-PS1-2. Analyze and interpret data *on the properties of substances* before and after the substances interact to determine if a chemical reaction has occurred.

Clarification Statement: Examples of reactions could include burning sugar or steel wool, milk curdling, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.

State Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze and interpret data to determine similarities and differences in findings.	**PS1.A: Structure and Properties of Matter** Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **PS1.B: Chemical Reactions** 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 those of the reactants.	**Patterns** Macroscopic patterns are related to the nature of microscopic and atomic- level structure.

Observable features of student performance by the end of the course:

1. **Organizing data**
    a. Students organize data about the characteristic chemical and physical properties (for example: boiling point, density, flammability, melting point, odor, solubility, etc.) of pure substances before (reactants) and after (products) a chemical reaction.
2. **Identifying relationships**
    a. Students analyze datasets to identify patterns (limited to differences and similarities), including the changes in chemical and physical properties of each substance before and after a chemical reaction.

3. **Interpreting data**
    a. Students use analyzed data to determine whether a chemical reaction has occurred.
    b. Students support their interpretation(s) of data by describing that the change in properties of substances is related to the arrangement of atoms before and after a chemical reaction.

7-PS1-2 Academic Language

Question/Sentence Stems

- I/We can observe (notice) the pattern of ________ presented in the data collected.
- I/We can observe (notice) the pattern of ________ in the data presented.
- The pattern seen in the collected data allows me/us to conclude (know) that ______.
- The observed pattern supports the conclusion that ________ is caused by ________, because ________.
- What are some similarities and differences among the observations/data?

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- atom
- boil
- boiling point
- chemical bond
- chemical reaction
- color
- compound
- condense
- density
- dissolve
- element
- energy
- evaporate
- flammability
- freeze
- freezing point
- gas
- interference
- liquid
- mass
- matter
- melt
- melting point
- molecule
- odor
- product
- property
- pure substance
- reactant
- solid
- solubility
- volume

7-PS1-3. Gather and make sense of information to describe that synthetic materials come from *natural resources and impact society*.

> ***Clarification Statement:*** Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, plastic made from petroleum, and alternative fuels.
> ***State Assessment Boundary:*** Assessment is limited to qualitative data.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods. Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	**PS1.A: Structure and Properties of Matter** Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. **PS1.B: Chemical Reactions** 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 those of the reactants. **ETS2.A: Interdependence of Science, Engineering, and Technology** Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.	**Structure and Function** Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

Observable features of student performance by the end of the course:

1. **Obtaining Information**
    a. Students obtain information from at least two published credible sources (for example: data, media, models, text, visual displays, etc.) about:
        i. synthetic materials and the natural resources from which they are derived,
        ii. chemical processes used to create synthetic materials from natural resources, and
        iii. societal need for synthetic material.
2. **Evaluating information**
    a. Students evaluate and describe whether the gathered information is relevant for determining:
        i. that synthetic materials, via chemical reactions, come from natural resources and
        ii. the effects of the manufacture and use of synthetic materials on society.
    b. Students determine the accuracy, credibility, and bias of informational sources.
    c. Students synthesize information that is presented (for example: diagrams, graphs, models, text, etc.) to describe how:
        i. synthetic materials are manufactured, including the required natural resources and chemical processes;
        ii. the properties of the synthetic material(s) that make it different from the natural resource(s) from which it was derived/manufactured;
        iii. the chemical and physical properties contribute to the function of the synthetic material;
        iv. the synthetic material meets a societal need or desire through the properties of its structure and function; and/or
        v. manufacturing and using synthetic materials effects natural resources and society.

7-PS1-3 Academic Language

Question/Sentence Stems

- The ______ materials help _______ to function because _______.
- This system performs _______ (describe functions). I think the materials enable those functions by _______.
- I think the function of _______ is supported by the structure of _______ in the system because _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- atom
- chemical property
- combustible
- conductive
- dissolve
- flammable
- matter
- mineral
- molecules
- natural gas
- natural resource
- negative impact
- oil
- petroleum
- physical property
- positive impact
- product
- reactant
- separation (for mixtures)
- synthetic

7-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction *and thus mass is conserved*.

Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms.
State Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to describe unobservable mechanisms.	**PS1.B: Chemical Reactions** 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 those of the reactants. The total number of each atom is conserved, and thus the mass does not change. Some chemical reactions release energy, others store energy.	**Energy and Matter** Matter is conserved because atoms are conserved in physical and chemical processes.

Observable features of student performance by the end of the course:

1. **Components of the model**
    a. Students develop/use a model (for example: photosynthesis, respiration, other simple chemical equations) to identify the relevant components for a chemical reaction, including:
        i. number of atoms of each element composing the molecules of the reactants and
        ii. number of atoms of each element composing the molecules of the products.

2. **Relationships**
    a. Students develop/use a model to describe the relationship between the relevant components, including:
        i. that a molecule of a reactant is made up of:
            1. the same elements and
            2. the same number of atoms of each element,
        ii. when a chemical reaction occurs, the atoms that make up the molecules of the reactants are rearranged to form new molecules (products),
        iii. atoms (element and number) that make up the products are equal to the atoms (element and number) that make up the reactants, and
        iv. each atom of an element has the same mass (limited to atomic mass).
3. **Connections**
    a. Students develop/use a model to describe that:
        i. The total number of atoms of each element found in the molecules of the reactants is equal to the total number of atoms of each element found in the new molecules of the product.
        ii. Mass is conserved during chemical reactions because, the mass of each atom remains the same, regardless of the molecules in which the atom is found.

7-PS1-5 Academic Language

Question/Sentence Stems

- What happens to _____ when you put it together with _____?
- Is there more, less, or the same of _____ when you combine it with _____?
- What happens to the matter in the system when _____?

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- atom
- atomic mass
- chemical bond
- chemical formula
- chemical reaction
- conserve
- dissolve
- element
- energy
- gas
- liquid
- mass
- matter
- molecule
- particle
- phase change
- product
- reactant
- solid
- solution
- state

7-PS1-6. Undertake a design project to construct, test, and modify a device *that either releases or absorbs* thermal energy by chemical processes.

Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride, combining baking soda and vinegar, or combining sodium bicarbonate tablets and water.
State Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.	**PS1.B: Chemical Reactions** Some chemical reactions release energy, others store energy. **ETS1.B: Developing Possible Solutions** A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. **ETS1.C: Optimizing the Design Solution** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.	**Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system.

Observable features of student performance by the end of the course:

1. **Using scientific knowledge to generate design solutions**
    a. Students design/construct a device to heat or cool, including:
        i. identifying the components within the system related to the design solution, including:
            1. the components within the system to or from which energy will be transferred to solve the problem and
            2. the chemical reaction(s) and the substances that will be used to either release or absorb thermal energy via the device;
        ii. describing how the transfer of thermal energy between the device and other components within the system will be tracked and used to solve a problem.
2. **Describing criteria and constraints, including quantification when appropriate**
    a. Students describe the criteria, including:
        i. features of a problem that are to be solved by the device, and
        ii. absorption or release of thermal energy by the device via a chemical reaction.
    b. Students describe the design constraints, which may include:
        i. availability and cost of materials,
        ii. time (for example: construction, function, etc.), and/or
        iii. safety.
3. **Evaluating potential solutions**
    a. Students evaluate a designed solution for its ability to solve the problem via the release or absorption of thermal energy.
    b. Students use the results of tests to systematically determine how well the design solution meets the criteria and constraints and which characteristics of the design solution performed best.
4. **Modifying the design solution**
    a. Students modify a device design based on the results of iterative testing and improve the design relative to the criteria and constraints.

7-PS1-6 Academic Language

Question/Sentence Stems

- _______________ happens to matter as it moves within the system.
- The energy is leaving the system by _______________.
- In this system, energy is entering by __________, doing _______ in the system, and leaving the system by __________.
- The energy for _____________ is from ___________.
- When you put energy into this system ___________.
- The flow of energy causes ______________ to occur in the system.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- chemical bond
- chemical change
- chemical potential energy
- chemical reaction
- compound
- concentration
- condense
- conduction
- conductor
- convection
- dissolve
- endothermic
- environment
- equilibrium
- evaporate
- exothermic
- insulator
- molecule
- optimize
- product
- prototype
- radiation
- reactant
- soluble/solubility
- solution
- system
- thermal energy

PS3 - Energy

7-PS3-1. Construct and interpret graphical displays of data to describe *the proportional relationships of* kinetic energy to the mass of an object and to the speed [sic] of an object.

> ***Clarification Statement:*** Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and being hit by a wiffle ball versus a tennis ball.
> ***State Assessment Boundary:*** Assessment does not include mathematical calculations of kinetic energy.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Construct and interpret graphical displays of data to identify linear and nonlinear relationships.	**PS3.A: Definitions of Energy** Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed [sic].	**Scale, Proportion, and Quantity** Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.

*There is a relationship between kinetic energy (KE) and velocity (v, speed with a directional component) as expressed within the formula $KE=1/2m*v^2$. Students are not expected to know the types of function for each graphical relationship, these are included below for teacher clarification.

Observable features of student performance by the end of the course:

1. **Organizing data**
   a. Students construct and use graphical displays to organize the following data:
      i. mass (m) of the object (units: g, kg),
      ii. velocity (v) of the object (units: m/s, m/min, km/min; km/h), and
      iii. kinetic energy (KE) of the object (unit: J).
         1. *Students need to understand that the joule is derived from an object's mass and its velocity but are not expected to calculate this value.

2. **Identifying relationships**
    a. Students use graphical displays of data to identify that kinetic energy:
        i. increases as mass, velocity, or both increase, or
        ii. decreases as mass, velocity, or both decrease.
3. **Interpreting data**
    a. Using analyzed data, students describe:
        i. The relationship between kinetic energy and mass has a direct relationship (linear function).
            1. Kinetic energy increases as the mass of an object increases.
            2. Kinetic energy decreases as the mass of an object decreases.
        ii. The relationship between kinetic energy and velocity has a direct relationship (quadratic function).
            1. Kinetic energy increases (quadruples) as the velocity of the object increases (doubles).
            2. Kinetic energy decreases (by a factor of four) as the velocity of the object decreases (by half).

7-PS3-1 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______ when comparing the [*quantity of mass/velocity*] and _______.
- ______ caused the patterns of ______ that I am observing. I know this because _____.
- The fact that the data showed that _______ always happened [after/whenever] _______ occurred means that _______ causes _______ because _______.
- If _ [*describe a change in the quantity of mass or velocity*] _ happens, I/we predict that _______ will occur because_______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- acceleration
- conversion
- deceleration
- elastic collision
- energy transfer
- inelastic collision
- inertia
- kinetic energy
- linear
- magnitude
- motion energy
- non-linear
- potential energy
- proportional
- ratio
- square root
- stationary
- vector
- velocity

7-PS3-2. Develop a model *to describe that when the arrangement of objects interacting* at a distance changes, different amounts of potential energy are stored *in the system*.

Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.

State Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to describe unobservable mechanisms.	**PS3.A: Definitions of Energy** A system of objects may also contain stored (potential) energy, depending on their relative positions. **PS3.C: Relationship Between Energy and Forces** When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object.	**Systems and System Models** Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems.

*The equation for potential energy (*PE*) is $PE = mgh$, where m is the mass of the object, g is acceleration (for objects on Earth, $g = 9.8\ m/s^2$) and h is the height (unit: meters [m]).

*Because distances between objects can be large or small, students may need to understand and apply the conventions of scientific notation when working with measured quantities.

Observable features of student performance by the end of the course:

1. **Components of the model**
   a. Students develop/use a model (conceptual, graphical, physical, etc.) of two objects interacting at a distance to identify the relevant components, including:
      i. system of two objects that interact,
      ii. potential energy (*PE*) (unit: joule [J]),
      iii. forces involved and units, when appropriate:
         1. force (F) (for example: weight, push, pull) (unit: newton [N]),
         2. electric PE (unit: volt [V]),
         3. gravity (g) (unit: m/s^2), and
         4. magnetic PE,
      iv. mass (m) of the objects (for example: unit: mg, g, kg), and
      v. distance (h) between the objects (for example: units: mm, cm, m, km).
2. **Relationships**
   a. Students develop/use a model to identify and describe relationships between components, including:
      i. When two objects interact at a distance, each object exerts a force on the other that can cause the transfer of energy between the objects.
      ii. As the relative position of two objects (neutral, charged, or magnetic) changes, the potential energy of the system changes dependent on the acting force (electric, gravitational, magnetic).
3. **Connections**
   a. Students develop/use a model to describe the relationship between the amounts of potential energy in a system between two stationary objects. Potential energy changes when the distance between two objects changes because:
      i. force must be applied to move two attractive objects farther apart, transferring energy into the system and/or
      ii. force must be applied to move two repellant objects together, transferring energy into the system.

7-PS3-2 Academic Language

Question/Sentence Stems

- The key components of the system are _________.
- In the system, _________ and _________are shown in the model.
- In the system, __________ and _________ work together to________.
- In the system, _________ and _________ interact in _________ way.
- If you change _________ in the system, _________ will occur.
- In the system, ______ is not shown in the model. This is not shown because _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- acceleration
- acceleration of gravity
- conductor
- distance
- distribution of charged particles
- electrical charge
- electromagnet
- electron
- force
- Gravity
- height
- insulator
- kinetic energy
- magnetic polarity
- mass
- momentum
- negatively charged
- neutrally charged
- period
- positively charged
- potential energy
- power
- proton
- speed
- spring
- velocity
- work

7-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, *energy is transferred* to or from the object.

> ***Clarification Statement:*** Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of the object.
> ***State Assessment Boundary:*** Assessment does not include calculations of energy.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon.	**PS3.B: Conservation of Energy and Energy Transfer** When the motion energy of an object changes, there is inevitably some other change in energy at the same time.	**Energy and Matter** Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

Observable features of student performance by the end of the course:

1. **Supported claims**
    a. Students make, support, or refute a claim that when the kinetic energy of an object changes, the energy is transferred to or from that object.
2. **Identifying scientific evidence**
    a. Students identify and describe the evidence used to support or refute a claim (for example: data, media, text, visual displays, etc.), including:
        i. the change in observable features (for example: motion, temperature, sound, etc.) of an object before and after the interaction that changes the kinetic energy and
        ii. the change in observable features of other components in the defined system.

3. **Evaluating and critiquing the evidence**
    a. Students evaluate the evidence and identify its strengths and weaknesses, including:
        i. types of sources,
        ii. sufficiency, including validity and reliability, of the evidence to make and defend the claim, and
        iii. any alternative interpretations of the evidence and why the evidence supports or does not support the claim as opposed to other claims.
4. **Reasoning and synthesis**
    a. Students use the following chain of reasoning to connect the appropriate evidence to support or refute a claim:
        i. Based on changes in the observable features of the object (for example: motion, temperature, sound, etc.), the kinetic energy of the object changed.
        ii. When the kinetic energy of the object increases or decreases, the energy of other components of the system increases or decreases, indicating that energy was transferred to or from the object.

7-PS3-5 Academic Language

Question/Sentence Stems

- _______ shows that _______ is the evidence that energy is being conserved in this system because _______.
- The flow of energy between _______ and _______ drives the changes to the system as seen by _______ because _______.
- In this system, energy is entering by _______, doing _______ in the system, and leaving the system by _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- air resistance
- Celsius
- chemical energy
- closed system
- conservation of energy
- electrical energy
- energy transfer
- force
- friction
- heat energy
- joule
- kinetic energy
- light energy
- mass
- mechanical energy
- open system
- pendulum
- potential energy
- pull
- push
- sound energy
- thermometer
- transformation of energy
- work

LS1 – From Molecules to Organisms: Structures and Processes

7-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in *the cycling of matter and flow of energy* into and out of organisms.

> ***Clarification Statement:*** Emphasis is on tracing movement of matter and flow of energy.
> ***State Assessment Boundary:*** Assessment does not include biochemical mechanisms of photosynthesis.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**LS1.C: Organization for Matter and Energy Flow in Organisms** 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. 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. In most animals and plants, oxygen reacts with carbon-containing molecules (sugars) to provide energy and produce carbon dioxide; anaerobic bacteria achieve their energy needs in other chemical processes that do not require oxygen. **PS3.D: Energy in Chemical Processes and Everyday Life** The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen (*secondary*).	**Energy and Matter** Within a natural system, the transfer of energy drives the motion and/or cycling of matter.

Observable features of student performance by the end of the course:

1. **Articulating the explanation of phenomena**
    a. Students articulate a statement that describes/explains that photosynthesis results in the cycling of matter and energy into and out of organisms.
2. **Evidence**
    a. Students identify and describe evidence necessary to construct an explanation, including:
        i. Producers (for example: plants, algae, and other photosynthetic microorganisms) require light energy (for example: sunlight, artificial light) and must take in carbon dioxide and water to survive.
        ii. Light energy is used to combine simple inorganic molecules (for example: carbon dioxide and water) into carbon-based molecules (for example: carbohydrates, sugar) and release oxygen, which can be used immediately or stored by the plant.
        iii. Consumers take in carbon-based molecules and oxygen to provide energy and materials for growth and survival.
        iv. Some consumers (primary) eat producers and some consumers (for example: secondary, tertiary, etc.) eat other consumers, which have themselves eaten photosynthetic organisms.
    b. Students use multiple valid and reliable sources of evidence.
3. **Reasoning**
    a. Students use the following chain of reasoning to connect the evidence and support or refute an explanation for energy and matter cycling during photosynthesis:
        i. Light energy drives the cycling of matter through the process of photosynthesis.
        ii. Producers (for example: plants, algae, and other photosynthetic microorganisms) take in matter (in the form of carbon dioxide and water) and use light energy to produce carbon-based organic molecules, which they can use immediately or store, and release oxygen into the environment through photosynthesis.
        iii. Producers use the carbon-based organic molecules produced and oxygen released through photosynthesis for energy, growth, and other necessary functions (for example: repair, reproduction, seed production, etc.).

iv. Consumers depend on matter from producers for growth and survival, including:
    1. Eating photosynthetic organisms (or other organisms that have eaten photosynthetic organisms), thus acquiring the carbon-based organic molecules that were produced through photosynthesis.
    2. Breathing in oxygen, which was released when producers used light energy to rearrange carbon dioxide and water during photosynthesis.

v. As photosynthetic organisms utilize light energy to chemically change the arrangements of atoms in molecules ($6H_2O$ + $6CO_2$ yields $C_6H_{12}O_6$ + $6O_2$) they create an energy storage molecule (sugar) that they and other living organisms can utilize.

7-LS1-6 Academic Language

Question/Sentence Stems

- __________ happens to matter as it moves within the system.
- The energy is leaving the system by __________.
- In this system, energy is transforming from __________ energy to _________ energy.
- The energy for __________ is from __________.
- When you put energy into this system _________.
- The flow of energy causes _________ to occur in the system.
- The energy is entering the system by _______.
- In the system, the cycling of matter occurs as __________ turns into _________.
- The matter in the system enters from _________.
- When the matter leaves the system, it goes _________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- atom
- carbon (C)
- carbon dioxide (CO_2)
- chemical energy
- chemical reaction
- chloroplast
- conserve
- consumer
- convert
- decomposer
- energy
- energy transfer
- glucose ($C_6H_{12}O_6$)
- matter
- microorganism
- molecule
- nutrient
- organelle
- organic
- organic matter
- organic molecule
- organism
- oxygen (O_2)
- photosynthesis
- primary consumer
- producer
- product
- reactant
- reaction
- secondary consumer
- solar energy
- tertiary consumer
- water (H_2O)

7-LS1-7. Develop a model to describe how *food molecules in plants and animals are rearranged* through chemical reactions forming new molecules that support growth and/or release energy *as this matter moves* through an organism.

Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.
State Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to describe unobservable mechanisms.	**LS1.C: Organization for Matter and Energy Flow in Organisms** 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. **PS3.D: Energy in Chemical Processes and Everyday Life** 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. (*secondary*).	**Energy and Matter** Matter is conserved because atoms are conserved in physical and chemical processes.

Observable features of student performance by the end of the course:

1. **Components of the model**
   a. Students develop/use a model (conceptual, graphical, physical, etc.) of how carbon-based molecules are rearranged as matter moves through an organism identifying the relevant components, including:
      i. Carbon-based molecules (for example: carbohydrates, sugar),
      ii. Oxygen,
      iii. Energy that is released or absorbed during biochemical reactions (for example: photosynthesis, cellular respiration, etc.), and
      iv. New types of molecules (for example: carbohydrates, lipids, proteins, nucleic acids) produced through biochemical reactions.

2. **Relationships**
    a. Students develop/use a model to identify and describe the relationships between components, including:
        i. During cellular respiration, carbon-based molecules (limited to glucose—$C_6H_{12}O_6$) undergo chemical reactions with oxygen, releasing stored energy.
        ii. The atoms are rearranged through biochemical reactions to form new molecules (for example: carbohydrates, lipids, proteins, nucleic acids).
3. **Connections**
    a. Students develop/use a model to describe:
        i. The number of each type of atom being the same before and after biochemical reactions (for example: balancing photosynthesis and respiration equations), indicating that the matter is conserved as it moves through an organism to support growth.
        ii. That all matter (atoms) used by the organism for growth comes from the products of the biochemical reactions (for example: photosynthesis, cellular respiration, etc.) involving the matter taken in by the organism.
        iii. Carbon-based molecules taken in by the organism are broken down and can then be rearranged to become the molecules that comprise the organism.
        iv. As complex molecules are rearranged, energy is released and can be used to support other processes within the organism.

7-LS1-7 Academic Language

Question/Sentence Stems

- _______ happens to matter as it moves within the system.
- The energy is leaving the system by _______.
- In this system, energy is entering by _______, doing _______ in the system, and leaving the system by _______.
- The energy for _______ is from _______.
- When you put energy into this system _______.
- The flow of energy causes _______ to occur in the system.
- The energy is entering the system by _______.
- In the system, the cycling of matter _______.
- The matter in the system enters from _______.
- When the matter leaves the system, it goes _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- adenosine triphosphate (ATP)
- atom
- biochemical reaction
- carbon (C)
- carbon dioxide (CO_2)
- cellular respiration
- chemical reaction
- chloroplast
- conserve
- consumer
- convert
- decomposer
- energy
- energy transfer
- glucose ($C_6H_{12}O_6$)
- mitochondrion
- molecular bond
- molecule
- nutrient
- organelle
- organic
- organic matter
- organic molecule
- oxygen (O_2)
- photosynthesis
- producer
- product
- reactant
- reaction
- rearranged
- water (H_2O)

LS2 – Ecosystems: Interactions, Energy, and Dynamics

7-LS2-1. Analyze and interpret data to provide evidence for *the effects of* resource availability on organisms and populations of organisms in an ecosystem.

Clarification Statement: Emphasis is on cause-and-effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.
State Assessment Boundary: Assessment does not include determining the carrying capacity of ecosystems.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Analyzing and Interpreting Data Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyze and interpret data to provide evidence for phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. 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. Growth of organisms and population increases are limited by access to resources.	**Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

*Because population sizes and resource quantities can be large, students may need to understand and apply the conventions of scientific notation when working with measured quantities.

Observable features of student performance by the end of the course:

1. **Organizing data**
    a. Students organize data that represent:
        i. Populations (for example: sizes, reproduction rates, growth information, etc.) of organisms as a function of resource availability.
        ii. Growth of individual organisms as a function of resource availability.

2. **Identifying Relationships**
    a. Students analyze datasets to identify and describe relationships (including relationships that can be used to predict outcomes in response to change), including:
        i. between the size of a population,
        ii. the growth and survival of individual organisms, and
        iii. resource availability.
3. **Interpreting data**
    a. Students use analyzed data to make predictions, including:
        i. Changes in the amount and availability of a given resource (for example: less food) may result in changes in the population of an organism (for example: less food results in fewer organisms).
        ii. Changes in the amount or availability of a resource (for example: more food) may result in changes in the growth of individual organisms (for example: more food results in faster growth).
        iii. Resource availability drives competition among organisms, both within and between populations.
        iv. Resource availability may have effects on a population's rate of reproduction.

7-LS2-1 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I determined that _________ caused _________.
- _________ caused the patterns I am observing. I know this because _________.
- If _______ happens, I predict that _________ will occur.
- When I change _________ in the system, _________ is affected.
- The evidence _________ presented in the scenario supports the claim that _________ causes _________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- biomass
- biotic
- carrying capacity
- competition
- consumer
- ecosystem
- food chain/web
- instability
- interspecific competition
- intraspecific competition
- limited resource
- niche
- nutrient
- population
- producer
- resource
- stability

7-LS2-2. Construct an explanation that *predicts patterns of interactions* among organisms across multiple ecosystems.

Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena.	**LS2.A: Interdependent Relationships in Ecosystems** Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared.	**Patterns** Patterns can be used to identify cause- and-effect relationships.

Observable features of student performance by the end of the course:

1. **Articulating the explanation of phenomena**
    a. Students articulate a statement that describes/explains that similar patterns of interactions occur between organisms and their environment, regardless of the ecosystem or the species involved.

2. **Evidence**
    a. Students identify and describe the evidence necessary for constructing explanations, including:
        i. Competition occurs when organisms within an ecosystem compete for shared resources.
        ii. Predation occurs between organisms within an ecosystem.
        iii. Parasitism occurs when one organism (the parasite) live on or inside another organism (the host) and causes the host harm.
        iv. Commensalism occurs when one species benefits while the other species neither benefits nor is harmed.
        v. Mutualism occurs between organisms within an ecosystem.
            1. Organisms involved in these mutually beneficial interactions can become so dependent upon one another that they cannot survive alone.
        vi. Resource availability, or lack thereof, can affect interactions between organisms (for example: organisms in a resource-limited environment may have a competitive relationship, while those same organisms may not be in competition in a resource-rich environment).
        vii. Competitive, predatory, parasitic, commensalism, and mutually beneficial interactions occur across multiple, different, ecosystems.
    b. Students use multiple valid and reliable sources for evidence.
3. **Reasoning**
    a. Students identify and describe quantitative or qualitative patterns of interactions among organisms that can be used to identify causal relationships within ecosystems.
    b. Students describe that regardless of the ecosystem or species involved, the patterns of interactions (for example: competition, mutualism, predation) are similar.
    c. Students use reasoning and patterns in the evidence to predict common interactions among organisms in ecosystems, including:
        i. predation,
        ii. parasitism,
        iii. commensalism,
        iv. competition, and/or
        v. mutualism.

7-LS2-2 Academic Language

Question/Sentence Stems

- I can observe (notice) the pattern of ________ presented in the data collected.
- I can observe (notice) the pattern of _________in the data presented.
- The pattern seen in the collected data allows me to conclude (know) that ________.
- The ______ structures help _______ to function because _______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- autotroph
- beneficial
- biotic
- commensalism
- competition
- consumer
- decomposer
- detrimental
- disperse
- ecological role
- ecosystem
- evolve
- genetic
- heterotroph
- host
- infection
- interdependent
- mutualism
- mutually beneficial
- parasite
- parasitism
- predation
- predator
- prey
- producer
- relative
- survival
- symbiosis

7-LS2-3. Develop a model to describe *the cycling of matter and flow of energy* among living and nonliving parts of an ecosystem.

> ***Clarification Statement:*** Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.
> ***State Assessment Boundary:*** Assessment does not include the use of chemical reactions to describe the processes.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Developing and Using Models Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Develop a model to describe phenomena.	**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems** 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.	**Energy and Matter** The transfer of energy can be tracked as energy flows through a natural system.

Observable features of student performance by the end of the course:

1. **Components of the model**
    a. Students develop/use a model (conceptual, graphical, physical, etc.) and identify the relevant components, including:
        i. Organisms that can be classified as producers, consumers, and/or decomposers.
        ii. Abiotic components of an ecosystem (for example: water, minerals, air) that can provide matter to or receive matter from biotic components.

2. **Relationships**
    a. Students develop/use a model to describe relationships between components, including:
        i. Energy transfer within an ecosystem.
        ii. Energy transfer and matter cycling (cycling of atoms):
            1. Among producers, consumers, and decomposers.
            2. Between abiotic and biotic components of an ecosystem (for example: producers use matter from the abiotic parts of the ecosystem and light energy to produce carbon-based molecules [for example: carbohydrates, sugar] from inorganic materials [for example: CO_2, H_2O]).
3. **Connections**
    a. Students develop/use a model to describe the cycling of matter and flow of energy among abiotic and biotic components of an ecosystem, including:
        i. When consumers (primary, secondary, tertiary, etc.) consume organisms, there is a transfer of energy and a cycling of atoms (matter) that were originally captured from the abiotic parts of the ecosystem by producers.
        ii. The transfer of matter (atoms) and energy between abiotic and biotic parts of an ecosystem at every level within the ecosystem, which allows matter to cycle and energy to transfer within an ecosystem.
    b. Students develop/use a model to trace energy transfer and matter cycling in an ecosystem based on consistent and measurable patterns, including:
        i. That the matter (atoms) that make up the organisms in an ecosystem are cycled repeatedly between abiotic and biotic parts of the ecosystem.
        ii. That matter and energy are conserved through transfers within an ecosystem.

7-LS2-3 Academic Language

Question/Sentence Stems

- I can observe (notice) the pattern of ________ presented in the data collected.
- The pattern seen in the collected data allows me to conclude (know) that ________.
- The observed pattern supports the conclusion that ________ is caused by ________, because ________.
- The pattern of ________is changing over time.
- The following predictions can be made about ________when using the pattern of ________ found in the data.
- ________ are some similarities and differences among the_____________.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- atmosphere
- atom
- autotroph
- biochemical reaction
- biosphere
- biotic
- carbon (C)
- carbon cycle
- carbon dioxide (CO_2)
- chemical reaction
- chemosynthesis
- consumer
- decomposer
- ecosystem
- energy transfer
- environment
- geosphere
- heterotroph
- hydrosphere
- molecule
- nitrogen (N)
- organic matter
- organism
- oxygen (O)
- photosynthesis
- primary consumer
- producer
- product
- reactant
- recycling of matter
- secondary consumer
- tertiary consumer

7-LS2-4. Construct an argument supported by empirical evidence that *changes to* physical or biological components of an ecosystem *affect populations*.

Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems. Disruptions to any physical or biological component of an ecosystem can lead to shifts in its populations.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** 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.	**Stability and Change** Small changes in one part of a system might cause large changes in another part.

Observable features of student performance by the end of the course:

1. **Supported claims**
    a. Students make, support, or refute a claim that changes to abiotic/biotic components of an ecosystem can affect the populations living there.

2. **Identifying scientific evidence**
    a. Students identify and describe the evidence needed to support or refute a claim, including:
        i. Changes in the abiotic/biotic components of an ecosystem, including the magnitude of the changes (for example: data about rainfall, fires, predator removal, species introduction, etc.).
        ii. Changes in the populations of an ecosystem, including the magnitude of the changes (for example: types of species present, changes in population size, and relative prevalence of a species within the ecosystem, etc.).
        iii. Relationships between changes in the components of an ecosystem with the changes in populations.
    b. Students use multiple valid and reliable sources of evidence.
3. **Evaluating and critiquing the evidence**
    a. Students evaluate and identify the strengths and weaknesses of the evidence, including:
        i. types of sources,
        ii. sufficiency, including validity and reliability, of the evidence to make and defend the claim, and
        iii. any alternative interpretations of the evidence and why the evidence supports or does not support the students claim, as opposed to any other claims.
4. **Reasoning and synthesis**
    a. Students use the following chain reasoning to connect the appropriate evidence:
        i. Specific changes in the abiotic/biotic components of an ecosystem cause changes that can affect the survival and reproductive likelihood of organisms within that ecosystem.
        ii. Factors that affect the survival and reproduction of organisms can cause changes in the populations of those organisms.
        iii. A single abiotic/biotic change in an ecosystem can produce a variety of outcomes.
        iv. A change in the survival and reproductive likelihood of a species/organism can result from various abiotic/biotic changes in the ecosystem.
        v. Some small changes in abiotic and biotic components of an ecosystem are associated with large changes in a population, suggesting that small changes in one component of an ecosystem can cause large changes in another component.

7-LS2-4 Academic Language

Question/Sentence Stems

- The things that stay the same are ________.
- The things that change are ________.
- The things that are changing slowly in this system are ________.
- The ________(event) changed this system by ________.
- ________ was affected by the change of ________.
- ________ are causing this system to be unstable.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- abiotic
- anthropogenic
- autotroph
- biodiversity
- biomass
- biotic
- carrying capacity
- competition
- consumers
- decomposers
- ecosystem
- heterotroph
- instability
- interaction
- mutually beneficial interactions
- populations
- predator
- prey
- producers
- stability

7-LS2-5. Evaluate *competing design solutions for maintaining* biodiversity and ecosystem services.

> ***Clarification Statement:*** Humans can benefit from services that are provided by healthy ecosystems. These ecosystem services could include climate stabilization, water purification, nutrient recycling, pollination, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** 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. **LS4.D: Biodiversity and Humans** 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. (*secondary*) **ETS1.B: Developing Possible Solutions** There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. **ETS2.B: Influence of Science, Engineering, and Technology on Society and the Natural World** The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.	**Stability and Change** Small changes in one part of a system might cause large changes in another part.

*Ecosystem services are defined as benefits humans acquire from ecosystems.

Observable features of student performance by the end of the course:

1. **Identifying the design solution and supporting evidence**
    a. Students identify and describe:
        i. A competing design solution for maintaining biodiversity and ecosystem services.
        ii. A problem involving biodiversity/ecosystem services is solved by a design solution, including information about why biodiversity and/or ecosystem services are necessary to maintaining a healthy ecosystem.
        iii. The evidence about performance of a design solution.
2. **Identifying additional relevant evidence**
    a. Students identify and describe the additional evidence (for example: data, information, etc.) that is relevant to a problem, design solution, and evaluation of the solution, including:
        i. variety of species (biodiversity) found in the identified ecosystem, and
        ii. factors that affect the stability of the biodiversity of an ecosystem.
    b. Students collaboratively define and describe criteria and constraints for the evaluation of the design solution.
3. **Evaluating and critiquing the design solution**
    a. Students use scientific evidence to evaluate solutions, including:
        i. Compare the ability of the competing design solutions to maintain ecosystem stability and biodiversity.
        ii. Clarify the strengths and weaknesses of the competing designs with respect to each criterion and constraint (for example: scientific, social, and economic considerations, etc.).
        iii. Assess possible side effects of a design solutions on other aspects of the ecosystem, including the possibility that a small change in one component of an ecosystem can produce a large change in another component of the ecosystem.

7-LS2-5 Academic Language

Question/Sentence Stems

- The things that stay the same are ________.
- The things that change are ________.
- The things that are changing slowly in this system are ________.
- The ________(event) changed this system by ________.
- ________was affected by the change of ________.
- ________ are causing this system to be unstable.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- biodiversity
- constraints
- criteria
- data
- design solution
- ecosystem
- habitats
- instability
- interaction
- invasive species
- native species
- niche
- non-native species
- optimal
- population
- preservation
- problem
- resources
- stability

ESS3 – Earth and Human Activity

7-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources *are the result of* past and current geoscience processes.

> ***Clarification Statement:*** Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**ESS3.A: Natural Resources** Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.	**Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

Observable features of student performance by the end of the course:

1. **Articulating the explanation of phenomena**
    a. Students articulate a statement describing/explaining that past and current geoscience processes have caused the uneven distribution of the Earth's resources, including that:
        i. The uneven distributions of the Earth's mineral, energy, and groundwater resources are the results of past and current geologic processes.
        ii. Resources are typically limited and nonrenewable due to factors such as:
            1. the long amounts of time required for some resources to form and/or
            2. the environment in which resources were created forming once or only rarely in the Earth's history.
2. **Identifying the scientific evidence to construct the explanation**
    a. Students identify and describe the evidence necessary to construct an explanation, including:
        i. type and distribution of Earth resources,
        ii. evidence for the past and current geologic processes (for example: volcanic activity, sedimentary processes, etc.) that have resulted in the formation of each of Earth resources, and
        iii. long-term and short-term positive or negative consequences of natural resource use on the people and natural environment.
    b. Students use multiple valid and reliable sources of evidence.
3. **Reasoning**
    a. Students use the following chain of reasoning to connect the appropriate evidence:
        i. The Earth's resources are formed due to past and current geologic processes.
        ii. The environment or conditions that formed the resources are specific to certain areas and/or times on Earth, thus identifying why those resources are found only in those specific places/periods.
        iii. As resources as used, they are depleted from the sources until they can be replenished, mainly through geologic processes.
        iv. Many resources continue to be formed in the same ways that they were in the past.
            1. The amount of time required to form most of these resources (for example: minerals, fossil fuels, etc.) is much longer than timescales of human lifetimes, these resources are limited to current and near-future generations.
            2. Some resources (for example: geothermal heat, etc.) can be replenished on human timescales and are limited based on distribution.

7-ESS3-1 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- In this situation, even a small change of _______ can cause a big effect on _______.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _______ caused _______, the following evidence is needed _______.
- The fact that the data showed that _______ always happened after (or whenever) _______ occurred means that _______ causes _______ because ______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- agricultural
- aquifer
- biosphere
- conservation
- consumption
- deposition
- distribution
- efficient
- energy source
- extract
- fault
- fold
- geologic process
- geologic trap
- geoscience
- groundwater
- hydrothermal
- impact
- interdependence
- irreversible
- marine sediment
- metal ore
- natural gas
- non-renewable
- oil shale
- organic
- petroleum
- regulation
- renewable
- renewable energy
- reservoir
- soil
- subduction zone
- tar sand
- tectonic plate
- uplift
- water table
- weathering

7-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human *impact on the environment*.

Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Apply scientific principles to design an object, tool, process or system.	**ESS3.C: Human Impacts on Earth Systems** 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. 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. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.	**Cause and Effect** Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.

Observable features of student performance by the end of the course:

1. **Using scientific knowledge to generate design solutions**
    a. Students use scientific information and principles to generate a design solution related to human impact on the environment that:
        i. addresses the results of human activity,
        ii. incorporates technologies that can be used to monitor and minimize negative effects that human activities have on the environment, and
        iii. incorporates technologies that can be used to enhance positive impacts for both the natural environment and people.
    b. Students identify relationships between human activity and negative environmental impacts based on scientific principles.
2. **Describing criteria and constraints, including quantification when appropriate**
    a. Students define and quantify criteria and constraints for a solution, including:
        i. individual or societal needs/desires,
        ii. constraints imposed by economic conditions (for example: costs of building, maintaining the solution, etc.), and
        iii. addressing and reducing the potential for increases in negative impacts on the natural environment with an increase in population size and/or increased per capita use of resources.
3. **Evaluating potential solutions**
    a. Students describe how well the solution meets the criteria and constraints, including monitoring/minimizing human impact using the relationships between relevant scientific principles about the processes that occur in/among Earth systems and human impact on the environment.
    b. Students identify limitations of the use of technologies employed by the solution.

7-ESS3-3 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- In this situation, even a small change of _______ can cause a big effect on _______.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _______ caused _______, the following evidence is needed _______.
- The fact that the data showed that _______ always happened after (or whenever) _______ occurred means that _______ causes _______ because ______.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- agriculture
- anthropogenic changes
- aquifer
- atmosphere
- biomass
- biosphere
- competing designs
- conservation
- constraints
- consumption
- cost-benefit analysis
- criteria
- degradation
- destabilization
- development
- Earth system
- economic
- ecosystem
- environment
- fertile
- geoengineering
- geosphere
- groundwater
- hydrosphere
- impact
- industry
- land usage
- levee
- mineral
- natural resource
- ozone
- pollutant
- pollution
- population
- preservation
- river delta
- sea level
- stabilize
- trade-off
- urban development
- waste management
- water usage
- wetlands

7-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources *impact Earth's systems*.

Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Engaging in Argument from Evidence Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	**ESS3.C: Human Impacts on Earth Systems** 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. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.	**Cause and Effect** Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.

*Because population sizes and per capita data can be large, students may need to understand and apply the conventions of scientific notation when working with measured quantities.

Observable features of student performance by the end of the course:

1. **Supported claims**
    a. Students make, support, or refute a claim that increases in the size of the human population and per-capita consumption of natural resources affect Earth systems.

2. **Identifying scientific evidence**
    a. Students identify evidence to support or refute a claim, including:
        i. changes in the size of human population(s) in a region or ecosystem over a given timespan;
        ii. per-capita consumption of resources by humans in a region or ecosystem over a given timespan;
        iii. changes in appearance, composition, and/or structures in Earth systems in a region or ecosystem over a given timespan ; and/or
        iv. the ways engineered solutions have altered the effects of human activities on Earth's systems.
3. **Evaluating and critiquing evidence**
    a. Students evaluate and identify the strengths and weaknesses of the evidence, including:
        i. types of sources,
        ii. sufficiency, including validity and reliability, of the evidence to make and defend the claim, and
        iii. any alternative interpretations of the evidence and why the evidence supports or does not support the students claim, as opposed to any other claims.
4. **Reasoning and synthesis**
    a. Students use the following chain of reasoning to connect the evidence:
        i. Increases in the size of the human population or in the per-capita consumption of a given population cause increases in the consumption of natural resources.
        ii. Natural resource consumption causes changes in Earth systems.
        iii. Human population growth affects natural resource consumption and natural resource consumption affects Earth systems.
        iv. Engineered solutions alter the effects of human populations on Earth systems by changing the rate of natural resource consumption or mitigating the effects of changes in Earth systems.

7-ESS3-4 Academic Language

Question/Sentence Stems

- By looking at patterns in the data, I/we determined that _______ caused _______.
- _______ caused the patterns I am observing. I know this because _______.
- If _______ happens, I/we predict that _______ will occur.
- Even though I/we cannot see _______, it explains why _______ is happening.
- When I/we change _______ in the system, _______ is affected.
- In this situation, even a small change of _______ can cause a big effect on _______.
- The probability that _______ caused _______ is _______. I/We know this because _______.
- The evidence _______ presented in the scenario supports the claim that _______ causes _______.
- In order to conclude that _______ caused _______, the following evidence is needed _______.
- The fact that the data showed that _______ always happened after (or whenever) _______ occurred means that _______ causes _______ because ______.

Terminology to Support Student Discourse about Phenomena

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- acidification
- aesthetics
- agricultural efficiency
- biomass
- composition
- concentration
- conservation
- consumption
- delta
- fertile
- fossil fuels
- geosphere
- glacier
- groundwater
- hydrosphere
- lakes
- manufactured
- mass
- natural resources
- non-renewable
- oil shales
- per capita
- perishable
- pollution
- recycling
- renewable
- rivers
- synthetic
- tar sands
- urban planning
- volume

7-ESS3-5. Ask questions to clarify evidence of the factors *that have impacted* global temperatures *over the past century*.

> ***Clarification Statement:*** Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.

Science and Engineering Practices	Disciplinary Core Ideas	*Crosscutting Concepts*
Asking Questions and Defining Problems Asking questions and defining problems in grades 6-8 builds on grades K-5 experiences and progresses to specifying relationships between variables and clarifying arguments and models. Ask questions to identify and clarify evidence of an argument.	**ESS3.D: Global Climate Change** 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. 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. **ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World** All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus, technology use varies from region to region and over time.	**Stability and Change** Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Observable features of student performance by the end of the course:

1. **Addressing phenomena of the natural world**
    a. Students evaluate a claim and the supporting evidence as a basis for formulating questions. Students ask questions that would identify and clarify the evidence, including:
        i. The relevant ways in which natural processes may have affected the patterns of change in global temperatures over the past century (for example: volcanic activity, changes in incoming solar radiation, etc.).
        ii. The relevant ways in which human activities may have affected the patterns of change in global temperatures over the past century
        iii. (for example: combustion of fossil fuels, cement production, agricultural activity, etc.).
        iv. The influence of natural processes/human activities on a gradual or sudden change in global temperatures in natural systems (for example: glaciers and arctic ice, and plant and animal seasonal movements and life cycle activities, etc.).
        v. The influence of natural processes/human activities on changes in the concentration of carbon dioxide and other greenhouse gases in the atmosphere over the past century.
2. **Identifying the scientific nature of the question**
    a. Student questions can be answered by examining evidence/data for patterns to connect natural processes/human activities to changes in global temperatures over the past century changes in natural processes/human activities related to greenhouse gas production to changes in the concentrations of carbon dioxide and other greenhouse gases in the atmosphere.

7-ESS3-5 Academic Language

Question/Sentence Stems

- The things that stay the same are _______.
- The things that change are _______.
- The things that are changing slowly/quickly in this system are _______.
- The _______(event) changed this system by _______.
- _______ was affected by the change of _______.
- _______ are causing this system to be unstable.

Terminology to Support Student Discourse about Phenomena

*Teaching words or concepts in isolation or prior to experiences that give context (frontloading) deprives students of sense-making opportunities that lead to a greater depth of conceptual understanding.

- agriculture
- anthropogenic impact
- atmosphere
- atmospheric change
- atmospheric composition
- biosphere
- carbon dioxide (CO_2)
- catastrophic
- climate change
- combustion
- concentration
- consumption
- cycle
- degradation
- destabilize
- environmental
- force
- forest
- fossil fuel
- freeze
- glacial
- global
- greenhouse effect
- greenhouse gas
- impact
- industry
- intensity
- local
- magnitude
- mechanism
- natural process
- natural resource
- nonrenewable
- physical change
- pollutant
- pollution
- radiation
- renewable
- role
- rotation
- runoff
- sea level
- solar
- surface temperature
- time scale
- weather condition

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