

## Massachusetts Science Frameworks Related to Climate Change

### Earth and Space Science

#### Grades 3–5

- Explain how air temperature, moisture, wind speed and direction, and precipitation make up the weather in a particular place and time.
- Distinguish among the various forms of precipitation (rain, snow, sleet, and hail), making connections to the weather in a particular place and time.
- Describe how global patterns such as the jet stream and water currents influence local weather in measurable terms such as temperature, wind direction and speed, and precipitation.
- Differentiate between weather and climate.
- Describe how water on earth cycles in different forms and in different locations, including underground and in the atmosphere.
- Give examples of how the cycling of water, both in and out of the atmosphere, has an effect on climate.
- Recognize that the earth revolves around (orbits) the sun in a year's time and that the earth rotates on its axis once approximately every 24 hours.

#### Grades 6-8

##### Mapping the Earth

- Recognize, interpret, and be able to create models of the earth's common physical features in various mapping representations, including contour maps.

##### Heat Transfer in the Earth System

- Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through the earth's system.
- Explain the relationship among the energy provided by the sun, the global patterns of atmospheric movement, and the temperature differences among water, land, and atmosphere.

##### Earth's History

- Explain and give examples of how physical evidence, such as fossils and surface features of glaciation, supports theories that the earth has evolved over geologic time.

##### The Earth in the Solar System

- Explain how the tilt of the earth and its revolution around the sun result in an uneven heating of the earth, which in turn causes the seasons.

#### Grade 9 or 10

##### Matter and Energy in the Earth System

- The earth has internal and external sources of energy. The sun is the major external source of energy while the primary sources of internal energy are generated through radioactive decay and gravitational attraction from the earth's original formation.
  - Identify the earth's principal sources of internal and external energy, e.g., radioactive decay, gravity, solar energy.
- Global atmospheric processes are driven by energy from the sun, unequal heating between the equator and poles, the earth's rotation and revolution, and the influence of land and water. Human affairs can dramatically influence and be influenced by atmospheric phenomena.
  - Explain how the transfer of energy through radiation, conduction, and convection contributes to global atmospheric processes, e.g., storms, winds.
  - Explain how the layers of the atmosphere affect the dispersal of incoming radiation through reflection, absorption, and reradiation.
  - Provide examples of how the unequal heating of the earth and the Coriolis Effect influence global circulation patterns, and show their impact on Massachusetts weather and climate.
  - Explain how the revolution of the earth and the inclination of the axis of the earth cause the earth's seasonal variations (equinoxes and solstices).

- Describe how the inclination of the incoming solar radiation can impact the amount of energy received by a given surface area.
- Describe the various conditions associated with frontal boundaries and cyclonic storms (e.g., thunderstorms, winter storms [nor'easters], hurricanes, and tornadoes) and their impact on human affairs, including storm preparations.
- **Oceans redistribute matter and energy around the earth, through surface and deepwater currents, tides, waves, and interaction with other earth spheres.**
  - Explain the dynamics of oceanic currents, including upwelling, density, and deep water currents, the local Labrador Current and the Gulf Stream, and their relationship to global circulation within the marine environment and climate.
  - Describe the effects of longshore currents, storms, and artificial structures (e.g., jetties, sea walls) on coastal erosion in Massachusetts.
  - Explain what causes the tides and describe how they affect the coastal environment.
- **Scientists use various instruments and methods to investigate the earth as a system.**
  - Explain how scientists study the earth system through the use of a combination of ground-based observations, satellite observations, and computer models of the earth system, and why it is necessary to use all of these tools together.

### The Earth's Sources of Energy

- **Numerous earth resources are used to sustain human affairs. The abundance and accessibility of these resources can influence their use.**
  - Recognize, describe, and differentiate between renewable (e.g., solar, wind, water, biomass) and nonrenewable (e.g., fossil fuels, nuclear [Ura-235]) sources of energy.
  - Compare the advantages and limitations of renewable and nonrenewable sources of energy..
  - Describe ways in which people have tried to control the use of renewable and nonrenewable sources of energy, e.g., scientific advances, prices.
  - Describe the effects on the environment of using both renewable and nonrenewable sources of energy.
  - Describe ways in which scientists are addressing effects on the environment of using both renewable and nonrenewable sources of energy, e.g., creation of new technologies.

### Earth Processes and Cycles

- **Interactions among the lithosphere, hydrosphere, and atmosphere have resulted in ongoing evolution of the earth system over geologic time.**
  - Explain that weather is the most significant source of erosion and how both physical and chemical weathering lead to the formation of sediments and soils, affect the shape of rocks, and create specific landscapes depending on what weathering process is dominant under a specific climate.
  - Describe how glaciers, gravity, wind, temperature changes, waves, and rivers cause weathering and erosion. Give examples of how the effects of these processes can be seen in our local environment.
  - Explain the nitrogen and carbon cycles and their roles in the improvement of soils for agriculture.
  - Describe the evolution of the atmosphere.
  - Describe how the oceans store carbon dioxide as dissolved  $\text{HCO}_3^-$  and  $\text{CaCO}_3$  precipitate.
- **Water is continually being recycled by the hydrologic cycle through the watersheds, oceans, and the atmosphere by processes such as evaporation, condensation, precipitation, runoff, and infiltration. This life-giving cycle is continually and increasingly impacted by human affairs.**
  - Explain how water flows into and through a watershed, e.g., aquifers, wells, porosity, permeability, water table, capillary water, runoff.
  - Compare and contrast the processes of the hydrologic cycle including evaporation, condensation, precipitation, surface runoff and groundwater percolation, infiltration, and transpiration.
- **Geologic time can be determined by analyzing rocks and fossils.**

## **Life Science**

### **Grades PreK-2**

#### **Evolution and Biodiversity**

- Recognize that fossils provide us with information about living things that inhabited the earth years ago.

#### **Living Things and Their Environment**

- Recognize that people and other animals interact with the environment.
- Identify the ways in which an organism's habitat provides for its basic needs (plants require air, water, nutrients, and light; animals require food, water, air, and shelter).

### **Grades 3-5**

#### **Plant Structures and Functions**

- Differentiate between observed characteristics of plants and animals that are fully inherited and characteristics that are affected by the climate or environment.

#### **Adaptations of Living Things**

- Give examples of how changes in the environment (drought, cold) have caused some plants and animals to die or move to new locations (migration).
- Give examples of how organisms can cause changes in their environment to ensure survival. Explain how some of these changes may affect the ecosystem.

### **Grades 6-8**

#### **Evolution and Biodiversity**

- Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.
- Relate the extinction of species to a mismatch of adaptation and the environment.

#### **Living Things and Their Environment**

- Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.

#### **Energy and Living Things**

- Recognize that producers (plants that contain chlorophyll) use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis.

#### **Changes in Ecosystems Over Time**

- Identify ways in which ecosystems have changed throughout geologic time in response to physical conditions, interactions among organisms, and the actions of humans.

### **Grade 9 or 10**

#### **The Chemistry of Life**

- Explain the significance of carbon in organic molecules.

#### **Structure and Function of Cells**

- Describe how cells function in a narrow range of physical conditions, such as temperature and pH, to perform life functions that help to maintain homeostasis.
- Explain the interrelated nature of photosynthesis and cellular respiration.

#### **Ecology**

- **Ecology is the interaction between living organisms and their environment.**
  - Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen).
  - Identify the factors in an ecosystem that influence fluctuations in population size.
  - Analyze changes in an ecosystem resulting from natural causes, changes in climate, human activity, or introduction of non-native species.

## **Physical Sciences**

### **Grades 3-5**

#### **States of Matter**

- Compare and contrast solids, liquids, and gases based on the basic properties of each of these states of matter.
- Describe how water can be changed from one state to another by adding or taking away heat.

#### **Forms of Energy**

- Identify the basic forms of energy (light, sound, heat, electrical, and magnetic).
- Give examples of how energy can be transferred from one form to another.

#### **Light Energy**

- Light can be reflected, refracted, and absorbed.

### **Grades 6-8**

#### **Elements, Compounds, and Mixtures**

- Recognize that there are more than 100 elements that combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.
- Differentiate between an atom and a molecule.

#### **Heat Energy**

- Recognize that heat is a form of energy and that temperature change results from adding or taking away heat from a system.
- Give examples of how heat moves in predictable ways, moving from warmer objects to cooler ones until they reach equilibrium.

### **Grade 10 or 11**

#### **Heat and Heat Transfer**

- Heat is energy that is transferred between bodies that are at different temperatures by the processes of convection, conduction, and/or radiation.
- Explain the relationship among temperature change in a substance for a given amount of heat transferred, the amount (mass) of the substance, and the specific heat of the substance.