# Massachusetts Tests for Educator Licensure™
# Test Objectives
# Field 14: Earth Science

**SUBAREAS:**

SCIENTIFIC INQUIRY
ASTRONOMY
METEOROLOGY
GEOLOGY AND OCEANOGRAPHY

## SCIENTIFIC INQUIRY

**0001 Understand types and uses of natural resources, the effects of human activities on the environment, and the need to preserve the environmental integrity of the earth's ecosystems.**

For example: the classification, uses, and importance of natural resources and methods of locating and obtaining natural resources; the positive and negative effects of human activities on the earth's environment (e.g., reclamation of strip mines, ocean dumping); and strategies for dealing with environmental problems.

**0002 Understand the nature of scientific inquiry, the role of observation and experimentation in science, and the relationships between earth science, technology, and other fields of knowledge.**

For example: processes by which new scientific knowledge and hypotheses are generated and rejected; ethical issues related to earth science (e.g., accurately reporting experimental results); evaluating the appropriateness of a specified experimental design to test a given hypothesis in earth science; the role of communication among scientists in promoting scientific progress; and similarities and differences between science and technology (e.g., science as investigating the natural world, technology as solving human adaptation problems).

**0003 Understand the processes of gathering, organizing, reporting, and interpreting scientific data in the context of earth science investigations.**

For example: evaluating the appropriateness of a given method or procedure for collecting data for a specified purpose; appropriate and effective graphic representations (e.g., graph, table, diagram) for organizing and reporting given experimental data; procedures and criteria for formally reporting experimental procedures and data to the scientific community; and relationships between factors (e.g., inverse, direct, linear) as indicated by experimental data.

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**0004 Understand how to create, use, and interpret physical and mathematical models (e.g., maps, charts, graphs, diagrams) commonly used in earth science.**

For example: alternative models for conveying given information from earth science; methods by which given physical and graphic models are created; classifying different types of maps (e.g., topographic, geologic) used in earth science and analyzing the information conveyed by each type of map; and interpreting diagrams relating to earth science (e.g., crustal movements).

**0005 Understand proper and safe use of equipment and materials used in earth science investigations.**

For example: operating principles for various instruments; basic safety procedures in a laboratory or field situation (e.g., wearing safety glasses); and applying proper procedures for dealing with given accidents and injuries in the earth science laboratory or in the field.

**ASTRONOMY**

**0006 Understand the physical characteristics and motions of the earth as well as the evidence of and methods used to determine these characteristics and motions.**

For example: historical methods used to study the characteristics and motions of the earth (e.g., Foucault pendulum); the physical characteristics of the earth (e.g., diameter, tilt of axis, distance from the sun) and how they can be determined; interpreting evidence of the earth's motions (e.g., satellite photos, apparent motion of the sun); and the consequences of the earth's motions (e.g., length of day, change of seasons, length of year).

**0007 Understand the structure, composition, and features of the sun (including its production and transmission of energy) and the importance of the sun to Earth processes.**

For example: methods by which the sun's diameter, surface temperature, and chemical composition are determined; the layers of the sun; the sun's source of energy (fusion reaction); the solar surface as the immediate source of energy for the earth's surface; and the sunspot cycle and its possible effects on the earth's climate.

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**0008 Understand the properties, features, and movements of the earth's moon; the interactions among the earth, moon, and sun (including phases, tides, and eclipses); and the role of technology and exploration in obtaining knowledge about the earth, moon, and sun.**

For example: relating surface features (e.g., maria, craters, mountains) of the earth's moon to events in the history of the moon; the relationship between the height of ocean tides and the relative positions of the earth, moon, and sun; the relationship between the phases of the moon and the relative positions of the earth, moon, and sun; and how the lunar exploration program has added to our knowledge of the earth-moon system.

**0009 Understand the scale and organization of the solar system, the role of gravity in the solar system, characteristics of the bodies within the solar system, and physical and mathematical models that describe these objects and their real and apparent motions.**

For example: characteristics (e.g., size, density, surface temperature) of the planets; relative sizes, distances, tilts, and positions of the planets; the position of the planets on the ecliptic; the origin and properties of comets and meteors; using the apparent motion of celestial objects to infer solar system models (i.e., geocentric, heliocentric); and applying Kepler's laws to describe and predict the motions of the planets.

**0010 Understand stars, their motions and life cycles, and the methods and technology used to study them.**

For example: comparing types of telescopes (e.g., optical, radio, infrared, ultraviolet) and the ways in which they are used to acquire information on star characteristics; methods and uses of spectroscopy; types of stars (e.g., pulsars, Cepheid variables) and their characteristics; using the H-R diagram to analyze the life cycle of stars; and analyzing stellar life cycles to understand the formation and initial development of the solar system.

**0011 Understand evidence regarding the size, structure, scale, and motions of the universe, the Milky Way galaxy, and the solar system.**

For example: evidence regarding the location of the solar system within the Milky Way galaxy; historical methods of inferring the size, structure, and motions of the galaxy and the solar system (e.g., star observations and counts); the evidence for and interpretations of an expanding universe (e.g., red shift and the Doppler effect); and analyzing types of evidence used to infer scales and relative motions of the solar system, the Milky Way galaxy, and the universe (e.g., in relation to relative size and distance).

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## METEOROLOGY

**0012 Understand the composition, structure, and properties of the earth's atmosphere and the mechanisms and effects of energy transfer involving the earth-atmosphere system.**

For example: properties (e.g., density, composition, temperature) of the atmosphere from the earth's surface through the thermosphere and the significance of changes in these properties; analyzing how various wavelengths of solar radiation (e.g., ultraviolet, visible light, infrared) are affected as the radiation enters and passes through the atmosphere and is absorbed by and radiated from the earth's surface; the processes by which energy is transferred to and within the atmosphere (e.g., radiation, convection, conduction); and analyzing global wind patterns in terms of latitudinal variations in insolation and the Coriolis effect.

**0013 Understand the properties of water, conditions in the atmosphere that favor phase changes, and the energy relationships among phase changes, cloud formation, and precipitation.**

For example: relating the physical properties of water (e.g., high specific heat, surface tension) to the chemical structure and properties of water molecules; energy changes involved in the transition between phases of water (i.e., latent heat); atmospheric conditions under which fog and clouds with various characteristics form (e.g., adiabatic temperature changes, dew-point, atmospheric stability); conditions under which precipitation forms; and predicting the type of precipitation that will fall to the earth's surface under given conditions.

**0014 Understand characteristics of broad-scale weather systems and local weather, the relationship between them, and the methods and instruments used to collect weather data.**

For example: types and characteristics of air masses, their movements, and the kinds of fronts that form between air masses; the horizontal and vertical movements of air in high- and low-pressure areas; and the use of weather instruments (e.g., thermometer, psychrometer) for collecting given types of weather data.

**0015 Understand weather maps, how they are prepared, and how they are used.**

For example: interpreting symbols used on weather maps; the methods used to generate weather maps; inferring recent weather in a given location based on one or more weather maps; and predicting future weather in a given location based on one or more weather maps.

**0016 Understand the principles and technology of weather forecasting and the effects of weather and weather forecasting on humans.**

For example: the use of weather models in forecasting; the role of computers and satellite photographs in generating weather forecasts; types of hazardous weather; types and functions of weather precautions; and the role of the National Weather Service in issuing weather alerts.

**0017 Understand the locations and characteristics of the earth's major climatic regions and analyze factors that affect local climate and the relationship between weather and climate.**

For example: inferring the climatic zone in which a given area is located based on temperature and precipitation data; factors that affect the climate in a given region (e.g., insolation, wind patterns, topography); and the relationship between the climate of a region and its weather.

**0018 Understand the effects of human activities and natural processes on the atmosphere, theories about the long-range effects of human activities on global climate, and methods of controlling and minimizing these effects.**

For example: common air pollutants and their sources and effects; pollutants and atmospheric chemical reactions involving these pollutants; factors that affect local air pollutant concentrations (e.g., population density); and analyzing the theory of global warming due to increased levels of atmospheric carbon dioxide from the burning of fossil fuels.

## GEOLOGY AND OCEANOGRAPHY

**0019 Understand the processes of mineral and rock formation, the characteristics of different types of minerals and rocks, and the methods used to identify and classify them.**

For example: using classification schemes (e.g., Mohs' scale of hardness, crystal form, chemical composition) to identify common rock-forming minerals; the processes by which different kinds of rocks are formed; and classifying a given rock as sedimentary, igneous, or metamorphic.

**0020 Understand the structure of the earth, the constructional forces that have shaped its surface, theories and evidence of crustal movements, and the effects of crustal movements on landscape.**

For example: the use of seismic waves to infer the earth's internal structure; using the theory of dynamic equilibrium (e.g., isostasy) to explain landscape development; evidence for continental drift and seafloor spreading; and applying the theory of plate tectonics to explain landscape development and geologic phenomena (e.g., volcanism, earthquakes) and to predict future movements of land masses.

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**0021 Understand erosional-depositional processes that change the earth's surface (e.g., weathering, erosion) and the relationship between these processes and landscape development.**

For example: the processes of mechanical, chemical, and biological weathering and factors that affect the rate at which rocks weather and soils are produced; the processes of erosion by various agents (e.g., wind, water, glaciers) and factors that affect erosion rates and patterns; the processes by which given landscape features (e.g., eskers, moraines) are formed; and the effects of glaciation on the Massachusetts landscape.

**0022 Understand characteristics of the major geologic time divisions and theories and supporting evidence of the earth's geologic history.**

For example: the conditions and characteristic fossils of the various geologic periods; applying the laws and principles of geology (e.g., law of original horizontality, law of superposition) to interpret diagrams of rock strata; the principles, applications, and limits of radioactive dating; and using paleontological information to infer the geologic history of a given area.

**0023 Understand the hydrologic cycle and the processes by which water moves on and beneath the earth's surface, and use this knowledge to analyze local water budgets.**

For example: analyzing a cross-sectional diagram of a water table and surrounding rock strata to predict the movement of groundwater and the behavior of wells; factors affecting the movement of groundwater (e.g., aquifers, gradient); and the effects of various factors (e.g., vegetation, gradient, rock strata) on components of a local water budget.

**0024 Understand ocean water and its movements.**

For example: the circulation patterns in the oceans and factors that influence these patterns (e.g., temperature variations, wind systems, Coriolis effect); and types, causes, and effects of tidal and wave motions of ocean water.

**0025 Understand the structure and topography of the ocean basin.**

For example: identifying ocean zones (e.g., littoral, benthic) in terms of their physical characteristics; the major structural features of the ocean floor; and factors involved in changing the structure of the ocean floor.

**0026 Understand marine life and the marine habitat.**

For example: the characteristics and major groups of marine plants and animals; zonation of marine plants and animals; and relationships between marine organisms and the marine environment.