HIGH SCHOOL SCIENCE CORE

Ninth to Twelfth Grades ILOs

The Intended Learning Outcomes (ILOs) describe the skills and attitudes students should learn as a result of science instruction. They are an essential part of the Science Core Curriculum and provide teachers with a standard for evaluation of student learning in science. At each grade level, student learning should include instruction and practice of the ILOs listed for that grade. Students should attain mastery of these skills by the end of the grade level specified.

The main intent is that students will value and use science as a process of obtaining knowledge based upon observable evidence.

Students will be able to:

1. Use Science Process and Thinking Skills

a. Observe and identify or describe objects, patterns and events.
b. Use comparisons to relate and understand observations and phenomena.
c. Evaluate and sequence data according to given criteria.
d. Select and use appropriate technological instruments to collect and analyze data.
e. Plan and conduct experiments.
f. Formulate research questions.
g. Identify a researchable problem.
h. Predict or hypotheses results of investigations based upon prior data.
i. Identify variables and describe the relationships between them.
j. Plan procedures to control independent variables.
k. Collect data on the dependent variable(s).
l. Select the appropriate format (e.g., graph, chart, diagram) and use it to summarize the data obtained.
m. Analyze data and construct reasonable conclusions.
n. Distinguish between factual statements and inferences.
o. Develop and use classification systems.
p. Construct models, simulations and metaphors to describe and explain natural phenomena.
q. Use mathematics as a precise method for showing relationships.

2. Manifest Scientific Attitudes and Interests

a. Demonstrate a sense of curiosity about nature.
b. Read and look at books and other science materials voluntarily.
c. Maintain an open and questioning mind toward ideas.
d. Seek and weigh evidence before drawing conclusion.
e. Check reports of observations for accuracy.
f. Accept responsibility for actively helping to resolve social, ethical, and ecological problems related to science and technology.
g. Recognize and reject pseudoscience as a source of scientific knowledge.

3. Understand Science Concepts, Principles and Systems

a. Know and explain science information specified for the subject being studied.

b. Distinguish between examples and non-examples of concepts that have been taught.
c. Apply principles and concepts of science to explain various phenomena.
d. Solve problems by applying science principles and procedures.

4. Communicate Effectively using Science Language and Reasoning

a. Prepare written and oral reports of investigations.
b. Use precise scientific language in oral and written communication.
c. Use correct English in oral and written reports.
d. Use reference sources to obtain information and cite the sources.
e. Use mathematical language and reasoning to communicate information.

5. Demonstrate Awareness of Social and Historical Aspects of Science

a. Cite examples of how science affects human life.
b. Give instances of how technological advances have influenced the progress of science and how science has influenced advances in technology.
c. Understand the cumulative nature of scientific knowledge.
d. Recognize contributions to science knowledge that have been made by both women and men.

6. Understand the Nature of Science

a. Understand that science investigations are not always based on the same set of procedures, and there is not one “scientific method.”
b. Understand that science findings are tentative and therefore never final. Knowledge based upon these findings is subject to revision in light of new evidence.
c. Understand that scientific conclusions are based on the assumption that natural laws operate today as they did in the past and that they will continue to do so in the future.
d. Understand the use of the term "theory" in science, and that the scientific community validates each theory before it is accepted. When new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.
e. Understand that various disciplines of science are interrelated and share common rules of evidence to explain phenomena in the natural world.
f. Understand that scientific inquiry is characterized by a common set of values that include logical thinking, precision, open-mindedness, objectivity, skepticism, reproducibility of results and honest and ethical reporting of findings. These values function as criteria in distinguishing between science and non-science.
g. Understand that science and technology may raise ethical issues to which science, by itself, does not provide solutions.

Earth Systems Science

Introduction

Course Description

Earth Systems Science provides the concepts and skills needed to understand how Earth came into existence, has changed over time and functions today. Earth Systems Science provides students with an understanding of how the parts of a system interact.

Students will learn how to explain cosmic and global phenomena in terms of interactions of energy, matter and life. These explorations range from the realization that all elements heavier than helium were made in stars to an understanding of how rain influences a desert ecosystem.

Throughout this course students experience science as a way of knowing based on making observations, gathering data, designing experiments, making inferences, drawing conclusions and communicating results. Students see that the science concepts apply to their lives and their society. This course will provide students with science skills to make informed and responsible decisions.

Understanding planet Earth as a system involves combining concepts and skills from life, physical and earth sciences. It builds upon students' experience with integrated science in grades seven and eight. It leads to deeper explorations of topics in biology, geology, chemistry and physics.

Instructional Strategies

Science Benchmark

Science provides evidence that the universe is more than 10 billion years old. The most accepted theory states that the universe expanded explosively from a hot, dense chaotic mass. Gravity causes clouds of the lightest elements to condense into massive bodies. The mass and density of these bodies become great enough for nuclear fusion to occur creating stars. This nuclear fusion releases energy and fuses light elements into heavier elements. Some stars explode, producing clouds of heavy elements from which other stars, planets and celestial bodies may form.

Standard I: Students will understand that scientific evidence supports theories that explain how the universe and solar system developed.

Objective 1: Describe the big bang theory and evidence supporting it.

a. Determine the motion of a star relative to Earth based on a red or blue shift in the light from the star.
b. Explain how evidence of red and blue shifts is used to determine if the universe is expanding or contracting.
c. Describe the big bang theory and evidence that supports this theory.
d. Investigate and report how science over time has changed the accepted ideas regarding the nature of the universe throughout history.

Objective 2: Relate the elements occurring in our solar system to the formation of heavy elements in stars.

a. Identify the nuclear reaction that occurs in stars and relate this reaction to the products formed.
b. Compare stars that produce heavy elements to the sun (e.g., age, mass).
c. Relate the amount of mass used in a fusion reaction to the amount of energy produced (e.g., a small amount of mass can be changed into a huge amount of energy).
d. Explain the origin of the heavy elements on Earth (e.g., heavy elements were formed by fusion in ancient stars).

e. Present evidence that the process that formed Earth's heavy elements continue in stars today.

Objective 3: Relate the structure of the solar system to the formation of the universe.

a. Describe the formation of planets and bodies in the
b. Relate the system
c. Relate the composition of the elements on Earth to their origin.

Science language student should use:	big bang, blue shift, heavy element, mass, nuclear fusion, red shift, theory, universe

Science Benchmark

Earth environment supports an interconnected system of living organisms. This system is unique in the solar system. Biodiversity on Earth is determined by biotic and abiotic factors. Throughout Earth's history the number and distribution of species have changed over time in response to environmental changes.

Standard II: Students will understand that the features of Earth's evolving environment affect the living system and that life on Earth is unique in the solar system.

Objective 1: Describe the unique physical features of Earth environment that make life on Earth possible.

a. Describe the Earth's Atmosphere and compare it to other planets in the solar system.
b. Relate the presence of water on Earth to the presence of life in the solar system.
c. Compare the levels of solar energy on Earth to that on other planets.
d. Determine the planet in the solar system that has surface features that can support life.
e. Research and report on conditions that support life on Earth but not on other planets in the solar system.

Objective 2: Analyze how ecosystems differ from each other due to abiotic and biotic factors.

a. List abiotic factors that affect ecosystems (e.g., temperature, water, nutrients, sunlight, pH and topography).
b. Compare how abiotic factors influence different ecosystems.
c. Predict how an ecosystem will change as a result of changes in an abiotic and/or biotic factor.
d. Plan and conduct an experiment to investigate how abiotic factors influence organisms and how life influences its physical environment.

Objective 3: Explain how Earth's diversity of life changes through time.

a. Compare the diversity of life in various biomes (e.g., number of species, biomass, kinds of organisms).
b. Explain factors that contribute to the extinction of a species.
c. Compare the evidence supporting various theories that explain the causes of large-scale extinctions that have occurred in the past.
d. Compare possible causes of past mass extinctions with factors causing the loss of species today.

Science language student should use:	abiotic, atmosphere, biodiversity, biome,

	biotic, ecosystem, extinction, planet, system

Science Benchmark

The theory of plate tectonics explains the features of Earth's surface, earthquakes and volcanoes. Plates move very slowly pressing against one another in places, sliding past one another in places and pulling apart in other places. The internal energy of the Earth drives the movement of the plates. The slow movement of materials within Earth results from heat flowing out from the deep interior and the action of gravity on regions of different density. Evidence for plate tectonics includes: age of the sea floor, spreading of the seafloor, fossil record, and patterns and distribution of earthquakes and volcanoes. Processes in the geosphere affect the atmosphere, biosphere and hydrosphere and the processes occurring in these spheres affect the geosphere.

Standard III: Students will understand the forces and systems that move Earth's plates and interact with other Earth systems.

Objective 1: Explain the evidence that supports the theory of plate tectonics.

a. Define and describe the location of the major plates and plate boundaries.
b. Compare the movement and results of movement along convergent, divergent and transform plate boundaries.
c. Relate the location of earthquakes and volcanoes to plate boundaries.
d. Explain Alfred Wegener's continental drift hypothesis, his evidence, and why it was not accepted in his time.
e. Describe evidence for and historical development of the current theory of plate tectonics.

Objective 2: Describe how the movement of material within Earth results from heat energy and gravitational forces and moves Earth's plates.

a. Identify the energy sources that cause material to move within Earth.
b. Model convection currents and use it to show how temperature and density drive the currents.
c. Relate the models of convection currents to the movement of materials within the Earth.
d. Relate convection within the Earth to the movement of plates.

Objective 3: Relate changes resulting from plate motion to other Earth systems.

a. Predict the effects of mountain building on climate and biomes.
b. Report on the impacts of volcanic eruptions on weather/climate, waterways and surrounding ecosystems.
c. Provide example of the effect of the biosphere on the geosphere (e.g., soil formation, human effects).

Science language student should use:	Plate tectonics, convergent, divergent, transform, plate, convection current, hypothesis, theory, sea floor spreading, biomes, climate, weather, geosphere, biosphere, hydrosphere, volcanic eruption

Science Benchmark

Water cycles through different holding places in the hydrosphere, with the ocean being the largest reservoir for water. The energy from the sun moves water from one reservoir to another resulting in the water cycle. The water cycle results in salt water becoming fresh water. Fresh water, limited in supply is essential for life. Fresh water may become depleted or polluted.

Standard IV: Students will understand that water cycle through reservoirs in the hydrosphere and affects the other spheres of the Earth system.

Objective 1: Explain the water cycle in terms of its reservoirs, the movement among reservoirs, and the energy to move water.

a. Identify the reservoirs of Earth's water cycle (e.g., ocean, atmosphere, biosphere, groundwater).
b. Graph or chart the amounts of water found in oceans, ice caps/glaciers, groundwater, lakes, rivers, and the atmosphere.
c. Illustrate the movement of water on Earth and describe how the processes that move water use energy from the sun (e.g., evaporation of water, melting of ice/snow, movement of water vapor by wind, ocean currents).
d. Explain how the amount of water in a given reservoir remains relatively constant even though water is entering and leaving that reservoir (i.e., concept of dynamic balance).
e. Relate the uses of the water cycle to the conversion of solar energy into other energy forms (e.g., hydroelectric, moving objects).

Objective 2: Evaluate the importance of freshwater to the biosphere.

a. Locate and list sources of freshwater available locally and globally.
b. Relate the physical and chemical properties of water to a water pollution issue.
c. Describe relationship to a specific ecosystem.
d. Make inferences about the quality and/or quantity of water using data collected from local water systems.
e. Analyze how communities deal with water shortages, distribution, and quality when designing a long-term water use plan.

Objective 3: Analyze the physical and biological dynamics of the oceans.

a. Describe the physical dynamics of the oceans (e.g., wave action, ocean currents, El Niño, tides).
b. Determine how physical properties of oceans affect organisms (salinity, depth, tides, temperature).
c. Research and report on changing ocean levels over geologic time.
d. Model energy flow in ocean ecosystems.

Science language student should use:	groundwater , reservoir, salinity, El Niño, dynamic, balance, tide, hydroelectric

Science Benchmark

Earth's atmosphere interacts with and is changed by the geosphere, hydrosphere, and biosphere. The atmosphere changes rapidly compared to the other spheres. Atmospheric changes affect climate and life in over short and long periods of time.

Standard V: Students will understand that Earth's atmosphere interacts with and is altered by the geosphere, hydrosphere, and biosphere.

Objective 1: Describe how matter in the atmosphere cycles through other Earth systems.

a. Trace movement of a carbon atom from the atmosphere through a plant, animal, and decomposer, and back into the atmosphere.
b. Diagram the nitrogen cycle and provide examples of human actions that affect this cycle (e.g., fertilizers, crop rotation, fossil fuel combustion).
c. Interpret evidence suggesting that humans are influencing the carbon cycle.
d. Research ways the biosphere, hydrosphere, and geosphere interact with the atmosphere (e.g., volcanic eruptions putting ash and gases into the atmosphere, hurricanes, air pollution, changes in vegetation).

Objective 2: Trace how the atmosphere has been altered by living systems and has itself strongly affected living systems over the course of Earth's history.

a. Define ozone and compare its effects in the lower and upper atmosphere.
b. Describe the role of living organisms in producing the ozone layer and how the ozone layer affected the development of life on Earth.
c. Compare the rate of change in the atmosphere to the rate of change in other Earth systems.
d. Analyze data relating to the concentration of atmospheric CO_2 over the past 100 years.
e. Compare the rate of CO_2 input by humans to natural depletion rates through the carbon cycle.
f. Research and report on international efforts to protect the atmosphere.

Science language student should use:	carbon cycle, climate, decomposer, matter, nitrogen cycle, ozone layer, depletion, fossil fuel,

Science Benchmark

The sun is the major source of Earth's energy. Some of the solar radiation that reaches Earth is reflected but most is absorbed. Gases in the atmosphere trap some of the heat energy and delay its radiation to space. This greenhouse effect retains energy longer in the Earth system. Currents in the atmosphere and hydrosphere distribute solar heat energy. These currents help determine global and local weather and climate patterns.
Photosynthesis uses a small but vital part of the total solar energy for the biosphere. This energy is stored in the chemical bonds of sugars formed in plants.

Standard VI: Students will understand that the sun is the major source of Earth's energy and is distributed through all of Earths Systems.

Objective 1: Describe the transformation of solar energy into heat and chemical energy on Earth and eventually the radiation of energy to space.

a. Illustrate the distribution of energy coming from the sun that is reflected, changed into heat, or stored by plants.
b. Describe photosynthesis in terms of converting light energy into chemical energy.
c. Investigate the conversion of light energy from the sun into heat energy by various Earth materials.

d. Demonstrate how absorbed solar energy eventually leaves the Earth system as heat radiating to space.
e. Research to construct a model that demonstrates the reduction of heat loss due to a greenhouse effect (e.g., call Virginia at 1-801-402-5151)

Objective 2: Relate the solar energy that reaches Earth to the distribution and effect on weather.

a. Explain how uneven heating at the equator and Polar Regions creates atmospheric and oceanic convection currents that move energy around Earth.
b. Describe the Coriolis Effect and its role in global wind and ocean current patterns.
c. Relate how weather patterns result from interactions among ocean currents, air currents and topography.
d. Using the tools of meteorology collect, graph, interpret, and analyze weather data.

Objective 3: Relate variations in Earth's global climate to changes in solar energy absorption, atmospheric composition and ocean currents.

a. Describe the difference between weather and climate.
b. Relate short-term climatic cooling to volcanic activity.
c. Explain how convection currents influence El Niño.
d. Research and report how Earth's climate has changed over geologic time (e.g., distribution of continents, glacial coverage, changes in mountain ranges, vegetation).

Science language student should use:	absorbed, Coriolis Effect, El Niño, energy, greenhouse gas, meteorology, radiation, reflected, topography