MICHIGAN HIGH SCHOOL SCIENCE

Michigan Standards for Teaching and Learning

Earth Science	Boardworks High School Earth Science Presentations
E2.1 Earth Systems Overview	
E2.1a Explain why the Earth is essentially a closed system in terms of matter.	Recycling Nutrients
E2.1b Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.	Heat Transfer and Global Interactions Recycling Nutrients The Atmosphere The Carbon Cycle The Water Cycle
E2.1c Explain, using specific examples, how a change in one system affects other Earth systems.	–
E2.2 Energy in Earth Systems	
E2.2a Describe the Earth's principal sources of internal and external energy (e.g. radioactive decay, gravity, solar energy).	Gravity and Orbits Solar Energy
E2.2b Identify differences in the origin and use of renewable (e.g. solar, wind, water, biomass) and nonrenewable (e.g. fossil fuels, nuclear [U-235]) sources of energy.	Crude Oil Fossil Fuel Nuclear Fission Solar Energy
E2.2c Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.	Conduction and Convection Heat Transfer and Global Interactions Plate Tectonics
E2.2d Identify the main sources of energy to the climate system.	Heat Transfer and Global Interactions Weather and Climate
E2.2e Explain how energy changes form through Earth systems.	–
E2.2f Explain how elements exist in different compounds and states as they move from one reservoir to another.	The Carbon Cycle The Nitrogen Cycle
E2.3 Biogeochemical Cycles	
E2.3a Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans.	Greenhouse Gases The Carbon Cycle
E2.3b Explain why small amounts of some chemical forms may be beneficial for life but are poisonous in large quantities (e.g. dead zone in the Gulf of Mexico, Lake Nyos in Africa, fluoride in drinking water).	–
E2.3c Explain how the nitrogen cycle is part of the Earth system.	The Nitrogen Cycle

E2.3d Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g. improve soils for agriculture) or harm (e.g. act as a pollutant) society.	Greenhouse Gases The Carbon Cycle
E2.4 Resources and Human Impacts on Earth Systems	
E2.4a Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits.	Air Pollution Climate Change Fossil Fuels Nuclear Fission Solar Energy
E2.4b Explain how the impact of human activities on the environment (e.g. deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems.	Air Pollution The Carbon Cycle Human Impact on the Environment Water Pollution
E2.4c Explain ozone depletion in the stratosphere and methods to slow human activities to reduce ozone depletion.	The Impact of Using CFCs
E2.4d Describe the life cycle of a product, including the resources, production, packaging, transportation, disposal, and pollution.	–
E3.1 Advanced Rock Cycle	
E3.1a Discriminate between igneous, metamorphic, and sedimentary rocks and describe the processes that change one kind of rock into another.	Erosion, Transportation and Deposition The Rock Cycle Volcanoes Weathering
E3.1b Explain the relationship between the rock cycle and plate tectonics theory in regard to the origins of igneous, sedimentary, and metamorphic rocks.	The Rock Cycle Plate Tectonics
E3.1c Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition.	–
E3.1d Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive.	The Rock Cycle Volcanoes
E3.1e Explain how the texture (foliated, nonfoliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism.	The Rock Cycle
E3.2 Interior of the Earth	
E3.2a Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated.	Earth's Structure
E3.2b Explain how scientists infer that the Earth has interior layers with discernable properties using patterns of primary (P) and secondary (S) seismic wave arrivals.	–
E3.2c Describe the differences between oceanic and continental crust (including density, age, composition).	Earthquake Causes

E3.2d Explain the uncertainties associated with models of the interior of the Earth and how these models are validated.	–
E3.3 Plate Tectonics Theory	
E3.3a Explain how plate tectonics accounts for the features and processes (sea floor spreading, mid-ocean ridges, subduction zones, earthquakes and volcanoes, mountain ranges) that occur on or near the Earth's surface.	Earthquake Causes Plate Tectonics
E3.3b Explain why tectonic plates move using the concept of heat flowing through mantle convection, coupled with the cooling and sinking of aging ocean plates that result from their increased density.	Plate Tectonics
E3.3c Describe the motion history of geologic features (e.g. plates, Hawaii) using equations relating rate, time, and distance.	–
E3.3d Distinguish plate boundaries by the pattern of depth and magnitude of earthquakes.	Earthquake Causes
E3.r3e Predict the temperature distribution in the lithosphere as a function of distance from the mid-ocean ridge and how it relates to ocean depth.	–
E3.r3f Describe how the direction and rate of movement for the North American plate has affected the local climate over the last 600 million years.	–
E3.4 Earthquakes and Volcanoes	
E3.4a Use the distribution of earthquakes and volcanoes to locate and determine the types of plate boundaries.	Earthquake Causes
E3.4b Describe how the sizes of earthquakes and volcanoes are measured or characterized.	Earthquake Causes Volcanoes
E3.4c Describe the effects of earthquakes and volcanic eruptions on humans.	Earthquake Effects Volcanoes
E3.4d Explain how the chemical composition of magmas relates to plate tectonics and affects the geometry, structure, and explosivity of volcanoes.	–
E3.4e Explain how volcanoes change the atmosphere, hydrosphere, and other Earth systems.	The Atmosphere
E3.4f Explain why fences are offset after an earthquake, using the elastic rebound theory.	–
E4.1 Hydrogeology	
E4.1a Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).	–
E4.1b Explain the features and processes of groundwater systems and how the sustainability of North American aquifers has changed in recent history (e.g. the past 100 years) qualitatively using the concepts of recharge, residence time, inputs, and outputs.	–
E4.1c Explain how water quality in both groundwater and surface systems is impacted by land use decisions.	–

E4.2 Oceans and Climate	
E4.2a Describe the major causes for the ocean's surface and deep water currents, including the prevailing winds, the Coriolis effect, unequal heating of the earth, changes in water temperature and salinity in high latitudes, and basin shape.	Heat Transfer and Global Interactions
E4.2b Explain how interactions between the oceans and the atmosphere influence global and regional climate. Include the major concepts of heat transfer by ocean currents, thermohaline circulation, boundary currents, evaporation, precipitation, climatic zones, and the ocean as a major CO2 reservoir.	Conduction and Convection Heat Transfer and Global Interactions Preciptation The Carbon Cycle
E4.2c Explain the dynamics (including ocean-atmosphere interactions) of the El Niño-Southern Oscillation (ENSO) and its effect on continental climates.	ENSO
E4.2d Identify factors affecting seawater density and salinity and describe how density affects oceanic layering and currents.	Heat Transfer and Global Interactions
E4.2e Explain the differences between maritime and continental climates with regard to oceanic currents.	–
E4.2f Explain how the Coriolis effect controls oceanic circulation.	Heat Transfer and Global Interactions
E4.r2g Explain how El Niño affects economies (e.g. in South America).	ENSO
E4.3 Severe Weather	
E4.3a Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).	Earthquake Effects ENSO River Flooding Tropical Cyclones
E4.3b Describe the damage resulting from, and the social impact of thunderstorms, tornadoes, hurricanes, and floods.	Extreme Flooding Hurricane Case Studies River Flooding Tropical Cyclones
E4.3c Describe severe weather and flood safety and mitigation.	Managing Earthquakes River Flooding
E4.3d Describe the seasonal variations in severe weather.	–
E4.3e Describe conditions associated with frontal boundaries that result in severe weather (thunderstorms, tornadoes, and hurricanes).	–
E4.3f Describe how mountains, frontal wedging (including dry lines), convection, and convergence form clouds and precipitation.	Precipitation
E4.3g Explain the process of adiabatic cooling and adiabatic temperature changes to the formation of clouds.	–
E5.1 The Earth in Space	
E5.1a Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe.	Structure of the Universe Planets of the Solar System

E5.1b Describe how the Big Bang theory accounts for the formation of the universe.	Doppler Effect Astronomical Distances
E5.1c Explain how observations of the cosmic microwave background have helped determine the age of the universe.	Doppler Effect Observing the Universe
E5.1d Differentiate between the cosmological and Doppler red shift.	Doppler Effect Observing the Universe
E5.2 The Sun	
E5.2a Identify patterns in solar activities (sunspot cycle, solar flares, solar wind).	–
E5.2b Relate events on the Sun to phenomena such as auroras, disruption of radio and satellite communications, and power grid disturbances.	–
E5.2c Describe how nuclear fusion produces energy in the Sun.	Nuclear Fusion Properties of Stars The Life Cycle of Stars
E5.2d Describe how nuclear fusion and other processes in stars have led to the formation of all the other chemical elements.	The Life Cycle of Stars
E5.2x Stellar Evolution	
E5.2e Explain how the Hertzsprung-Russell (H-R) diagram can be used to deduce other parameters (distance).	Properties of Stars
E5.2f Explain how you can infer the temperature, life span, and mass of a star from its color. Use the H-R diagram to explain the life cycles of stars.	Properties of Stars
E5.2g Explain how the balance between fusion and gravity controls the evolution of a star (equilibrium).	The Life Cycle of Stars
E5.2h Compare the evolution paths of low-, moderate-, and high-mass stars using the H-R diagram.	Properties of Stars
E5.3 Earth History and Geologic Time	
E5.3a Explain how the solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 Ga (billion years ago).	Planets of the Solar System
E5.3b Describe the process of radioactive decay and explain how radioactive elements are used to date the rocks that contain them.	Planets of the Solar System Radioactive Dating
E5.3c Relate major events in the history of the Earth to the geological time scale, including formation of the Earth, formation of an oxygen atmosphere, rise of life, Cretaceous-Tertiary (K-T) and Permian extinctions, and Pleistocene ice age.	Earth's Structure Fossil Record
E5.3D Describe how index fossils can be used to determine time sequence.	–
E5.3x Geological Dating	
E5.3e Determine the approximate age of a sample, when given the half-life of a radioactive substance (in graph or tabular form) along with the ratio of daughter to parent substances present in the sample.	Radioactive Dating
E5.3f Explain why C-14 can be used to date a 40,000 year old tree, but U-Pb cannot.	–

E5.3g Identify a sequence of geologic events using relative-age dating principles.	Radioactive Dating
E5.4 Climate Change	
E5.4a Explain the natural mechanism of the greenhouse effect, including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone).	Air Pollution Climate Change Greenhouse Gses
E5.4b Describe natural mechanisms that could result in significant changes in climate (e.g. major volcanic eruptions, changes in sunlight received by the earth, and meteorite impacts).	The Atmosphere
E5.4c Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels, and the average global temperature over the past 150 years.	Evidence for Climate Change
E5.4d Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity of the biosphere).	Evidence for Climate Change Predicating Climate Change The Carbon Cycle
E5.4e Based on evidence from historical climate research (e.g. fossils, varves, ice core data) and climate change models, explain how the current melting of polar ice caps can impact the climatic system .	–
E5.4f Describe geologic evidence that implies climates were significantly colder at times in the geologic record (e.g., geomorphology, striations, and fossils).	–
E5.4g Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat- trapping capacity.	Greenhouse Gases
E5.r4h Use oxygen isotope data to estimate paleotemperature.	Radioactive Dating
E5.r4i Explain the causes of short-term climate changes such as catastrophic volcanic eruptions and impact of solar system objects.	–
E5.r4j Predict the global temperature increase by 2100, given data on the annual trends of CO2 concentration increase.	Greenhouse Gases