MIDDLE SCHOOL EARTH SCIENCE CURRICULUM MAP AND PACING GUIDE

This pacing guide is based on NGSS performance standards and gives a basic outline of the material to cover in a middle school setting.

Class periods are based on projected time requirements by major subject area using various text resources.

Class period allotments acount for 155-180 instructional days, teacher's discretion on actual instructional days per unit is expected.

Listed under assessment/resources are labs from the Argument-Driven Inquiry in Earth and Space Science lab book (will be provided to interested schools) and links to resources to help structure activities and labs to meet performance expectations.

Vocabulary shown is based on key vocab in related text sources and may be expanded/edited as needed to meet lesson goals.

Vocabulary listed is shown for the entire "unit" and may not be specifically tied to the individual standard as it appears in this pacing guide.

Class Periods	**Standard**	**Performance Expectation**	**Clarification**	**Disciplinary Core Ideas**	**Key Vocabulary**	**Assessment/ Resources links**	**Catholic Identity**
SCIENTIFIC METHOD							
7-10 class periods			Examine the steps used by scientists to investigate the natural world.	There is no set "formula" for conducting scientific research, but there are universally accepted steps that can help define, organize, conduct experiments, and to collect and analyze data to help researchers stay on track.	hypothesis, dependent variable, independent variable, quantitative data, qualitative data	Students will be assessed as they construct and carry out their labs and research throughout the year.	Roger Bacon (c. 1214-1294) - Francisan friar who is described as the forerunner to the modern scientific method.
SPACE SYSTEMS							
MS-ESS1-1, MS-ESS1-2, MS-ESS1-3; 30-35 class periods	**MS-ESS1-1**	Develop and use a model of the Earth-Sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and moon, and seasons.	Examples of models could include physical, graphical, or conceptual models.	**ESS1.A-** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. **ESS1.B -** This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilts relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	Rotation, Revolution, Lunar and Solar Eclipse, Phases of the Moon, Axis, Craters, Sunspots, Aurora, Teloscopes	Argument-Driven Inquiry in Earth and Space Science Lab 1 - Moon phases: Why does the appearance of the moon change over time in a predictable pattern? and Lab 2 - Seasons: What causes the differences in average temperature and the changes in day length that we associate with the change in seasons on Earth?	United States Catholic Catechism for Adults: How does a modern view of Earth from space give us a new respect for creation?

	MS-ESS1-2	Develop and use a model to describe the role of gravity in the motions within the galaxies and the solar system.	Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models could include physical models (such as a model of the solar system scaled using various measures) or conceptual models (such as mathematical proportions). Assessment does not inlcude Kepler's Laws or apparent retrograde motion.	**ESS1.A -** Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B -** The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.	Gravity, Orbit, Solary System, Galaxy, Universe, Planet, Moon/Satellites, Asteroid, Meteor, Comet, Law of Universal Gravitation, Orbit, Tides, Big Bang Theory, Nebula, Star Life Cycle, Spiral Galaxy	Argument-Driven Inquiry in Earth and Space Science Lab 3 - Gravity and orbits: How does changing the mass and velocity of a satellite and the mass of the object that it revolves around affect the nature of the satellite's orbit?	Saint Dominic, patron saint of astronomers, August 4. Would God create life elsewhere in the universe?
	MS-ESS1-3	Analyze and interpret data to determine scale properties of objects in the solar system.	Emphasis is on the analysis of data from instruments, telescopes, and spacecrafts to determine similarities and differences among solar system objects. Examples include size of layers (crust and atmosphere), surface features (volcanoes), and orbital radius.	**ESS1.B -** The solar system consists of the Sun and a collection of objects, including planets and their moons, comets, and asteroids that are held in orbit around the Sun by its gravitational pull.	Comet, Asteriod, Meteor, Planet, Terrestrial Planets, Gas Giants	Scale model lab (free download from Teachers Pay Teachers): https://www.teacherspayteachers.com/Product/Scale-Model-of-Solar-System-Lab-Activity-NGSS-Middle-School-MS-ESS1-3-1568504	
HISTORY OF EARTH							
MS-ESS1-4, MS-ESS2-2, MS-ESS2-3; 40-45 class periods	**MS-ESS1-4**	Construct a scientific explanation based on evidence for rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.	Empahsis is on how analysis of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history (such as the last Ice Age or earliest evidence of life).	**ESS1.C -** The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analysis of rock strata and the fossil record provide only relative dates, not an absolute scale.	Index Fossil, Relative Age, Relative Dating, Paleontologist, Law of Superposition, Original Horizontality, Era, Period, Absolute Dating, Half-life, Geologic Time Scale	Argument-Driven Inquiry in Earth and Space Science Lab 5 - Geologic time and the fossil record: Which time intervals in the past 650 million years of Earth's history are associated with the most extinctions and which are associated with the most diversification of life?	God created Earth. Appreciate Earth's past.

	MS-ESS2-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying temporal and spatial scales.	Emphasis is on processes change Earth's surface at temporal and spatial scales that can be large (uplift of mountains) or small (rapid landslides), and how many geoscience processes (earthquakes, volcanoes) usually behave gradually and are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by water, ice, and wind. Emphasis on processes that shape geologic landscapes.	**ESS2.A -** The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its furture. **ESS2.C -** Water's movements - both on the land and underground - cause weathering and erosion, which change the land's surface features and create underground formations.	Weathering, Erosion, Deposition, Physical Weathering, Chemical Weathering, Seismic Waves, Seismology, Tsunami, P-waves, S-waves	Argument-Driven Inquiry in Earth and Space Science Lab 6 - Plate interactions: How is the nature of the geologic activity that is observed near a plate boundary related to the type of plate interaction that occurs at that boundary? (also aligns to MS-ESS2-3)	Psalm 68:17 - Zion is the mountain God has chosen. 1 King 19:11-13 - Biblical comfort from earthquakes and other natural disasters.
	MS-ESS2-3	Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.	Examples of data could include similarities of rock and fossil types on different continents, the shapes of continents, and the locations of ocean structures (ridges and trenches).	**ESS1.C -** Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. **ESS2.B -** Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.	Sea-floor spreading, Mid-Ocean Ridge, Pangaea, Black Smokers	Argument-Driven Inquiry in Earth Science Lab 6 - Plate interactions: How is the nature of the geologic activity that is observed near a plate boundary related to the type of plate interaction that occurs at that boundary? (also aligns to MS-ESS2-2)	
EARTH'S SYSTEMS							

MS-ESS2-1, MS-ESS2-4, MS-ESS3-1; 20-25 class periods	**MS-ESS2-1**	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.	Emphasis is on the processes of melting, crystalization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.	**ESS2.A -** All Earth's processes are the result of energy flowing and matter cycling within and among the planet's system. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.	Mantle, Core, Crust, Asthenosphere, Convection, Convection Current, Current, Conduction, Radiation, Lithosphere	Argument-Driven Inquiry in Earth and Space Science Lab 8 - Surface erosion by wind: Why do changes in wind speed, wind duration, and soil moisture affect the amount of soil that will be lost due to wind erosion? and Lab 10 - Deposition of sediments: How can we explain the deposition of sediments in water?	
	MS-ESS2-4	Develop a model to describe the cycling of water through Earth's systems driven by energy from the Sun and the force of gravity.	Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Models can be conceptual or physical.	**ESS2.C -** (1) Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation, sublimation, deposition, precipitation, infiltration, and runoff. (2) Global movements of water and its changes in form are driven by sunlight and gravity.	Transpiration, Evaporation, Condensation, Precipitation, Sublimation, Deposition, Infiltration, Runoff, Hydrosphere, Fresh Water, Frozen Water, Glaciers, Reservoir, Water Table, Groundwater, Water Cycle, Percolation, Aquifer, Watershed	Argument-Driven Inquiry in Earth and Space Science Lab 11- Soil texture and soil water permeability: How does soil texture affect soil water permeability? and Lab 12 - Cycling of water on Earth - Why do the temperature and the surface area to volume ratio of a sample affect its rate of evaporation?	

	MS-ESS3-1	Construct a scientific explanation based on evience for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geologic processes.	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 could include petroleum, metal ores, and soil.	**ESS3.A -** 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.	Renewable and Nonrenewable Resources, Atmosphere, Biosphere,	Argument-Driven Inquiry in Earth and Space Science Lab 13 - Characteristics of minerals: What are the identities of the unknown minerals? and Lab 14 - Distribution of natural resources: Which proposal for a new copper mine maximizes the potential benefits while minimizing the potential costs?	Catholic social teaching - Share mineral resources with poor countries. How are poor countries' resources stolen?
WEATHER AND CLIMATE							
MS-ESS2-5, MS-ESS2-6, MS-ESS3-5; 20-25 class periods	**MS-ESS2-5**	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.	Emphasis is on how air flows from regions of high pressure to low pressure, the complex interactions at air mass boundaries, and the movements of air masses affect weather. Emphasis is on how weather can be predicted within probabilistic ranges. Data can be provided to students or obtained through lab experiments.	**ESS2.C -** The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. **ESS2.D -** Because these patterns are so complex, weather can only be predicted probabilistically.	Climate, Windward, Leeward, Ocean Currents, Monsoon, Air Mass, Fronts, Altitude, Pressure, Barometer, Hurricane, Tornado,	Argument-Driven Inquiry in Earth and Space Science Lab 15 - Air masses and weather conditions: How do the motions and interactions of air masses result in changes in weather conditions?	

	MS-ESS2-6	Develop and use a model to describe how unequal heating and rotation of Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.	Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis is on the sunlight-driven latitudinal banding caused by differences in density that create convection currents in the atmosphere, the Coriolis effct, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle.	**ESS2.C -** Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. **ESS2.D -** (1) Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (2) The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.	Convection Cells, Atmosphere, Air Pressure, Density, Temperature	Argument-Driven Inquiry in Earth and Space Science Lab 16 - Surface materials and temperature change: How does the nature of the surface material covering a specific location affect heating and colling rates at that location?	
	MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.	Examples of factors could inlcude human activites and natural processes. Examples of evidence could include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as CO2 and methane, and the rates of human activites. Emphasis on major role that human activites play in causing a rise in global temperatures.	**ESS3.D -** Human activites, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature (global warming). 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 human behavior and on applying that knowledge wisely in decisions and activities.	Global Warming, Carbon Footprint, Chlorofluoro - carbon, Ozone Layer, Greenhouse Gases	Argument-Driven Inquiry in Earth and Space Science Lab 17 - Factors that affect global temperature: How do cloud cover and greenhouse gas concentration in the atmosphere affect the surface temperature of Earth? and Lab 18 - Carbon dioxide levels in the atmosphere: How has the concentration of atmospheric carbon dioxide changed over time?	
HUMAN IMPACTS							

MS-ESS3-2, MS-ESS3-3, MS-ESS3-4; 20-25 class periods	**MS-ESS3-2**	Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.	Emphasis is on how some natural hazards, such as volcanic eruptions, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards could include those resulting from interior processes and surface processes, or from severe weather events. Examples of data could include the locations, magnitudes, and frequencies of the natural hazards.	**ESS3.B -** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events.	Faults, Earthquake, Focus, P waves, S waves, Magnitude, Hurricane, Tornado, Volcanoes, Hot Spot, Ring of Fire	Argument-Driven Inquiry in Earth and Space Science Lab 20 - Predicting hurricane strength: How can someone predict changes in hurricane wind speed over time? and Lab 21: Forecasting extreme weather: When and under what atmospheric conditions are tornadoes likely to develop in the Oklahoma City area?	Catholic social teaching: to provide aid to people in areas affected by natural disasters.
	MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	Examples of the design process could inlcude examining human environmental impacts, assessing kinds of solutions that are feasable, and designing and evaluating solutions that could reduce that impact. Examples of human impacts could include water usage, land usage, and pollution.	**ESS3.C -** (1) Human activies have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environment can have different impacts (negative and positive) for different living things. (2) Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involed are engineered otherwise.		Argument-Driven Inquiry in Earth and Space Science Lab 22 - Minimizing carbon emissions: What type of greenhouse gas emission reduction policy will different regions of the world need to adopt to prevent the average global surface temperature on Earth from increasing by 2 degress Celsius between now and the year 2100? and Lab 23 - Human use of natural resources: Which combination of water use policies will ensure that the Phoenix metropolitan area water supply is sustainable? (both labs also align to MS-ESS3-4)	Reduce human activities that may cause climate change (ozone depletion and global warming). How have humans adapted?

	MS-ESS3-4	Contruct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.	Examples of evidence could include grade-appropriate databases on human populations and the rates of consumption of food and natural resources. Examples of impacts could include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they make the decisions for the actions society takes.	**ESS3.C -** Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involed are engineered otherwise.		Argument-Driven Inquiry in Earth and Space Science Lab 22 - Minimizing carbon emissions: What type of greenhouse gas emission reduction policy will different regions of the world need to adopt to prevent the average global surface temperature on Earth from increasing by 2 degress Celsius between now and the year 2100? and Lab 23 - Human use of natural resources: Which combination of water use policies will ensure that the Phoenix metropolitan area water supply is sustainable? (both labs also align to MS-ESS3-3)	
ENGINEERING DESIGN (TO INCLUDE IN ALL MIDDLE SCHOOL SCIENCE CLASSES) - Incorporate engineering design throughout the school year. One example lab is provided below ("Earthquake engineering design challenge").							
	MS-ETS1-1	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	No clarification statement provided with performance expectation.	**ETS1.A** - The more precisely a design task's critera and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.		Earthquake engineering design challenge: https://smile.oregonstate.edu/lesson/earthquake-engineering-and-design-challenge	
	MS-ETS1-2	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	No clarification statement provided with performance expectation.	**ETS1.B** - There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.		Earthquake engineering design challenge: https://smile.oregonstate.edu/lesson/earthquake-engineering-and-design-challenge	
	MS-ETS1-3	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	No clarification statement provided with performance expectation.	**ETS1.B** - Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. **ETS1.C** - 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.		Earthquake engineering design challenge: https://smile.oregonstate.edu/lesson/earthquake-engineering-and-design-challenge	

	MS-ETS1-4	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	No clarification statement provided with performance expectation.	**ETS1.B** - (1) A solution needs to be tested, and then modified on the basis of the test reults, in order to improve it. (2) Models of all kinds are important for testing solutions. **ETS1.C** - 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.		Earthquake engineering design challenge: https://smile.oregonstate.edu/lesson/earthquake-engineering-and-design-challenge	