Astronomy Scope and Sequence

Grading Period	Unit Title	Learning Targets
Throughout the School Year		B.(1) Scientific processes. The student, for at least 40% of instructional time, conducts laboratory and field investigations using safe, environmentally appropriate, and ethical practices. The student is expected to: (A) demonstrate safe practices during laboratory and field investigations, including chemical, electrical, and fire safety, and safe handling of live and preserved organisms; and (B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials. B.(2) Scientific processes. The student uses scientific methods during laboratory and field investigations. The student is expected to: (A) know the definition of science and understand that it has limitations, as specified in subsection (b)(2) of this section; (B) know that scientific hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power which have been tested over a wide variety of conditions are incorporated into theories; (C) know that scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well-established and highly-reliable explanations, but they may be subject to change as new areas of science and new technologies are developed; (D) distinguish between scientific hypotheses and scientific theories; (E) plan and implement investigative procedures, including asking questions, formulating testable hypotheses, and selecting, handling, and maintaining appropriate equipment and technology; (F) collect data individually or collaboratively, make measurements with precision and

	accuracy, record values using appropriate units, and calculate statistically relevant quantities to describe data, including mean, median, and range; (G) demonstrate the use of course apparatuses, equipment, techniques, and procedures; (H) organize, analyze, evaluate, build models, make inferences, and predict trends from data; (I) perform calculations using dimensional analysis, significant digits, and scientific notation; and (J) communicate valid conclusions using essential vocabulary and multiple modes of expression such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports. B.(3) Scientific processes. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to: (A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student; (B) communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials; (C) draw inferences based on data related to promotional materials for products and services; (D) evaluate the impact of research and technology on scientific thought, society, and the environment; (E) describe the connection between astronomy and future careers; and (F) research and describe the history of astronomy and contributions of scientists.	
First Grading Period	Discovering the Night Sky	*Explain the importance of distance measurements in astronomy. *Describe the nature and use of constellations. *Define the elements of the equatorial coordinate system on the celestial sphere. *Define two solstices and two equinoxes. *Explain the orientation of the ecliptic on the celestial sphere and how it produces seasons on the Earth. *Describe the daily and yearly motions of the Earth. *Describe what precession is, what effect it has on our observations of stars, and why it occurs. *Draw a diagram to explain how lunar phases are controlled by the relative positions of the Sun and the Moon.

		*Explain when and why solar and lunar eclipses occur and why these eclipses do not occur every month.
	Gravitation and the Motion of the Planets	*Compare and contrast the Ptolemaic and Copernican cosmologies by explaining a variety of naked-eye observations, using both models. *State Kepler's three laws of planetary motion; describe the geometric content and observational consequences of each. *List Galileo's telescopic observations and explain the success or failure of Ptolemaic and Copernican models in accounting for them. *State and identify examples of Newton's three laws of motion. *State Newton's law of universal gravitation; identify the characteristics of this law that explain Kepler's laws in terms of Newton's laws.
	Light and Telescopes	*investigate and explain cellular processes, including homeostasis, energy conversions, transport of molecules, and synthesis of new molecules *compare the structure and functions of different types of biomolecules *compare the reactants and products of photosynthesis and cellular respiration in terms of energy and matter
	Formation of Our Solar System	*List the most abundant elements in the solar system and indicate the likely origin of each. *Describe the major stages in the formation of the solar system and how it evolved to its current state. *Explain how the differences between the inner and the outer planets have resulted despite their common origin. *Compare and contrast the general physical characteristics of the various groups of planets and list the members of each group. *Describe the characteristics of dwarf planets and explain why this designation was created. *Describe several methods astronomers use to find exoplanets.

	Earth and the Moon	*Describe the chemical evolution of the Earth's atmosphere. *Describe the basic characteristics of plate tectonics on the Earth, including the observational evidence and the underlying cause. *List the major divisions of the Earth's interior and describe the chemical composition and relative physical conditions in each. *Describe the relationship of the Van Allen belts and the northern lights to the Earth's magnetic field. *List the various layers in the Earth's atmosphere and describe the physical characteristics by which they differ. *Describe the effect of increasing carbon dioxide in the Earth's atmosphere on the average global atmospheric temperature. *List and describe the nature and probable origin of lunar surface features visible in photographs. *Indicate the range in ages of lunar rocks taken from different areas on the lunar surface and explain what they indicate about the stages in the formation of the moon. *Describe the key elements of the collision-ejection theory and summarize the evidence that might support it.
Second Grading Period	Terrestrial Planets	*Compare and contrast the atmospheres of the terrestrial planets in terms of temperature, pressure, and chemical composition. *List the properties that Mercury has in common with the other terrestrial planets and with the Moon. *Compare and contrast the surfaces of Mercury, Mars, and Venus with that of the Earth in terms of geologic structures and evidence regarding tectonic activity. *Describe plausible explanations for the absence of water vapor in the Venusian and Martian atmospheres. *Discuss the contributions of the various spacecraft missions to our understanding of the terrestrial planets. *Discuss the evidence for the existence of water on Mars's surface in the past and the location and form of that water today. *Compare the magnetic fields of Mercury, Venus, and Mars with that of the Earth. *Describe the surface features of Mars revealed by recent missions to the red planet.

	Outer Planets	*Describe the chemical evolution of the Earth's atmosphere. *Describe the basic characteristics of plate tectonics on the Earth, including the observational evidence and the underlying cause. *List the major divisions of the Earth's interior and describe the chemical composition and relative physical conditions in each. *Describe the relationship of the Van Allen belts and the northern lights to the Earth's magnetic field. *List the various layers in the Earth's atmosphere and describe the physical characteristics by which they differ. *Describe the effect of increasing carbon dioxide in the Earth's atmosphere on the average global atmospheric temperature. *List and describe the nature and probable origin of lunar surface features visible in photographs. *Indicate the range in ages of lunar rocks taken from different areas on the lunar surface and explain what they indicate about the stages in the formation of the moon. *Describe the key elements of the collision-ejection theory and summarize the evidence that might support it.
	Space Rocks	*Sketch the location of the asteroid belt in the solar system and explain the nature and origin of the Kirkwood gaps. *Describe the relationships among meteoroids, meteorites, meteors, and meteor showers. *List the principal classes of meteorites; compare and contrast their compositions and frequencies in space and on Earth. *Compare and contrast dwarf planets, asteroids, meteoroids, and comets in terms of orbital characteristics, chemical composition, size, and structure.
Third Grading Period	The Sun	*Name the three layers of the solar atmosphere and describe the relative temperatures and densities in each. *Describe flares, spicules, granules, prominences, and sunspots and identify the layer in the solar atmosphere in which each is found. *Indicate what is observed in helioseismology and explain its value in investigating the Sun. *Explain the nuclear fusion process that is the principal energy source in the solar interior and describe the physical conditions required for this process to proceed effectively.

		*State and explain the equilibrium conditions that are assumed to prevail in the solar interior and make the computations of stellar models possible. *List and describe the two primary mechanisms for energy transport in stellar interiors and indicate in which regions of the solar interior, if any, each is dominant. *Explain how the detection of solar neutrinos provides a probe of the Sun's core.
	Stars	*Describe the magnitude system and how the brightness of a light source changes with distance. *Estimate the brightness ratio of two stars when given their magnitudes. *Describe the observations necessary for the determination of basic physical properties of stars, such as mass, temperature, luminosity, chemical composition, sizes, and motions. *Explain the classification of stars according to their spectra and luminosity. *Draw and describe the H-R diagram and its usefulness for displaying physical properties of stars and in expanding our knowledge about stellar sizes and distances. *List the classes of binary stars and state the criteria for determining membership in each. *Draw, label, and describe a graph of the mass-luminosity relation and specify limitations on its applicability. *Explain the characteristics of the radial velocity curves for binary stars. *Describe the differences between the light curves for total and partial eclipsing binary stars.
	Stellar Evolution	*Describe the physical properties and visual appearances of objects associated with pre– main sequence stellar evolution. *Identify the defining characteristic of main-sequence stars and compare the relative lifetimes on the main sequence for stars of different mass. *List the names of nuclear fusion reactions and indicate the classes of stars in which each reaction is thought to be active. *Identify the physical property normally thought to control the life cycles of stars and planets. *Explain how observations of open and globular star clusters contribute to

		the testing and extension of current theoretical models for stellar evolution. *Identify the stages of stellar evolution in which mass loss is significant. *Compare and contrast RR Lyrae and Cepheid variable stars in terms of period, population membership, luminosity, and evolutionary status. *Describe how a plot of the main sequence of a star cluster can be used to determine the cluster's age. *Describe what happens to stars when core helium fusion ceases. *Explain how heavy elements are created. *Describe the characteristics of the end of stellar evolution. *Compare and contrast those stars that go out relatively gently with those that go out with a bang. *Understand the incredible density of the matter in neutron stars and describe how these objects are observed.
	Black Holes	*Provide brief descriptions of the special and general theories of relativity. *List the principal features used to describe black holes and explain the significance of each. *List the three properties that completely characterize a black hole. *Describe how energy can be extracted from certain types of black holes and indicate what property a black hole must have to allow such extraction. *Discuss the evidence that suggests that black holes exist in binary systems and briefly describe how searches for such objects are conducted.
Fourth Grading Period	The Milky Way Galaxy	*List the contributions of Leavitt, Shapley, and Hubble to astronomy. *Discuss the importance of Cepheids in finding extragalactic distances. *Describe the history of events leading to the present understanding of the basic structure of the universe. *Draw and label diagrams of the Milky Way from top and side views, showing the major components. *Indicate the approximate dimensions of the components of the Milky Way and note the location of the Sun in each diagram. *Describe the galactic distribution of interstellar material, nebulae, and open and globular star clusters, as well as specify the defining physical characteristics of each. *Define differential rotation and discuss the observations used to establish the rotation curve of the Galaxy and its value in probing the structure of the Milky Way.

		*Discuss the “missing mass” problem. *Explain how we know there is a supermassive black hole at the center of the Milky Way.
	Galaxies	*Draw and label the tuning fork diagram, showing the principal Hubble classes for galaxies, and describe the criteria for the assignment of subclasses. *Discuss the differences between flocculent spirals and grand-design spirals. *Explain what spiral arms are and how they are sustained. *Compare and contrast the contents of the various Hubble classes of galaxies. *Describe the distribution of galaxies in space, and distinguish between regular and irregular clusters of galaxies. *Explain the observational basis for the dark matter problem in spiral galaxies and in clusters of galaxies. *Discuss the role of collisions and mergers in our understanding of galaxies. *State the Hubble law and describe how the Hubble constant is evaluated and how it is used to determine the distances of galaxies.
	Cosmology	*Describe the evidence that suggests that the universe is expanding. *Explain the origin of the Hubble law and the cosmic microwave background radiation in the Big Bang theory of cosmology. *Discuss the effect of the mean density of the universe on its future, its rate of expansion with time, and its shape or geometry. *Contrast the meaning of the expanding universe theories with inflationary universe theories and explain the isotropy and flatness problems in the context of the inflationary models. *Define what antimatter is and how it is affected by the presence of matter. *List the four basic forces in nature and review the progress made to date in attempts to unify these forces.

	Astrobiology	*Explain how astronomers search for extraterrestrial life. *Discuss the Drake equation and make estimates for the various factors in it. *Explain why radio telescopes are used in the search for extraterrestrial signals. *Outline the results to date of the SETI program. *Be mindful of the pressing astrobiological questions of the day, such as: Why is Earth habitable? How, when, and why did it become habitable? Are, or were, any other bodies in our Solar System habitable? Might planets orbiting other stars be habitable? What sorts of stars are most likely to have habitable planets?