Astronomy Curriculum Maps

Unit 1: How do the patterns we observe in the sky bring order to our lives?
Unit 2: What clues to our origin exist in the cosmos?

NOTE: Astronomy is a one semester laboratory-oriented course that will provide the student with an introduction to the concepts of modern astronomy, the origin and history of the Universe and the formation of the Earth and the solar system.

Grade: 11-12 Subject: Astronomy	**Unit 1: How do the patterns we observe in the sky bring order to our lives?**
Big Idea/Rationale	Humans have been observing the night sky for millennia. As our ancestors began to recognize patterns in the stars, they soon took note that the arrival of certain celestial objects correlated with the changing of the seasons. The daily changes in the shape of the moon were predictable, as were the annual movements of the stars. Over time, these patterns were incorporated into our modern calendar, as well as many religious calendars around the world. With the birth of scientific thinking in the 17th century, the movements of the celestial sphere were no longer seen as mystic- humans began piecing together the order of the cosmos, of which they are still doing today. As humans continued to explore the fundamental concepts of light and gravity while applying new technology such as the telescope, new insights and perspectives emerged that shaped the way we view the cosmos.
Enduring Understanding (Mastery Objective)	1. Astronomers use direct and indirect observations to learn about celestial objects. Most of these observations are made through collecting E-M radiation through telescopes or spectrometers. 2. Constellations can provide a "road map" to astronomers for locating celestial objects in the night sky. 3. Knowledge of the Earth-Moon-Sun system has allowed humans to organize time into the modern calendar. 4. Seasonal changes on Earth are generated by the incoming angle of solar radiation. 5. Astronomers use direct and indirect observations to learn about celestial objects. Most of these observations are made through collecting E-M radiation through telescopes or spectrometers. 6. All objects have gravity, which is an attractive force present throughout the universe. 7. Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. 8. All objects have gravity, which is an attractive force present throughout the universe. 9. Large groupings of stars are organized into galaxies, while galaxies are also clumped together in groups.
Essential Questions (Instructional Objective)	1. How big is the universe? 2. Why do objects in the universe move the way they do? 3. How can the patterns we observe in the night sky help us bring order to our lives on Earth?

	4. How do humans track time with the motions of the Earth, Moon, and Sun? 5. How has our view of Earth's place in the Universe changed since ancient times? 6. How does changing technology change our perspective of the cosmos? 7. What can light inform us about the cosmos? 8. How is a telescope like a time machine? 9. How does gravity affect the organization of the cosmos? 10. How has the space program contributed to our understanding of the solar system?
Content (Subject Matter)	1. A light year is the distance light travels in one year, thus making it a measure of distance rather than time. 2. Distances of celestial bodies can be found from tiny shifts they appear to make (parallax) as the Earth orbits the Sun. 3. Stars form patterns, or constellations, whose shapes do not change. 4. Some constellations can only be seen during certain times of year (seasonal), while others can be seen all year round (circumpolar). 5. Light can be theorized either as a wave of energy or a stream of particles called photons. 6. Atoms can emit or absorb light when their electrons shift to lower- or higher-energy orbitals. 7. Each kind of atom emits (or absorbs) light at a unique set of wavelengths (colors). 8. The wavelengths of the radiation emitted by a moving object are seen to be shifted if the object is moving toward or away from the observer. 9. Astronomers use telescopes to gather light and thereby make dim objects observable. 10. Telescopes use lenses and mirrors to redirect a large amount of light to a focused spot. 11. Astronomers use special-purpose telescopes to observe non-visible wavelengths. Many of these are in orbit, so they are not affected by the blurring or light by Earth's atmosphere. 12. Newton's laws of motion allow us to describe and predict an object's motion of we know the forces acting on it. 13. If no forces act on an object, inertia keeps the object moving in a straight line at a constant speed. 14. Gravity controls the motion of most astronomical objects. 15. The force of gravity between two objects depends on their mass and the distance between them: the greater the separation, the weaker the force; the greater their mass, the greater the force. 16. Orbital motion allows us to determine the mass of astronomical objects. 17. The mass and radius of an object determine the strength of the gravitational pull at its surface (surface gravity) and the speed needed to escape its gravitational pull (escape velocity)

	18. The Moon's gravity creates tides in the Earth's oceans. Most places on Earth experience 2 high and 2 low tides every 24 hours. 19. Seasons are caused by the tilt of the Earth's axis relative to its orbit, which produces different amounts of heating in different regions during the year. 20. Eclipses occur when the Earth, Sun, and Moon all align, which are only possible two times per year. 21. The darkest shadow of an eclipse (umbra) is where observers on Earth will observe a total eclipse. The lighter shadow, or penumbra, indicate a partial eclipse. 22. Cycles of the Moon, Sun, and stars are the basis for keeping time and our calendar.
Skills/ Benchmarks (NGSS Standards)	HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. HS-ETS1-2. Design a solution to a complex, real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Materials and Resources	• The Universe at Your Fingertips (UAYFT) - Instructional Resources for Astronomy • Comins, N.F. and W.J. Kaufmann. Discovering the Universe. 7th ed. • Arny, T.T. and S.E. Schneider. Explorations: An Introduction to Astronomy. 6th ed. (2010.) • Project Earth Science: Astronomy. NSTA Press • PHet Simulations Online • Starry Night Software • Heavens-Above online sky charts: http://www.heavens-above.com • United Streaming Videos Online • Cosmos- A Spacetime Odyssey- DVD Box Set • PBS Videos- Origins, NOVA • NASA: http://www.nasa.gov • Imagine the Universe: http://imagine.gsfc.nasa.gov/index.html • Black Hole Encyclopedia: http://blackholes.stardate.org/ • Messier Index: http://www.seds.org/messier/data2.html • Astronomy Picture of the Day: http://apod.nasa.gov/apod/ • US Naval Observatory Astronomical Data: http://aa.usno.navy.mil/ • Current human spaceflight: http://spaceflight.nasa.gov/home/index.html • Raritan Valley Community College • Project ASTRO • New Jersey Earth Science Teachers Association (NJESTA) • National Science Teachers Association (NSTA) • New Jersey Education Association (NJEA) • The American Museum of Natural History, Hayden Planetarium • Newark Museum- Newark, NJ • The New Jersey State Observatory- High Bridge, NJ
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Grade: 11-12 Subject: Astronomy	Unit 2: What clues to our origin exist in the cosmos?
Big Idea/Rationale	One of the most enduring and essential questions of astronomy is, “How did we get here?” What series of events brought humans to be thriving on a rocky planet in an outer arm of a spiral galaxy? This unit focuses on our origins, not just life on Earth, but the origins of the cosmos. The atoms that build our bones, blood, and organs were formed from billions of dead stars. The universe still vibrates with cosmic background radiation from the Big Bang over 13.7 billion years ago. Analysis of the movement of distant galaxies provides evidence that the universe is expanding. Astronomers are discovering new planets that orbit distant stars every day- what are the chances life exists elsewhere in the cosmos?
Enduring Understanding (Mastery Objective)	1. Knowledge of our Solar System has deepened and evolved with technological advances including telescopes, probes, and other unmanned spacecraft 2. Terrestrial and Jovian planets have many similarities and differences which can be attributed to the formation of the Solar System from the Solar nebula. 3. Information about smaller objects in our solar system can help inform astronomers about Earth during its infancy. 4. Stars undergo a life cycle, during which elements of the Periodic Table are created and distributed throughout the Universe. 5. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. 6. Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presences of an element, even in microscopic quantities. 7. Other than the hydrogen and helium formed at the time of the Big Bang nuclear fusion within the stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. 8. The Universe was created 13.7 billion years ago when all energy was confined to a singularity and then began inflating. This is known as the Big Bang Theory 9. Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. 10. Many astronomers believe that life has formed numerous other places in the Universe, yet all searches have found nothing thus far.

Essential Questions (Instructional Objective)	1. How does gravity organize our solar system? 2. Where do elements come from? 3. What galactic evidence can astronomers attribute to the theory of an expanding Universe? 4. What clues to our origin exists in the cosmos? 5. How do astronomers search for life outside of our Solar System? 6. How does changing technology change our perspective of the cosmos?
Content (Subject Matter)	1. The Solar System consists of the Sun, the eight planets, their moons, and smaller objects such as dwarf planets, asteroids and comets. 2. The Moon was probably formed from debris blasted out of the Earth by the impact of a planet-sized object shortly after the Earth's formation. 3. The planets orbit the Sun within a flat disk-shaped region, held there by the Sun's gravity. 4. The inner and outer planets have many differences between them, but the differences are derived from their distance from the Sun during the formation of the solar system. 5. The Jovian planets have deep, thick atmospheres, no solid surfaces, many moons, and rings. 6. Smaller, planet-like objects that orbit the sun are classified as "Dwarf Planets". 7. Other numerous objects much smaller than planets orbit the sun including asteroids, comets, and meteoroids. 8. Galaxies are often found in groups and larger clusters. 9. Galaxies have a variety of shapes, but three types dominate: spiral, elliptical, and irregular. 10. Deep observations of distant galaxies allow us to see what galaxies looked like when they were young. 11. The Sun is an immense ball of gas whose size remains relatively in balance between gravity pulling inwards and gas pressure from nuclear fusion pushing outwards. 12. Nuclear fusion in the Sun's core converts 4 hydrogen nuclei into a helium nucleus. The loss of mass is released as energy according to Einstein's formula $E=mc^2$. 13. Motions in the Sun's interior generate magnetic effects such as sunspots, prominences, and flares. 14. Asteroids and comets are left-over from the formation of the Solar System and provide information about early conditions. 15. The flow of heat drives motions inside Earth and Venus but Mars and Mercury have cooled due to their smaller size, thus have no internal motion. 16. Other planets (exoplanets) have been discovered orbiting other stars in our galaxy, but we have yet to determine whether these systems resemble our own Solar System. 17. The Solar System formed about 4.6 billion years ago from an interstellar gas cloud that collapsed and shrank under the force of its own gravity.

	18. Distances of stars can be found from tiny shifts they appear to make (parallax) as the Earth orbits the Sun. 19. Stars form from interstellar clouds of gas and dust called nebulae. 20. Classification of stars by their temperature and intrinsic brightness shows that stars can be divided into three main groups: main-sequence stars, red giants, and white dwarfs. 21. When stars burn all their hydrogen in their core, the core shrinks and heats, causing the outer layers to expand and cool. This makes the star turn into a red giant. 22. The more massive the star, the higher the temperatures in the core, allowing the fusion of heavier elements. 23. Stars like the sun drive off most of their atmosphere in the red giant phase; their core becomes a cooling white dwarf. 24. High-mass stars may explode as a supernova, surviving afterward as either a neutron star or a black hole. 25. A black hole forms if the core of a massive star becomes so dense that the escape velocity at the surface of the core reaches the speed of light. 26. The farther a galaxy is from us, the faster it recedes (Hubble Law). 27. Evidence for the Big Bang comes from red-shift of distant galaxies and the detection of cosmic background microwave radiation. 28. Life on Earth had a common origin soon after Earth's formation. The conditions necessary for life exist outside of our Solar System.
Skills/ Benchmarks (NGSS Standards)	HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation. HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

	HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
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