Phoenixville Area School District Understanding by Design (UbD) Science Template

Grade Level &/or HS Subject: Environmental Science   Unit Name: Earth's Place in the Universe

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">Overarching NGSS & PA Standards:

<u>HS-ESS1-1</u>
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 that eventually reaches the Earth in the form of radiation.

<u>HS-ESS1-2</u>
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Ask questions and/or define problems
Develop and/or use models
Plan and/or carry out investigations
Analyze and interpret data using computational thinking
Obtain, evaluate, and communicate information (supported by evidence)
Construct explanations and design solutions</td></tr>
<tr><td colspan="2">Meaning-Making</td></tr>
<tr><td>Students will understand that…

Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.

Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars.

Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.

Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.</td><td>ESSENTIAL QUESTIONS
Students will keep considering...

What is the universe, and what is Earth's place in it?

What is the universe, and what goes on in the stars?

What are the predictable patterns caused by Earth's movement in the solar system?</td></tr>
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<table>
<tr><td rowspan="3">composition of matter in the universe.

<u>HS-ESS1-3</u>
Communicate scientific ideas about the way stars, over their life cycle, produce elements.

<u>HS-ESS1-4</u>
Use mathematical or computational representations to predict the motion of orbiting objects in the solar system

Which branch(es) of science apply:

LS PS
E&SS</td><td colspan="2">Knowledge and Skills Acquisition</td></tr>
<tr><td>UNDERSTANDINGS
Students will know…

ESS1.A: The Universe and Its Stars
-The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.
-The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
-The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stelar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.
-Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within 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.

ESS1.B: Earth and the Solar System
-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.

PS1.C: Nuclear Processes
-Spontaneous radioactive decays following a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other minerals.

PS3.D: Energy in Chemical Processes and Everyday Life
-Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.

PS4.B: Electromagnetic Radiation
-Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.</td><td rowspan="2">Students will be skilled at…

• Creating a model
• Describing relationships
• Making connections
• Articulating the explanation of phenomena
• Identifying evidence
• Reasoning to connect evidence and construct an explanation
• Communicating style and format
• Identifying relationships
• Using mathematical or computational representations in science</td></tr>
<tr><td>KEY VOCABULARY

nuclear fusion, proton-proton chain reaction, electromagnetic radiation, photons, H-R diagram, main-sequence stars, supernovae, ellipses, radioactive decay, light-year, Big Bang theory, spectroscopy, dark-line spectrum, bright-line spectrum, Doppler effect</td></tr>
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<table>
<tr><th colspan="3">Stage 2 – Evidence</th></tr>
<tr><th>Evaluative Criteria</th><th colspan="2">Assessment Evidence</th></tr>
<tr><td>Project Rubrics
Labs
Quizzes
Tests</td><td>PERFORMANCE TASK(S):

HS-ESS1-1
• Students use evidence to develop a model in which they identify and describe* the relevant components, including:
o Hydrogen as the sun’s fuel
o Helium and energy as the products of fusion processes in the sun
o That the sun, like all stars, has a life span based primarily on its initial mass, and that the sun’s lifespan is about 10 billion years
• In the model, students describe* relationships between the components, including a description* of the process of radiation, and how energy released by the sun reaches Earth’s system.
• Students use the model to predict how the relative proportions of hydrogen to helium change as the sun ages.
• Students use the model to qualitatively describe* the scale of the energy released by the fusion process as being much larger than the scale of the energy released by chemical processes.
• Students use the model to explicitly identify those chemical processes are unable to produce the amount of energy flowing out of the sun over long periods of time, thus requiring fusion processes as the mechanism for energy release in the sun.

HS-ESS1-2
• Students construct an explanation that includes a description* of how astronomical evidence from numerous sources is used collectively to support the Big Bang theory, which states that the universe is expanding and that thus it was hotter and denser in the past, and that the entire visible universe emerged from a very tiny region and expanded.
• Students identify and describe* the evidence to construct the explanation, including:
o The composition (hydrogen, helium and heavier elements) of stars
o The hydrogen-helium ratio of stars and interstellar gases; iii. The redshift of most galaxies and the redshift vs. distance relationship; and
o The existence of cosmic background radiation.
• Students use a variety of valid and reliable sources for the evidence, which may include students’ own investigations, theories, simulations, and peer review.</td><td>Differentiation Considerations:</td></tr>
</table>

	- Students describe* the source of the evidence and the technology used to obtain that evidence. - Students use reasoning to connect evidence, along with the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, to construct the explanation for the early universe (the Big Bang theory). Students describe* the following chain of reasoning for their explanation: - Redshifts indicate that an object is moving away from the observer, thus the observed redshift for most galaxies and the redshift vs. distance relationship is evidence that the universe is expanding. - The observed background cosmic radiation and the ratio of hydrogen to helium have been shown to be consistent with a universe that was very dense and hot a long time ago and that evolved through different stages as it expanded and cooled (e.g., the formation of nuclei from colliding protons and neutrons predicts the hydrogen-helium ratio [numbers not expected from students], later formation of atoms from nuclei plus electrons, background radiation was a relic from that time). - An expanding universe must have been smaller in the past and can be extrapolated back in time to a tiny size from which it expanded. HS-ESS1-3 - Students use at least two different formats (e.g., oral, graphical, textual, and mathematical) to communicate scientific information, and cite the origin of the information as appropriate. - Students identify and communicate the relationships between the life cycle of the stars, the production of elements, and the conservation of the number of protons plus neutrons in stars. Students identify that atom are not conserved in nuclear fusion, but the total number of protons plus neutrons is conserved. - Students describe that: - Helium and a small amount of other light nuclei (i.e., up to lithium) were formed from high-energy collisions starting from protons and neutrons in the early universe before any stars existed. - More massive elements, up to iron, are produced in the cores of stars by a chain of processes of nuclear fusion, which also releases energy. - Supernova explosions of massive stars are the mechanism by which elements more massive than iron are produced.	

- There is a correlation between a star's mass and stage of development and the types of elements it can create during its lifetime.
- Electromagnetic emission and absorption spectra are used to determine a star's composition, motion, and distance to Earth.

HS-ESS1-4

- Students identify and describe* the following relevant components in the given mathematical or computational representations of orbital motion: the trajectories of orbiting bodies, including planets, moons, or human-made spacecraft; each of which depicts a revolving body's eccentricity e = f/d, where f is the distance between foci of an ellipse, and d is the ellipse's major axis length (Kepler's first law of planetary motion).
- Students use the given mathematical or computational representations of orbital motion to depict that the square of a revolving body's period of revolution is proportional to the cube of its distance to a gravitational center ($T2 \propto R3$, where T is the orbital period and R is the semi-major axis of the orbit — Kepler's third law of planetary motion).
- Students use the given mathematical or computational representation of Kepler's second law of planetary motion (an orbiting body sweeps out equal areas in equal time) to predict the relationship between the distance between an orbiting body and its star, and the object's orbital velocity (i.e., that the closer an orbiting body is to a star, the larger its orbital velocity will be).
- Students use the given mathematical or computational representation of Kepler's third law of planetary motion ($T2 \propto R3$, where T is the orbital period and R is the semi-major axis of the orbit) to predict how either the orbital distance or orbital period changes given a change in the other variable.
- Students use Newton's law of gravitation plus his third law of motion to predict how the acceleration of a planet towards the sun varies with its distance from the sun, and to argue qualitatively about how this relates to the observed orbits.

Question Accuracy Project Rubrics	OTHER EVIDENCE:
	
	Optional
	• Project
	    ○ Adopt a Constellations
	• Labs
	    ○ Ellipses and Orbital Motion Lab
	    ○ Motions of the Moon Lab
	    ○ Electromagnetic Spectrum Lab
	    ○ Life Cycle of Stars Lab
	    ○ HR Diagram Lab
	    ○ Life Cycle of the Sun Lab
	    ○ Doppler Shift and the Changing Universe Lab
	• Unit Test
	    ○ Earth's Place in the Universe Test
		Differentiation Considerations: