

HS-ESS1-3 Earth's Place in the Universe

 California Science Test—Item Content Specification

# HS-ESS1-3 Earth's Place in the Universe

Students who demonstrate understanding can:

Communicate scientific ideas about the way stars, over their life cycle, produce elements.

[Clarification Statement: 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.] [*Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.*]

Continue to the next page for the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

| Science and Engineering Practices | Disciplinary Core Ideas | Crosscutting Concepts |
| --- | --- | --- |
| Obtaining, Evaluating, and Communicating InformationObtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.Communicate scientific ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). | ESS1.A: The Universe and Its Stars1. The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
2. 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.
 | Energy and MatterIn nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. |

## Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

### Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

8.2 Ability to communicate about science and engineering (especially regarding the investigations conducted and the observations made)

### Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

8.2.1 Ability to produce written and illustrated text that communicate one’s own ideas

8.2.2 Ability to use appropriate combinations of language, models, and mathematical expressions to communicate one’s understanding or to ask questions about a concept, event, system, or design

### Disciplinary Core Idea Assessment Targets

#### ESS1.A.6

* 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
* Explain that absorption spectra are used to determine a star’s composition and motion

#### ESS1.A.8

* Identify 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
* Identify that heavy elements, up to iron, are produced in the cores of high-mass stars by a chain of processes of nuclear fusion, which also releases energy, and elements heavier than iron can be produced in supernovas
* Recognize that there is a correlation between a star’s mass and the types of elements it can create during its lifetime

### Crosscutting Concept Assessment Target(s)

CCC5 Identify that, in nuclear processes, atoms are not conserved; but rather, the total number of protons plus neutrons is conserved

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a basic model of nuclear fusion:

* Describes how factors such as composition and temperature affect the rate of nuclear fusion and energy production (8.2.2, ESS1.A.8, and CCC5)

Task provides a question asking students to explain how the mass fraction of hydrogen and helium is represented inside the diameter of the present-day Sun:

* Generates a graphical representation, noting what the approximate mass fraction of each element was when the Sun was originally formed (8.2.1, ESS1.A.8, and CCC5)

Task provides three different possible end-of-life stages for a star, such as white dwarf, neutron star, and black hole. Three descriptions of life cycles are given which explain how these end-of-life stages come about, but some information is missing. Also provided is physical data about examples of a white dwarf, neutron star, and black hole:

* Utilizes the data provided to complete the description of each life cycle (8.2.2, ESS1.A.8, and CCC5)

Task provides an image of the path a main sequence star like the Sun would take superimposed on a graph where the x-axis is surface temperature, and the y-axis is luminosity. On the graph are diagonal dotted lines that indicate radius in terms of the radius of the Sun:

* Describes the temperature, luminosity, and radius of stars at various points on the diagram (8.2.2, ESS1.A.6, and CCC5)

Task provides an image of an old high-mass star with an inset image focused into a smaller center of the star where its fusing shells are located:

* Identifies the elements that are fusing in each layer of the shell (8.2.2, ESS1.A.8, and CCC5)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* The synthesis and relative abundance of hydrogen, helium, and trace light elements in the primordial universe
* The origin of heavy elements as it relates to the formation of supernovae
* The importance of stellar mass on the lifetime and chemical production of stars
* The use of spectroscopic absorption features to measure surface composition of stars
* Relative luminosity, radius, and surface temperature of the Sun and other stars

## Common Misconceptions

Note that the list in this section is not exhaustive.

* All stars and galaxies were formed at the moment of the Big Bang.
* All elements were formed at the moment of the Big Bang.
* Astronomers have directly observed a star going through its complete life cycle.
* Giants, supergiants, and red giants are interchangeable names for the same life cycle stage of a star.
* All stars are about the same size, age, and composition.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-ESS1-3 Evidence Statement [https://www.nextgenscience.org/sites/default/files/evidence\_statement/black\_white/HS-ESS1-3 Evidence Statements June 2015 asterisks.pdf](https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-ESS1-3%20Evidence%20Statements%20June%202015%20asterisks.pdf)

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12 <https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix1.pdf>

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