

HS-ESS1-2 Earth's Place in the Universe

California Science Test—Item Content Specifications

# HS-ESS1-2 Earth's Place in the Universe

Students who demonstrate understanding can:

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.

[Clarification Statement: 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), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

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 |
| --- | --- | --- |
| Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.  Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, theories, simulations, peer review) and 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. | ESS1.A: The Universe and Its Stars  1. The study of stars’ light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. 2. The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. | Energy and Matter Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. |
| Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena  * A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. | 8. 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.PS4.B: Electromagnetic Radiation  1. 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. (secondary) | Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology  * Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.   ***Connections to Nature of Science***  **Scientific Knowledge Assumes an Order and Consistency in Natural Systems**   * Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.  Science assumes the universe is a vast single system in which basic laws are consistent. |

## 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.

6.1 Ability to construct explanations of phenomena

### 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.

6.1.1 Ability to construct quantitative and/or qualitative explanations of observed relationships

6.1.2 Ability to apply scientific concepts, principles, theories, and big ideas to construct an explanation of a real-world phenomenon

### Disciplinary Core Idea Assessment Targets

#### ESS1.A.6

* Construct an explanation that includes a description of how the study of light spectra from stars allows scientists to determine chemical composition, movements, and their distances from Earth

#### ESS1.A.7

* Identify and describe the evidence required to construct the explanation including the composition of stars, the hydrogen to helium ratio of stars and interstellar gases, the redshift of the majority of galaxies and the redshift vs. distance relationship, and the evidence of cosmic background radiation

#### ESS1.A.8

* 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)
* Describe the following chain of reasoning for their explanation of the Big Bang theory:
  + 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 from different stages as it expanded and cooled
  + 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

#### PS4.B.8

* Construct an explanation that considers that the light spectra from stars can serve as a fingerprint for their elemental composition.

### Crosscutting Concept Assessment Target(s)

CCC5 Identify that energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems

## Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides spectra of stars at various distances:

* Explains the redshift pattern as indicating that more distant stars are moving away faster (6.1.1, ESS1.A.6, PS4.B.8, and CCC5)

Task provides distribution of elements across the universe:

* Identifies the distribution of hydrogen and helium as evidence for the Big Bang (6.1.1, ESS1.A.7, and CCC5)

Task provides a statement citing evidence that may or may not support the theory of the Big Bang:

* Explains the validity of the statement (6.1.2, ESS1.A.8, and CCC5)

## Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

* Comparisons of spectra of various stars
* Data about background radiation, hydrogen to helium ( H : He ) ratios, and temperatures throughout the universe
* A representation of distant objects

## Common Misconceptions

Note that the list in this section is not exhaustive.

* Redshifted stars appear red.
* All of the elements in the universe were created at the time of the Big Bang.
* The expansion of the universe causes everything (matter included) to grow larger.

## Additional Assessment Boundaries

None listed at this time.

## Additional References

HS-ESS1-2 Evidence Statement <https://www.nextgenscience.org/sites/default/files/evidence_statement/black_white/HS-ESS1-2%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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