Supplemental Educational Support Materials
for Special Feature: “Frontier Fields: Hubble Goes Deep”

Discussion questions

Q1: How is Hubble teaming up with nature to produce the Frontier Fields?

Answer: Hubble will use nature’s lenses to produce images of distant galaxies too faint and far away for the telescope to observe otherwise. These lenses are giant galaxy clusters whose immense gravity causes light to bend and concentrate like man-made lenses. Frontier Fields combines the power of Hubble with the power of these “natural telescopes” to reveal galaxies 10 to 100 times fainter than otherwise observable.

Q2: What are the parallel fields and why are they important?

Answer: The Frontier Fields will use six different galaxy clusters to look at the galaxies that are far beyond them. In addition, Hubble will observe six parallel fields. This will be done by using two of Hubble’s instruments at the same time.

While one of Hubble’s instruments is observing the galaxy cluster, the other instrument cannot look at the cluster. It can, however, look at another area close by, called a parallel field. The second instrument will observe the parallel field long enough to produce an image similar to the Hubble Ultra Deep Field (HUDF).

The Frontier Fields will ultimately produce six images of galaxy clusters and lensed galaxies as well as six images similar to the HUDF. The additional HUDF-like images will provide astronomers with more samples of the distant universe and help them answer the question of whether the HUDF and other deep fields are a typical sample of the distant universe.

Continued …
Q3: Why are the Frontier Fields important?

Answer:
The Frontier Fields are important for several reasons:

- The Frontier Fields will produce the deepest observations ever taken of galaxy clusters and the “lensed” or magnified galaxies behind them.
- They will produce six parallel fields similar to the HUDF.
- They will help us understand how galaxies form and develop.
- They will help trace the history of star formation and the growth of stars.
- They will provide measurements of the mysterious material known as dark matter within massive galaxy clusters.
- They will give us an early glimpse of the work that will be accomplished by the James Webb Space Telescope after its launch in 2018.

Vocabulary words

Astronomer(s)
A scientist who studies the universe and the celestial bodies residing in it, including their composition, history, location, and motion. Many of the scientists at the Space Telescope Science Institute are astronomers. Astronomers from all over the world use the Hubble Space Telescope.

Deep field
Astronomers use the term “deep field” when an observation of a point in the sky is taken for an extended period of time (many hours to many days of combined exposure). A deep field gathers much more light than a normal observation, so it captures faint objects. In the case of the Hubble Space Telescope, these deep fields are designed to capture faint galaxies that are also very distant.

Galaxy
A collection of stars, gas, and dust bound together by gravity. The smallest galaxies may contain only a few hundred thousand stars, while the largest galaxies have thousands of billions of stars. The Milky Way galaxy contains our solar system. Galaxies are classified or grouped by their shape. Round or oval galaxies are elliptical galaxies and those showing a pinwheel structure are spiral galaxies. All others are called irregular because they do not resemble elliptical or spiral galaxies.

Galaxy cluster
A collection of dozens to thousands of galaxies bound together by gravity.

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**Gravity (Gravitational force)**
The attractive force between all masses in the universe. All objects that have mass possess a gravitational force that attracts all other masses. The more massive the object, the stronger the gravitational force. The closer objects are to each other, the stronger the gravitational attraction.

**Infrared Light**
The part of the electromagnetic spectrum that has slightly lower energy than visible light, but is not visible to the human eye. Just as there are low-pitched sounds that cannot be heard, there is low-energy light that cannot be seen. For example, the heat from warm-blooded animals can be detected as infrared light.

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**Education Standards**

**Common Core Standards for English Language Arts**
http://www.corestandards.org/ELA-Literacy/CCRA/R/

**College and Career Readiness Anchor Standard for Reading**

**CCSS.ELA-Literacy.CCRA.R.10**
Read and comprehend complex literary and informational texts independently and proficiently.

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