

# Teachable MOMENTS

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## Dark Energy: Einstein's "Biggest Blunder" Now Seems Like an Accurate Explanation

### To the Teacher

The Hubble telescope has provided images and information that confirm the theory of dark energy—a repulsive force that causes the expansion of the universe. Scientists estimate that dark energy makes up 70% of the universe. Determining its properties has become the key goal of astronomy and physics. Hubble has provided a new clue! This is an opportunity to teach students about the

nature of science and of scientific inquiry. It can bring a new level of interest to the study of the universe and the strategies used to learn more about it. Take advantage of this “teachable moment” by focusing your high school students on new findings about dark energy, and by engaging them in research and discussion around the following standards and topics.

### Science Standards Addressed

#### National Science Education Standards for Grades 9–12

##### Earth and Space Science

##### Origin and Evolution of the Universe

The origin of the universe remains one of the greatest questions in science. The “big bang” theory places the origin between 10 and 20 billion years ago, when the universe began in a hot dense state; according to this theory, the universe has been expanding ever since.

##### Science As Inquiry

Scientists rely on technology to enhance gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry, and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of exploration, depends on the technology used.

##### History and Nature of Science

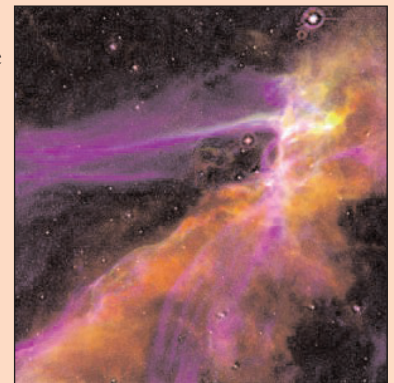
##### Nature of Scientific Knowledge

Scientists' explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational information about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods, and procedures, and make knowledge public.

#### Benchmarks for Science Literacy for Grades 9–12

##### The Universe

Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and x-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle an avalanche of data and increasingly complicated computations to interpret them; space probes send back data and materials from the remote parts of the solar system, and accelerators give subatomic particles energies that simulate conditions in the stars and the early history of the universe before stars formed.



##### Scientific Inquiry

Scientists assume that the universe is a vast single system in which the basic rules are the same everywhere. The rules may range from very simple to extremely complex, but scientists operate on the belief that the rules can be discovered by careful, systematic study.

## Suggestions for Introducing and Exploring the Topic of Dark Energy

- Share with students the science standards (both space science and inquiry/nature of science) that this topic addresses.
- Select an article or web site for students to read/review to provide context and background information, OR ask students to read/review articles/web sites of their choice and then discuss the range of information and ideas presented.

## Options for Implementing Student Prompts

(found on page 4)

- Break students into small groups. Assign a prompt to each. Provide time for research, drafting, and rehearsal. Student groups present to the class.
- Assign a prompt for homework. Review in class to see the range of responses, and identify the variety of research sources.
- Let students select one or more prompt to complete for a class assignment or project.

## Optional Extension Assignments

- Ask students to write a science fiction story including the idea of dark energy and the accelerating expansion of the universe.
- Have students research the Hubble telescope to provide specific examples of the advantages and disadvantages of its construction and technology.

## Dark Energy Web Sites

Hubble Finds Evidence for Dark Energy in the Young Universe

<http://hubblesite.org/newscenter/archive/releases/2006/52/>



New Clues About the Nature of Dark Energy: Einstein May Have Been Right After All

<http://hubblesite.org/newscenter/archive/releases/2004/12/text/>

Dark Energy

<http://physicsweb.org/articles/world/17/5/7>

What is Dark Energy?

[http://hurricanes.nasa.gov/universe/science/dark\\_energy.html](http://hurricanes.nasa.gov/universe/science/dark_energy.html)

Dark Energy Fills the Cosmos

<http://www.lbl.gov/Science-Articles/Archive/dark-energy.html>

Dark Energy: Astronomers Hot on Trail of Mysterious Force

[http://www.space.com/scienceastronomy/hubble\\_expansion\\_030410.html](http://www.space.com/scienceastronomy/hubble_expansion_030410.html)

Dark Energy: Astronomers Still 'Clueless' About Mystery Force Pushing Galaxies Apart

[http://www.space.com/scienceastronomy/astronomy/cosmic\\_darknrg\\_020115-1.html](http://www.space.com/scienceastronomy/astronomy/cosmic_darknrg_020115-1.html)

Hubble Telescope Gets Another Shot

<http://www.npr.org/templates/story/story.php?storyId=6429836>

Scientists Grapple with 'Dark Energy' Theory

<http://www.npr.org/templates/story/story.php?storyId=1577769>

'Dark Energy' Thought to Fuel Universe Expansion

<http://www.npr.org/templates/story/story.php?storyId=6501456>

Build Your Own Universe

<http://www.npr.org/templates/story/story.php?storyId=6545246>

Dark Energy in the Accelerating Universe

<http://snap.lbl.gov/brochure/>



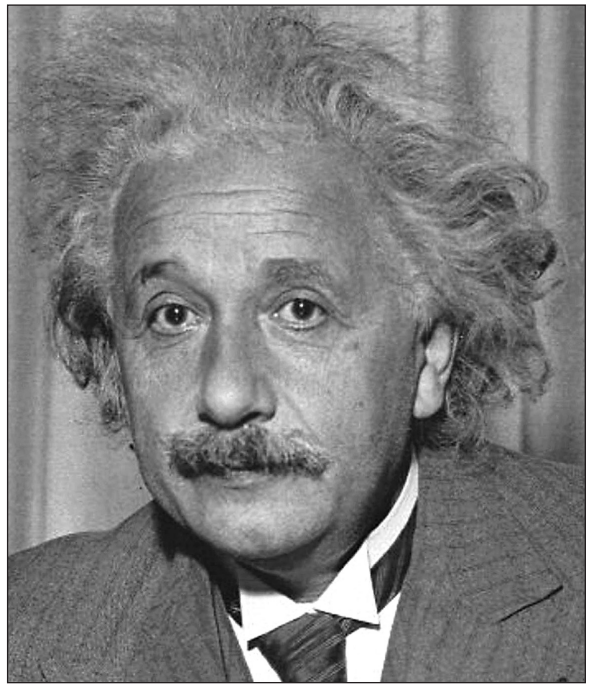
## Dark Energy: Einstein's "Greatest Blunder," or Brilliant Insight?

Albert Einstein first theorized about a repulsive force in the universe in 1917 when he developed his Theory of General Relativity. Einstein believed that the universe was static and posited a repulsive force to offset gravity. He included this term in his equations without any experimental or observational evidence for such a force.

In 1929, Edwin Hubble's study of the redshifted galaxies revealed the fact that the universe is expanding, not static. Einstein then retracted his theory of anti-gravity, calling it the "greatest blunder" of his career.

In 1998, scientists used telescopes to observe the acceleration of the expansion of space as evidenced by distant supernovae. Astrophysicists came to the realization that this was caused by a repulsive form of gravity in space and called it "dark energy." Einstein seemed to have been right after all.

The Hubble Telescope's recent observations show that dark energy was present 9 billion years ago. Although there is still a great deal about dark energy that isn't fully understood, scientists conclude that it is theoretically necessary to make sense of other information that we have about the universe.



1. Explain the role that technology has played in the development and exploration of the idea of dark energy.
2. Describe a technological advancement (something new or improved) that would enhance our understanding of dark energy.
3. Give another example of a scientific theory thought to be faulty, later proven to be accurate.
4. What are the long term implications of an expanding universe? Describe what could eventually happen, and explain how long it might take.
5. Explain the effect that you think dark energy has on our solar system. Justify your thinking.
6. Why do you think that understanding the nature of dark energy is the top priority of physics today?

## Suggested Answers

1. Answers may vary but should reference the need for observational data to confirm and refine theory. Initially, the development of powerful telescopes (used by Hubble) provided observational data about the expanding universe that seemed to contradict Einstein's theory about a "repulsive force." Improved technology in the form of a space telescope allowed scientists in the 1990s to observe the acceleration of the universe's expansion.
2. Answers will vary but may refer to the idea that as telescope technology improves, scientists will be able to see further through space and time—using the observation of distant supernovae to look back into time. This will enable them to better understand what effect dark energy has on the cosmos.
3. Answers will vary but might include the following: Copernicus's idea that the Earth revolves around the sun, Darwin's theory of evolution, and so forth.
4. Answers will vary but will likely discuss the idea of the universe eventually "dissolving." Some scientists discuss the idea of the universe "ripping apart," with everything from planets to atomic particles being pulled apart.
5. Answers will vary but should be supported with some evidence/observation/rationale.
6. Answers will vary but may discuss the fact that a better understanding of dark energy will help us to understand both the past and the future of the cosmos.