



The Hubble Ultra Deep Field

A Galaxy-studded Universe

This rich tapestry of galaxies represents the deepest portrait of the visible universe. Called the Hubble Ultra Deep Field (HUDF), the image contains as many as 10,000 galaxies of all shapes, sizes, colors, and ages.

Taken by NASA's Hubble Space Telescope, this benchmark view represents a "core sample" of galaxies at various distances and therefore different eras in our universe's history. This core sample yields clues to how galaxies evolve over time. Hubble's narrow view of the HUDF is similar to that seen through an eight-foot-long soda straw.

In images from ground-based telescopes, the patch of sky in which these galaxies reside is largely empty, because the galaxies are so small and faint. Located in the constellation Fornax, the region is so barren that only a handful of stars within the Milky Way Galaxy can be seen in ground-based images. Hubble's powerful vision snagged a view of the galaxies by taking a very deep exposure of the sky, staring at the HUDF area for more than 11 days.

The smallest, reddest galaxies in this image may be among the most distant known, existing when the universe was just 800 million years old. The nearest galaxies — the larger, brighter, well-defined spirals and ellipticals — thrived about 1 billion years ago, when the cosmos was 13 billion years old.

In vibrant contrast to the rich harvest of classic spiral and elliptical galaxies, there is a zoo of oddball galaxies littering the field. A few appear to be interacting. Their strange shapes are a far cry from the majestic spiral and elliptical galaxies we see today.

These oddball galaxies chronicle a period when the universe was younger and more chaotic. Order and structure were just beginning to emerge. Light from these faraway galaxies took billions of years to reach Earth. We see the galaxies, therefore, as they appeared billions of years ago.

By looking at galaxies stretching farther and farther back in time, astronomers have learned that galaxies evolve over time. The HUDF allows astronomers to put together snapshots of galaxies over many different eras so that they can tell a more complete story of how galaxies form and change.

VOCABULARY

Galaxy: A large collection of stars, gas, and dust held together by gravity.

Elliptical galaxy: A galaxy shaped like a football and containing mainly old stars with little gas or dust.

Spiral galaxy: A galaxy with spiral arms, which wind out from near the galaxy's center. The arms are composed of gas, dust, and young stars.

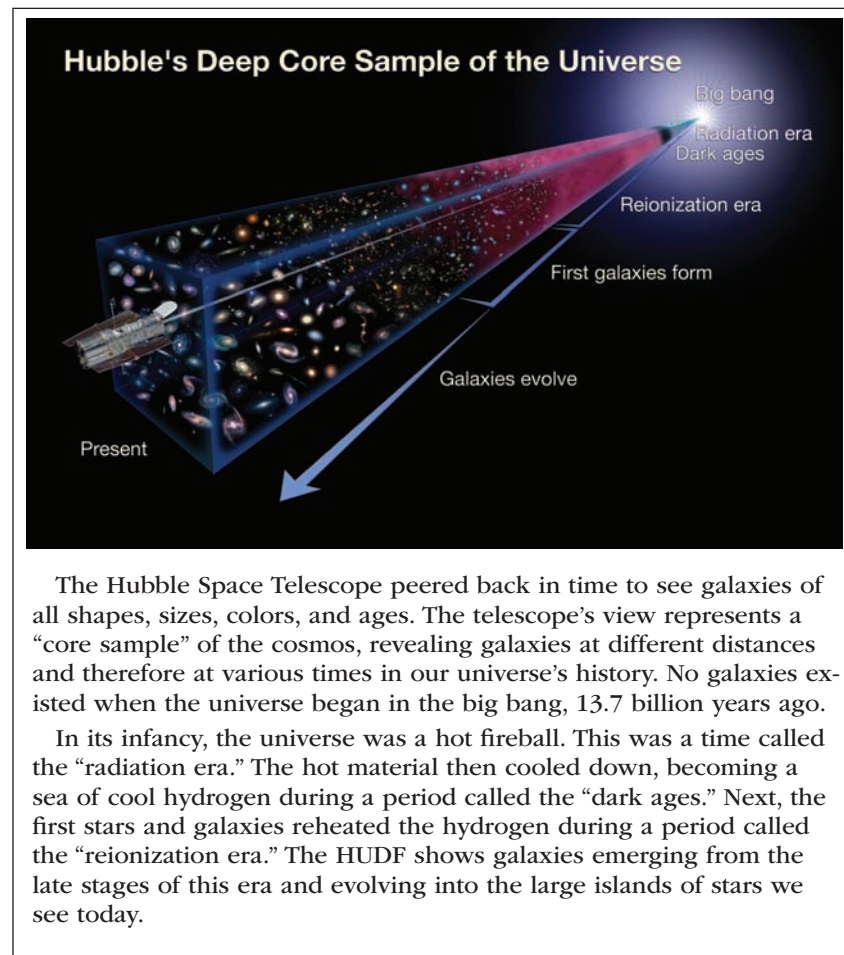
Credit for Hubble image: NASA, ESA, S. Beckwith (STScI), and the HUDF Team.

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The Hubble Space Telescope peered back in time to see galaxies of all shapes, sizes, colors, and ages. The telescope's view represents a "core sample" of the cosmos, revealing galaxies at different distances and therefore at various times in our universe's history. No galaxies existed when the universe began in the big bang, 13.7 billion years ago.

In its infancy, the universe was a hot fireball. This was a time called the "radiation era." The hot material then cooled down, becoming a sea of cool hydrogen during a period called the "dark ages." Next, the first stars and galaxies reheated the hydrogen during a period called the "reionization era." The HUDF shows galaxies emerging from the late stages of this era and evolving into the large islands of stars we see today.

You can get images and other information about the Hubble Space Telescope on the World Wide Web. Visit <http://www.stsci.edu/outreach> and follow the links.

The corresponding classroom activity for this lithograph can be found at: <http://amazing-space.stsci.edu/> or may be obtained by contacting the Office of Public Outreach at the Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218.





In Search of ... Galaxy Evolution

Description

Use the “Hubble Ultra Deep Field” (HUDF) lithograph as the initial source of information to engage your students in a Level One Inquiry activity. Students will use the images and text on this lithograph to generate questions about galaxies. They will conduct research to answer their questions, and analyze galaxies from different eras to determine how they have evolved and changed over time. This curriculum support tool is designed to be used as an introductory activity in a unit that has a scientific inquiry and/or a galaxy evolution theme.

About Inquiry-based Learning

The inquiry process is driven by a student’s own curiosity, wonder, interest, or passion to understand an observation or solve a problem. It involves a process of exploring the natural or material world. This exploration prompts students to ask questions and make discoveries in the search for new insights. A Level One Inquiry activity uses questions and problem-solving methods directed by the teacher. In this activity, teachers use the lithograph images to help students formulate questions about galaxy evolution. Teachers suggest selected resources about galaxies to help students answer their questions, compare galaxy structures and features, and examine the process of galaxy evolution. Students provide supporting evidence for their conclusions. This process can help prepare students to be more independent thinkers. Note: The preparation section below can direct you to resources for inquiry-based learning.

Grade Level

High school, grades 10–12.

Prerequisites

Students should be aware that galaxies are groups of stars, gas, and dust held together by gravity.

Misconceptions

Teachers should be aware of the following common misconceptions and determine whether their students harbor any of

them. Students may think all galaxies are the same size, shape, color, and age, and/or that most galaxies can be viewed without the aid of a telescope. In addition, students may not comprehend the vastness of the universe nor the number of galaxies it contains.

Purpose

The purpose of this activity is for students to participate in a Level One Inquiry-based activity using astronomical images and information. Students will gain experience using the Internet to search for information. They will practice the process skills of observing and analyzing. Students will organize their material and present a report. Students then will reflect on their learning.

Materials

- “Hubble Ultra Deep Field” lithograph.
- Computer with Internet connection for researching galaxies and galaxy evolution.

Instructions for the Teacher

Preparation

- Obtain copies of the lithograph for each student. The “HUDF” lithograph can be found at <http://amazing-space.stsci.edu/capture/galaxies/preview-hudf.php>.
- Preview the Overview page found at: <http://amazing-space.stsci.edu/eds/overviews/print/lithos/hudf.php>. Use the “Related Materials” section to (1) become familiar with inquiry-based learning, and/or (2) familiarize yourself with the galaxy types.
- Note that a similar list of “Related Websites” can be found on the preview page for the lithograph: <http://amazing-space.stsci.edu/capture/galaxies/preview-hudf.php>. Identify the appropriate Websites for your students to use.

Procedure

Before beginning this activity, evaluate your students’ misconceptions about galaxies by having them write down anything they know and understand about this topic. Use these statements to evaluate your students’ misconceptions in one of two ways. Have students volunteer

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their ideas about galaxies. From those ideas, identify their misconceptions and discuss them with the class. An alternative is to collect their written ideas about galaxies. From those ideas, compile a list of their misconceptions and discuss them with the class.

Ask students to look at the image of the galaxies on the front of the HUDF lithograph and write as many questions as they can about the features visible in the image.

Collect these questions and group them by common themes. Ask students to read the information on the back of the lithograph. Then ask them if they found the answers to any of their questions. Using the Internet, have students research their questions. The Internet sites listed on the preview page provide a starting point for their research. Tell students how to access other Websites.

Ask students to prepare a report in which they answer their questions, identify trends, and compare and contrast the changing characteristics of galaxies over time. This report could be in the form of a skit, a story, a graphic organizer, a Power Point presentation, or a written report—anything that conveys a student's understanding of the topic to another student, a group of students, or the entire class. Ask students to review their original questions to see if they were answered during their research or from talking with other students. Then ask them if they have any additional questions.

Instructions for the Student

Your teacher will ask you to write down things you know and understand about galaxies. You may be asked to share this information with the rest of the class. Study the image of the galaxies on the front of the lithograph, and write down as many questions as you can about what you see in the image. Then read the back of the lithograph, and check if any of your questions were answered.

Using your questions as a guide, conduct Internet research to find the answers to your questions, identify trends, and/or compare and

contrast the changing characteristics of galaxies over time, as directed by your teacher. Your teacher also will guide your search by providing some Websites to use. To demonstrate your understanding of the material you researched, your teacher will ask you to present a report. This report could be in the form of a skit, a story, a graphic organizer, a Power Point presentation, or whatever presentation you think will communicate the information you learned about galaxy evolution. You can work individually or in small groups. You can make your presentations to another classmate, another group of students, or the entire class.

Education Standards

Project 2061

<http://www.project2061.org/publications/bsl/online/bolintro.htm>

1. The Nature of Science.
- B. Scientific Inquiry.

By the end of the 12th grade, students should know that

- Sometimes, scientists can control conditions in order to obtain evidence. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns.

National Science Education Standards

<http://www.nap.edu/html/nses/>

Earth and Space Science, Content Standard D:

As a result of their activities in grades 9–12, all students should develop an understanding of the origin and evolution of the universe.

- Early in the history of the universe, matter, primarily the light atoms hydrogen and helium, clumped together by gravitational attraction to form countless trillions of stars. Billions of galaxies, each of which is a gravitationally bound cluster of billions of stars, now form most of the visible mass in the universe.

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