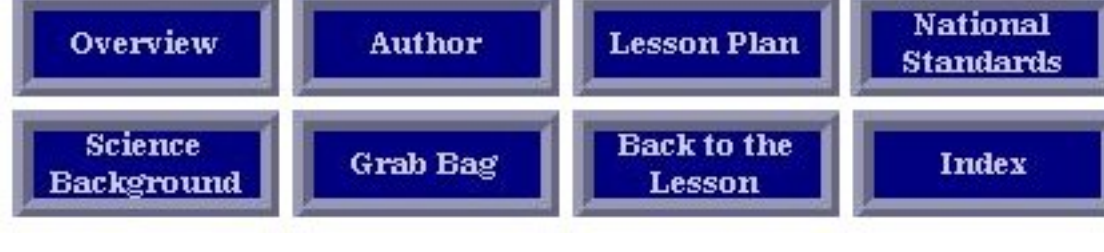


Hubble Deep Field Academy

Lesson Plan: Overview



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- **Description / overview of the lesson:**

Join Professor WifPic in examining the Hubble Deep Field image and simulate the process astronomers have gone through to count, classify, and identify objects in the image as well as estimate their distances from Earth. The lesson is modular so that all or part of it may be completed using computers and the Internet.

A hard copy version of the lesson will be available in the [Grab Bag](#) for those who do not have Internet access.

-

How to Prepare for an “Online exploration”

Decide if the activity meets your needs.

1. Check out the activity ahead of time by working through it as your students will. As you go through the activity, pay attention to the following:
 - How to navigate from one place to another.
 - The ability level. Can students work this activity successfully?
 - Natural breaks within the activity. Is there enough flexibility that students can complete all or selected parts within the time restraints of the daily schedule?
2. Check out the “Teaching Tips” for the following information.
 - *Overview:* Serves as a broad, comprehensive summary of the activity, including a description, the concepts covered, prerequisites, and the target audience.
 - *Science Background:* Provides information about the science behind the activity. It clarifies important concepts used in the activity and contains a message from the scientist who worked with the team to develop it.
 - *Lesson Plan:* Addresses specific recommendations for using the activities, including learning outcomes, new vocabulary, misconceptions, engagement activities (under the heading procedure/directions), and follow-up activities. Includes suggestions for using the activity in one-computer classrooms and those without computers.
 - *National Standards:* Provides alignment between the activity and the National Science Education Standards, the National Council of Teachers of Mathematics Curriculum and Evaluation Standards, and the Project 2061 Benchmarks for Scientific Literacy Standards. Many state and local standards were developed from these so it should be easy to check for correlations.
 - *Grab Bag:* Provides resources for educators who wish to customize the activity. Includes images from the activity, which can be used to develop your own interactive lesson. Also identifies resources used in the activity and others related to the topic, which can be used by students and educators to do further research.
 - *Activity Authors:* Provides information about the authors, including the educator(s) and scientist(s), who were involved with the activity’s development.

Before using the activities...

1. Check out your computers.
 - Review the Computer Needs section of the activity.
 - Reserve a time to use the computer lab.
 - Bookmark the activity on the Web browser (Netscape Navigator or Microsoft Explorer) of each student computer.
2. Determine a strategy for organizing your students. Options include the following:
 - Use a whole-class approach with one computer.
 - Use a team approach in a computer lab, with different students having specific responsibilities during the activity (such as “mouse user,” “note taker,” and “oral reader”).
 - Use a one-computer-per-student approach.
3. Think about how this online activity matches up with teaching materials that are already available to you. These might include:
 - Curriculum guides
 - Textbooks
 - Videos
 - Posters
 - Labs

Preparing students

1. Share the objectives and the key vocabulary words used in the activity.
2. Use a large monitor, LCD, or transparencies to give a preview of the activity and to demonstrate how to navigate within it.
3. Give your students a computer/Web pre-assessment to determine their computer experience and/or competence.
4. Organize your students in such a way that more experienced users are matched up with less experienced ones.
5. Try one of the Suggested Engagement Activities, which can be found under Procedure/Directions in the Lesson Plan section of the activity’s Teaching Tips.

While students are doing an activity...

1. Help individual students navigate through the activity.
2. Provide options for those who finish the activity early:
 - Have them review the activity again to define key vocabulary words.
 - Have them visit related Web links to conduct additional research.
 - Have them completing some type of assessment activity. A number of these can be found under Follow-up Activities/Extensions in the Lesson Plan section of the activity’s Teaching Tips.

Using the activities without an Internet connection

1. Order a CD of the activities.
2. For activity-specific suggestions, consult the Classrooms Without Computers section (in the Lesson Plan section of the activity’s Teaching Tips).
3. Print the information provided in the Science Background, which might be useful for content reading.
4. Download the activity in advance from the Amazing Space Web site. Instructions are in the Computer Needs section accessed from the activity’s title page.
5. Go to the activity’s Grab Bag section and select text, student activities, or other Internet links that direct you to related topics.

- **Subject:**

Astronomy

Math

- **Concepts:**

The size of the universe

The number of galaxies in the universe

Characteristics of galaxies used for classification and identification

- **Process skills acquired:**

Estimate

Classify

Predict

Interpret

Identify patterns using scientific data

- **Target audience / grade levels:**

6-8 grade

- **Preparation time:**

Appropriate time to review the lesson.

- **Execution time:**

3-4 class periods depending on the length of a class and ability level of the students.

- **Field tested:**

Sections of the lesson were tested with 55 students at "Space and Astronomy Day" at Johns Hopkins University.

- **Last update:**

August 18, 2003

Please, send your comments about this page to: amazing-space@stsci.edu

Hubble Deep Field Academy

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Hubble Deep Field Academy

Lesson Plan: Details



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• Goal / Purpose:

The purpose of this lesson is to allow students to experience the processes actual scientists go through to organize and synthesize new information. They will have the opportunity to ask and answer questions of their own about a previously unknown region of space and then to compare their analysis to that of real astronomers currently working on the same tasks. Our goal is that students will come to appreciate the importance of collaboration among scientists as well as the possibility of more than one acceptable answer to any scientific inquiry.

• Desired learning outcomes:

1. Generate questions that can be answered using scientific inquiry
2. Collect and interpret scientific data
3. Describe the characteristics used to classify galaxies and explain the relationships between those characteristics
4. Apply estimation skills to scientific data
5. Begin to conceptualize the vastness of the universe
6. Appreciate the interactive capabilities of the Internet

• Prerequisites:

Before attempting to complete this lesson, the student should have had experience:

1. Completing and interpreting data tables
2. Estimating based on representative samples
3. Visualizing the structure of the universe (stars and planets make up solar systems which make up galaxies).

• New vocabulary:

- [atmosphere](#)
- [Big Dipper](#)
- [deep field](#)
- [galaxy](#)
- [Hubble Space Telescope](#)
- [light pollution](#)
- [light year](#)
- [Milky Way Galaxy](#)
- [orbit](#)
- [star](#)
- [telescope](#)

• General preconceptions:

Students will probably have an understated idea of the size of the universe, not realize that the points of light they can observe in the sky are not necessarily individual stars, and believe that the size of an object in the sky is indicative of its distance from Earth.

• Preparation time:

Allow appropriate time to go over the lesson.

• Execution time:

3-4 class periods depending on the length of the class and the ability levels of the students.

• Physical layout of room:

Teachers may decide whether students will work individually or in small groups of two or three. To maximize learning, no more than three students should share a computer. Adaptations can be made to accommodate a classroom that has one computer with Internet access. Some suggestions include using an overhead projector with an LCD to project the computer image onto a screen or connecting the computer to a television monitor.

The "Hubble Deep Field Academy" can be used offline. Different software programs provide offline access to the Internet. These programs allow students to save Web pages to a local hard drive. Using the browser, students can open the Web pages locally and complete the lesson as if they were on the Internet. However, if this option is selected, students will not be able to view the references in the "Grab Bag" section on the Web.

• Materials:

- Computers with Internet access for as many students as possible.
- "Hubble Academy Log"
- Pen or pencil

• Procedure / directions:

Though the goal of this lesson is to make as much use of the Internet as possible, it has been arranged in a modular fashion so that any portion may be completed using computers or a paper version of the activity. Teachers should be aware that the number of computers directly connected to the Internet and the speed at which your system can process images may significantly alter the time to prepare this lesson.

• Engagement activity:

In the introductory activity of the Hubble Deep Field lesson, the student is introduced to Professor WiPic of the Hubble Academy, an alien creature who will help guide them through a brief history of the development and use of the telescope. The professor will then provide a hook for the students into the four lesson activities by addressing them as cadets recruited to help plan a daring mission to explore the Hubble Deep Field image of the edge of the known universe. To get them thinking as scientists the student will be required to write several questions that they want to have answered about the objects in the Hubble Deep Field image.

• Step-by-step instructions:

Activity One: Students will practice estimation skills in this activity as they begin to explore the Hubble Deep Field image. They will first give a rough estimate of the number of objects in the image. They will then go through several steps to use representative sampling techniques to improve on their original estimates. Finally, they will calculate the number of galaxies in the universe based on their own estimate.

Activity Two: In this Activity, students will classify selected objects from the Hubble Deep Field image based on their color and shape. Students will classify one Camera, (A, B, or C), containing 15 objects. Students will then compare their classification to a similar chart made by astronomers.

Activity Three: In this Activity, the problems and difficulties of determining the distances from Earth for objects in space will be addressed. Students will attempt to arrange 6 objects in the Hubble Deep Field image according to their distance from Earth. After making a guess based on visible observations alone, the students will draw a 3 dimensional representation of the objects. Lastly, students will try to explain the discrepancies between their answer and those of the astronomers.

Activity Four: This Activity is intended to be a review of the concepts presented in the other activities as well as an assessment of students' understanding of the lesson. Students will use a clickable galaxy icon to review information from the activities as they answer questions on paper. Students will then view an image of an object from the Hubble Deep Field image, the "oddball" object, that has been difficult for astronomers to classify. Students will make their own interpretations of the object based on knowledge acquired from the lesson. Lastly, an astronomers' interpretation will be presented for students to compare to their own answer.

• Evaluation / Assessment:

The "Hubble Academy Log" entries as well as Activity Four can be used as an effective basis for measuring students' success in the lesson. Other suggestions are:

- Have the students prepare oral reports based on what they learned after performing each activity
- Ask students to come up with a list of potential applications for which they would use the skills learned in this lesson: (1) representative sampling, (2) classifying and identifying objects, and (3) determining distances

• Follow-up activities / Interdisciplinary connections:

Lesson plans giving students the opportunity to visualize the size of very large numbers. All these lessons are included in the [Grab Bag](#) as downloadable activities.

- "What Does a Million Look Like?" -- by Kirk Fitch, Montgomery County, MD
- "999,999 Cans of Soda on the Wall?" -- by Kirk Fitch, Montgomery County, MD
- "How Many's a Million? Billion? Trillion?" -- by Kirk Fitch, Montgomery County, MD

• One-computer classroom:

It is recommended that teachers use an overhead, LCD, or large television screen to project images from the computer onto a classroom screen. To facilitate a more organized and predictable large-group presentation and avoid last-minute glitches, consider "bookmarking" the lesson (such as one of the pages you wish to use) and downloading it onto your hard disk. This will eliminate the inconvenience of unexpectedly going offline.

The introduction and each of the four activities have a "Hubble Academy Log" (worksheets) that you can print and copy beforehand. In addition, the images used in the lesson are available in the Grab Bag section and can be printed for student use. For example, in Activity 1 where students estimate the number of objects in a section of the Deep Field, teachers can give each student (or group) a section of the field to count. The several student answers can be used to calculate the number of objects in the field by using the "Back" button on the browser.

• Classrooms without computers:

If your classroom is not equipped with a computer, try one of the following:

If you have access to a computer with Internet access and a printer in the school library or at home, you may print selected parts of the lesson as paper copies or transparencies.

If your school has one or more computers located outside your classroom, students may experience the lesson individually or in small groups as a learning station.

Some students may have computers with Internet access at home. If so, consider assigning sections of the "Hubble Deep Field Academy" activities as homework or extra credit.

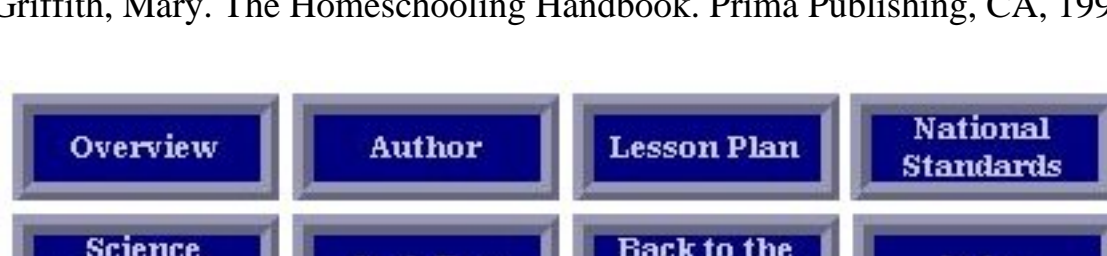
NASA offers free Hubble Deep Field lithographs and posters, as well as the Hubble Space Telescope Deep Field Lesson Package (EG-1997(01)-002-GSFC), which are available at your nearest NASA Educator Resource Center: http://spacelink.nasa.gov/Instructional_Materials/NASA.Educational.Products/

• Home schooler:

This lesson is easily followed without additional teacher support if the prerequisites are met. Parents can preview the lesson and examine the teacher pages ahead of time. A wealth of information can be found at [HubbleSite](#), the Hubble Space Telescope's Web site at the Space Telescope Science Institute. Here you can find background information on the telescope, pictures and news releases of past and present stories, education activities, and other science resources.

More information for the home-schooled can be found at:

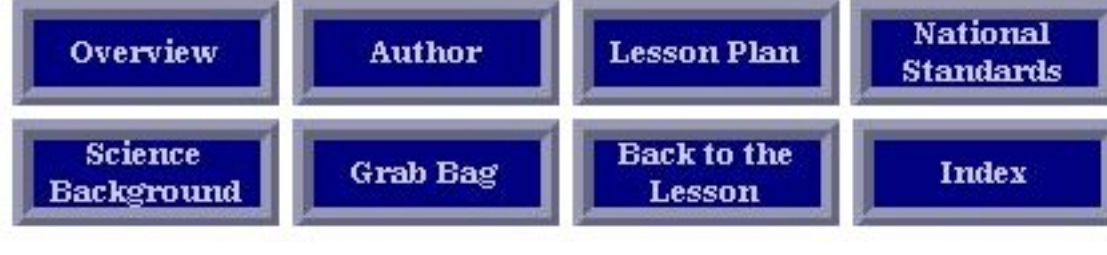
- American Homeschool Association Web Page (<http://www.home-ed-magazine.com/AHA/aha.html>)
- Yahoo Homeschooling Directory (http://dir.yahoo.com/Education/Theory_and_Methods/Homeschooling/)
- The Home School Learning Network (<http://www.homeschoollearning.com>)
- Griffith, Mary. The Homeschooling Handbook. Prima Publishing, CA, 1997.



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Hubble Deep Field Academy

Lesson Plan: National Standards



[National Science Education Standards](#)

[Project 2061 Benchmarks](#)

[National Council of Teachers of Mathematics Principles and Standards](#)

[Standards for Technological Literacy, International Technology Education Association](#)

From: [National Science Education Standards](#)

National Academy Press, 1996

CONTENT STANDARD A:

As a result of activities in grades 5-8, all students should develop:

ABILITIES NECESSARY TO DO SCIENTIFIC INQUIRY:

IDENTIFY QUESTIONS THAT CAN BE ANSWERED THROUGH SCIENTIFIC INVESTIGATIONS:

Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations.

Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation. (p. 145)

RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND PREDICTIONS:

Students should develop the ability to listen to and respect the explanations proposed by other students.

They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations. (p. 148)

COMMUNICATE SCIENTIFIC PROCEDURES AND EXPLANATIONS:

With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations. (p. 148)

USE MATHEMATICS IN ALL ASPECTS OF SCIENTIFIC INQUIRY:

Mathematics is essential to asking and answering questions about the natural world. **Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.** (p. 148)

CONTENT STANDARD G:

As a result of activities in grades 5-8, all students should develop understanding of:

NATURE OF SCIENCE

It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists. (p. 171)

From: [Benchmarks for Science Literacy](#)

American Association for the Advancement of Science

Oxford University Press, 1993.

THE NATURE OF SCIENCE:

The Scientific World View.

By the end of the 8th grade students should know that:

When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct. (p. 7)

The Scientific Inquiry.

By the end of the 8th grade students should know that:

Scientists differ greatly in what phenomena they study and how they go about their work. **Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypothesis and explanations to make sense of the collected evidence.** (p. 12)

THE PHYSICAL SETTING:

The Universe.

By the end of the 8th grade, students should know that:

The sun is a medium-sized star located near the edge of a disk-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. (p. 64)

The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. **The trip to that star would take the fastest rocket thousands of years. Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past.** (p. 64)

HISTORICAL PERSPECTIVES:

Displacing the Earth from the Center of the Universe.

By the end of 8th grade students should know that:

Telescopes reveal that there are many more stars in the night sky than are evident to the unaided eye.

HABITS OF MIND:

Values and Attitudes.

By the end of 8th grade students should:

Know why it is important in science to keep honest, clear, and accurate records. (p. 287)

Know that hypothesis are valuable, even if they turn out not to be true, if they lead to fruitful investigations. (p. 287)

Know that often different explanations can be given for the same evidence, and it is not always possible to tell which one is correct. (p. 287)

NCTM MATH STANDARDS:

By the end of the 8th grade, students should be able to:

Express numbers like 100, 1,000, and 1,000,000 as powers of 10. (p. 291) From: [National Council of Teachers of Mathematics](#)

Curriculum Standards for Grades 5-8:

Standard 1: Mathematics as Problem Solving In grades 5-8, the mathematics curriculum should include numerous and varied experiences with problem solving as a method of inquiry and application so that students can generalize solutions and strategies to new problem situations.

Standard 5: Number and Number Relationships In grades 5-8, the mathematics curriculum should include the continued development of number and number relationships so that students can understand, represent, and use numbers in a variety of equivalent forms (integer, fraction, decimal, percent, exponential, and scientific notation) in real-world and mathematical problem situations.

Standard 10: Statistics In grades 5-8, the mathematics curriculum should include exploration of statistics in real-world situations so that students can develop an appreciation for statistical methods as powerful means for decision making and be able to construct, read, and interpret tables, charts, and graphs.

From: [Standards for Technological Literacy, International Technology Education Association, 2002](#)

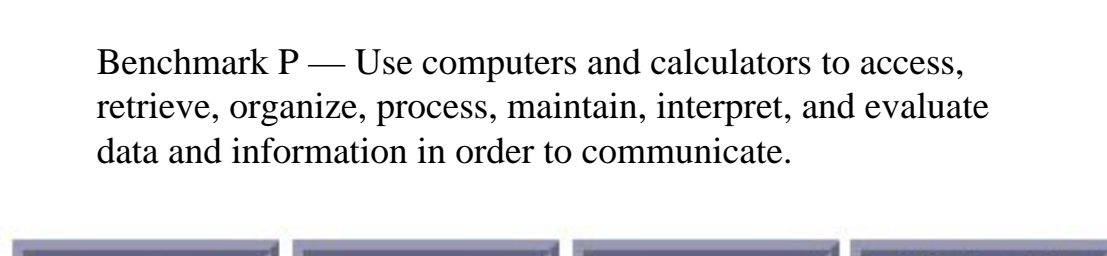
Standard 12 — Students will develop the abilities to use and maintain technological products and systems.

Grades 3-5

Benchmark F — Use computers to access and organize information.

Grades 9-12

Benchmark P — Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.



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Hubble Deep Field Academy

Teacher Page: Science Background



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- [How was the area covered by Hubble Deep Field selected?](#)
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[References](#)

• Science Background:

The following information is provided to give the teacher some additional knowledge about the Hubble Deep Field. You can choose to use this information with the students to do research on questions that you see mentioned here or use them as a form of review for class discussion.

1. What are the Hubble Deep Fields?

The Hubble Deep Field project was inspired by some of the first deep images to return from the telescope after the 1993 Hubble Space Telescope servicing mission. These images showed that the early universe contained galaxies in a bewildering variety of shapes and sizes. Some had the familiar elliptical and spiral shapes seen among normal galaxies, but there were many peculiar shapes as well. Such images of the early universe are likely to be one of the enduring legacies of the Hubble Space Telescope. Few astronomers had expected to see this activity presented in such amazing detail.

Impressed by the results of earlier observations such as the Hubble Medium Deep Survey, a special advisory committee convened by Robert Williams, then Director of the Space Telescope Science Institute (STScI), recommended that he use a significant fraction of his annual director's discretionary time to take the deepest optical picture of the universe, by aiming Hubble for 150 consecutive orbits on a single piece of sky. The research was done by pointing the telescope at one spot in the northern sky for 10 days in December of 1995 as a service to the entire astronomical community. Images from the Hubble Deep Field project were made available to the astronomers around the world shortly after completion of the observation.

Few thousand never before seen galaxies are visible in this "deepest-ever" view of the universe, called the "Hubble Deep Field" (later named the HDF-North). Besides the classical, the variety of other galaxy shapes and colors are important clues to understanding the evolution of the universe. Some of the galaxies may have formed less than one billion years after the Big Bang.

Hubble took a second deep look in the southern hemisphere in October of 1998, the HDF-South, to see if a similar result would be obtained. Each of the Hubble Deep Fields shows hundreds of galaxies in an area of the sky that is as small as the size of President Roosevelt's eye on a dime held at arm's length.

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2. What is the importance of the HDFs?

The HDFs contain the faintest galaxies we've ever been able to see over a large range of distances. Since seemingly "empty" spots were chosen, most of the galaxies in the Deep Fields lie billions of light-years away. The images show that the early universe contained galaxies in a bewildering variety of shapes and sizes. Some had the familiar elliptical and spiral shapes seen among galaxies today, but there were many peculiar shapes as well. Few astronomers had expected to see this activity presented in such amazing detail. Besides the classical elliptical and spiral galaxies, the variety of other galaxy shapes and colors are important clues to understanding the evolution of the universe. Some of the galaxies may have formed less than one billion years after the Big Bang. The HDFs are important because they can help answer such questions as:

• How many galaxies are there in the universe?

The Hubble Deep Field will be used to count galaxies ten times as faint as the deepest existing ground-based optical observations and nearly twice as faint as the deepest existing Hubble images.

• How did large-scale structure evolve in the universe?

The Hubble Deep Field will be used to perform a statistical study of the distribution of galaxies on the sky. This is an *essential test of models* for the structure of the universe and galaxy formation theories. The Hubble Deep Field will push such studies to fainter limits.

• How were galaxies assembled?

Detailed studies of the ages and chemical compositions of stars in our own galaxy suggest that it has led a relatively quiet existence, forming stars at a rate of a few suns a year for the last 10 billion years. Other spiral galaxies seem to have similar histories. If this is typical evolution for spiral galaxies, then predictions can be made for what they should have looked like at half their present age -- including their size, color and abundance. This information, combined with actual distances derived from ground-based spectroscopic observations, will provide a new test for theories of spiral galaxies.

The other major class of galaxies seen in the nearby universe is the elliptical, football-shaped aggregates of stars that appear to be very old and stopped forming stars long ago. There is currently debate about when such galaxies formed and whether they formed through collisions of other types of galaxies or through collapse of a pristine cloud of primordial gas in the very early universe. The Hubble Deep Field, along with other deep Hubble images, provides a snapshot through time, which can be used to search for distant elliptical galaxies, or primeval galaxies that might later evolve into elliptical galaxies.

• Is the universe open or closed?

The distribution of galaxies in the Hubble Deep Field images may yield clues to the curvature of space. The Hubble Deep Field results will be compared to models that predict how the universe should look if it is open or closed.

If space is negatively curved, as first described by Einstein in his Law of General Relativity, then the universe would be described as open. In an open universe, the universe would continue to expand forever because it lacked sufficient mass to establish the gravitational pull necessary to collapse back on itself. On the other hand, if space is described as positively curved then the universe folds back on itself. This is space described as unbounded but finite. Such a situation is called a closed universe. In this scenario the universe eventually stops expanding and then ultimately contracts back to a point.

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3. What are some of the key findings learned from the Hubble Deep Field-north image?

In the document titled: [Summary of Key Findings from the Hubble Deep Field](#) you will find information under these headings:

- Small Galaxies in the Early Universe
- Open versus Closed Universe
- Disturbed Galaxies
- Stellar Baby Boom
- In Search of Hidden Stars
- Missing Mass -- Still Missing

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4. How was the area covered by Hubble Deep Field-north selected?

The Hubble Deep Field is located at RA 12h 36m 49.4000s DEC +62d 12' 58.000" (J2000 Equinox). The field is optimally placed in the Northern Continuous Viewing Zone (CVZ). The CVZ is a special region where the Hubble Space Telescope can view the sky without being blocked by Earth or have interference from the Sun or Moon. This fixed the declination to be near +62 deg. The northern hemisphere was chosen to allow for long observations from the Very Large Array (VLA), Kitt Peak National Observatory (KPNO), and Keck observatories, although a second field in the southern CVZ was also desirable and has now (Fall 1998) been observed. The Hubble Deep Field is several degrees away from any bright star (>2 deg from stars <2 mag). The field is devoid of bright nearby galaxies, stars, known nearby clusters, and bright radio sources.

The position of the Hubble Deep Field is outlined on the attached [Digitized Sky Survey image](#).

Representing a narrow "keyhole" view all the way to the visible horizon of the universe, the Hubble Deep Field image covers in our sky 1/30th the diameter of the full Moon. This is so narrow, that just a few foreground stars of our Milky Way galaxy are visible and are vastly outnumbered by the menagerie of far more distant galaxies, some nearly as faint as 30th magnitude, or nearly four billion times fainter than the limits of human vision. Though the field is a very small sample of sky area it is considered representative of the typical distribution of galaxies in space because the universe, statistically, looks the same in all directions.

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5. How long did it take the Hubble Space Telescope to obtain the image of the HDF-N?

The image was assembled from many separate exposures (342 frames total were taken, 276 have been fully processed and used for this picture) with the Wide Field and Planetary Camera 2 (WFPC2), for ten consecutive days between December 18 to 28, 1995.

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6. What is a galaxy?

A galaxy is a massive system of stars, dust and gas held together by their mutual gravity. Galaxies are the basic units of mass in the universe and are visible from very great distances. Galaxies come in different sizes, shapes, colors and chemical compositions. Galaxies also have different ages and move at different speeds.

Our planet Earth is located in a spiral galaxy named the Milky Way.

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7. How far away are the galaxies seen in the Hubble Deep Field-north image?

The nearest galaxies seen in the Hubble Deep Field are about 2.5 billion light years away. The furthest are estimated to be about 10.5 billion light years away.

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8. How do astronomers measure the distances to galaxies?

Astronomers use what is called the "Distance Ladder" which has its roots in the measurement of the distance from the Earth to the Sun. By using the properties of various types of stars as "standard candles" estimates of distance to several 100 million parsecs are possible. Individual luminous stars called "Cepheid variables" have been studied in the Milky Way and other nearby galaxies. These stars have a variable brightness. Their light variation period has been accurately related to their luminosity, the number of ergs per second of light they produce. By knowing how bright the Cepheids appear to us on Earth, scientists can determine how far away they are and, by association, the distance to the host galaxy.

For galaxies so distant that individual stars cannot be seen, Astronomers have been using supernovae. There are several different classes of supernovae, so in order to use this technique scientists have to establish the type of supernova by using its "light curve." A supernova's light curve is the history of its brightness change following its eruption, usually measured over periods of a year. Supernovae can be seen out to a distance of a billion parsecs. Again, this gives scientists an opportunity to determine distance based upon apparent brightness.

Currently, there is a discrepancy between the various techniques for establishing distance. Scientists are gathering data to help them align the methods.

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• Words from the Scientist:

The Hubble Deep Field exemplifies the work that astronomers face today in attempting to understand how galaxies have formed and evolved over the history of the universe. When faced with objects we do not fully understand, it is most important to be measured or observed, and second, we have to discern what procedures we will follow in using our classification system. Sometimes the most important characteristics or methods are also the easiest to see or use, but sometimes nature is more subtle, and sometimes we find that our fundamental assumptions about a problem are unwieldy, or somehow unsuitable. Sometimes even our dominant assumptions about a problem are challenged, and we find that different questions need to be asked.

This is an exercise in which students can participate by identifying galaxies' observable traits to use for classification and then attempting to identify relationships and patterns among the traits. Once such patterns and relationships are established, the questions of why they exist and their significance can be addressed, and tests can be designed to probe for more answers. Just as scientists find in their own everyday work, students will see that the answers are not always easy or clear and that some amount of interpretation is always required. Perhaps even entirely new ways of looking at data may be required in order to reach plausible answers to questions.

This exercise helps students learn about the value of graphically representing data as a means of identifying trends, as well as the importance of sharing scientific results with peers. Although the lesson is designed for use in middle school science classes, it is hoped that these exercises will serve as a springboard which helps the student embark on a lifetime of learning, in any field of study. After all, even the oldest professional scientist is still a student of nature!

Ray Lucas

• References:

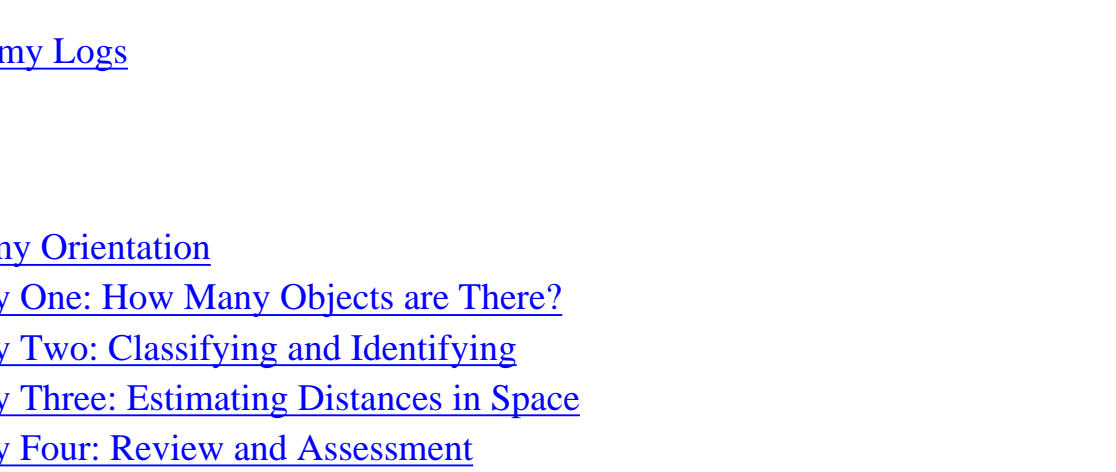
• Textbooks

National Geographic Picture Atlas of Our Universe, Roy A. Gallant
Explorations: An Introduction to Astronomy, Thomas T. Arny **Standards / science and math frameworks:**



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Hubble Deep Field Academy Lesson Plan: Grab Bag



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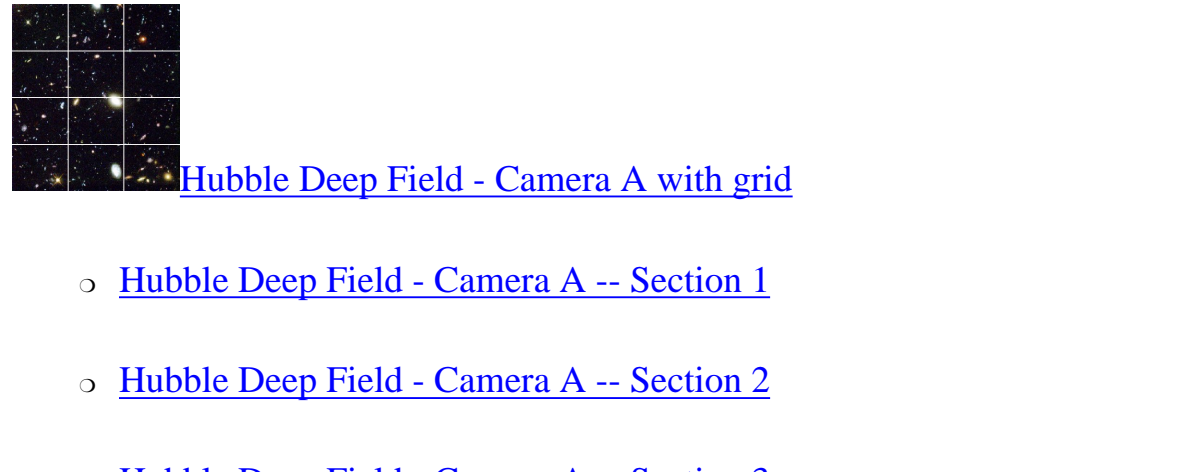
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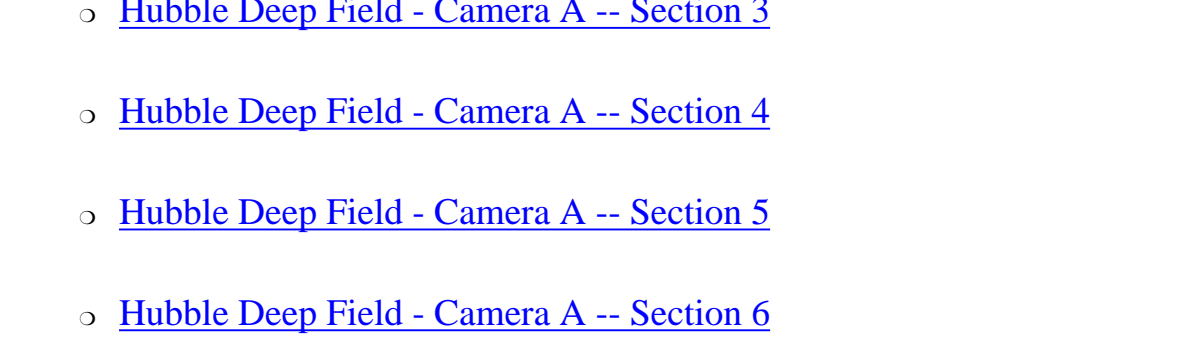


Note: Adobe Acrobat Reader is required.

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Images used in the Academy Orientation:

-  [Hubble Academy Intro Mural](#)
-  [Cadets listening to Professor WifPic](#)

-  [Cadets listening to Professor WifPic](#)

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-  [Hubble Deep Field - small version](#)

Images used in Activity One: How Many Objects are There?

-  [Hubble Deep Field](#)

-  [Hubble Deep Field - Camera A](#)

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- [Hubble Deep Field - Camera A -- Section 6](#)

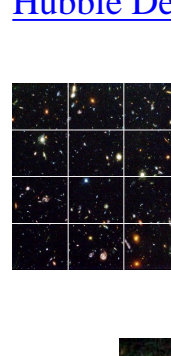
- [Hubble Deep Field - Camera A -- Section 7](#)

- [Hubble Deep Field - Camera A -- Section 8](#)

- [Hubble Deep Field - Camera A -- Section 9](#)

- [Hubble Deep Field - Camera A -- Section 11](#)

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Images used in Activity Two: Classifying and Identifying

-  [Professor WifPic](#)

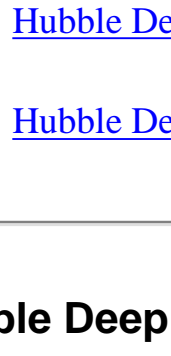
-  [Hubble Deep Field - Camera A](#)

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-  [Hubble Deep Field with numbered objects from 1 - 15](#)

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-  [Classification table -- star symbol](#)

-  [Classification table -- circular galaxy symbol](#)

-  [Classification table -- elliptical galaxy symbol](#)

-  [Classification table -- spiral galaxy symbol](#)

Images used in Activity Three: Estimating Distances in Space

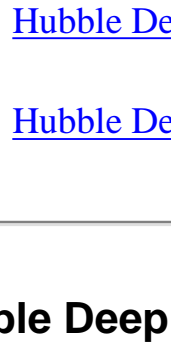
-  [Professor WifPic](#)

-  [Hubble Deep Field with objects labelled A - F](#)

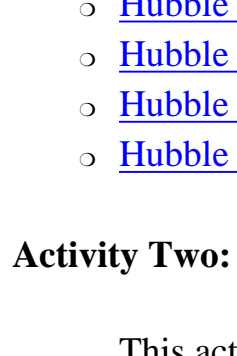
Images used in Activity Four: Review and Assessment

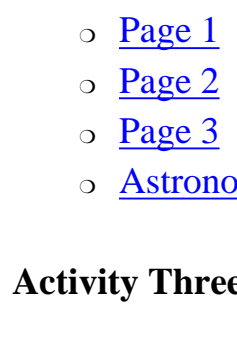
-  [Professor WifPic](#)


-  [Galaxies sign](#)

-  [Unknown object from Hubble Deep Field image](#)

Icons used in the Hubble Academy Lesson:

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 - [Hubble Deep Field -- Chip A with grid](#)
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- **Activity Two: Classifying and Identifying**

This activity requires the use of color images. Contact the [NASA Teacher Resource Center](#) closest to you to get a set of color lithographs.

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Extension Activities:

- "What Does a Million Look Like?" by Kirk Fitch, Montgomery County, MD
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- "999,999 Cans of Soda on the Wall?" by Kirk Fitch, Montgomery County, MD
- "How Many's a Million? Billion? Trillion?" by Kirk Fitch, Montgomery County, MD
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Other "Cool Stuff":

- [Hubble Deep Field Home Page at Space Telescope Science Institute](#)
- [Spiral Galaxy M100](#)
- [Cartwheel Galaxy Interactions](#)
- [Faint Irregular Galaxies](#)
- [Galaxy Features On-Line](#)

Other resources from ST Sci:

- [Hubble Space Telescope's Public Images Organized by Subject](#)
- [Hubble Deep Field Coordinates](#)
- [ExInEd - Exploration in Education](#)
- [Overview of the Hubble Space Telescope](#)

Other resources available outside ST Sci:

Below you will find a vast amount of information regarding the Hubble Space Telescope 2nd Servicing Mission. The information comes from many sources other than ST Sci.

Some of the resources are quite in depth, and it is easy to get lost. It is suggested that you bookmark this page before you examine each source. That way, should you get lost, you can simply use the bookmark to get you back to the main page.

Since the various sites are run by other parties, there is no way of guaranteeing their stability. You may occasionally find a site "under construction," or you may find that a site is completely gone. There is no way to control such situations as the sites are out of Space Telescope Science Institute's control.

This page is only a fraction of the information available throughout the web. If you do not find what you are looking for here, [GO FIND IT!!](#)

Resources:

- [Hubble Deep Field Project at the Space Telescope European Coordinating Facility](#)
- [CCD Images of Messier Objects -- University of Oregon](#)
- [Galaxies](#)
- [NASA SpaceLink](#)
- [Windows to the Universe -- University of Michigan](#)
- [Passport to Knowledge's: "Live from HST" Homepage](#)

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HUBBLE

DEEP FIELD

ACADEMY



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Then Become A...



Stellar Statistician



Cosmic Classifier



Galactic Guide



Universal Graduate

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<u>National Standards</u>	<u>National Science Education Standards, Project 2061 Benchmarks, National Council of Teachers of Mathematics Principles and Standards, Standards for Technological Literacy</u>
<u>Grab Bag</u>	Customize your lesson! Here you will find the resources used in this lesson and other "cool stuff" to make your own interactive lesson.
<u>Author</u>	Information about the authors.
<u>Back to the Lesson</u>	This link takes you back to the lesson!