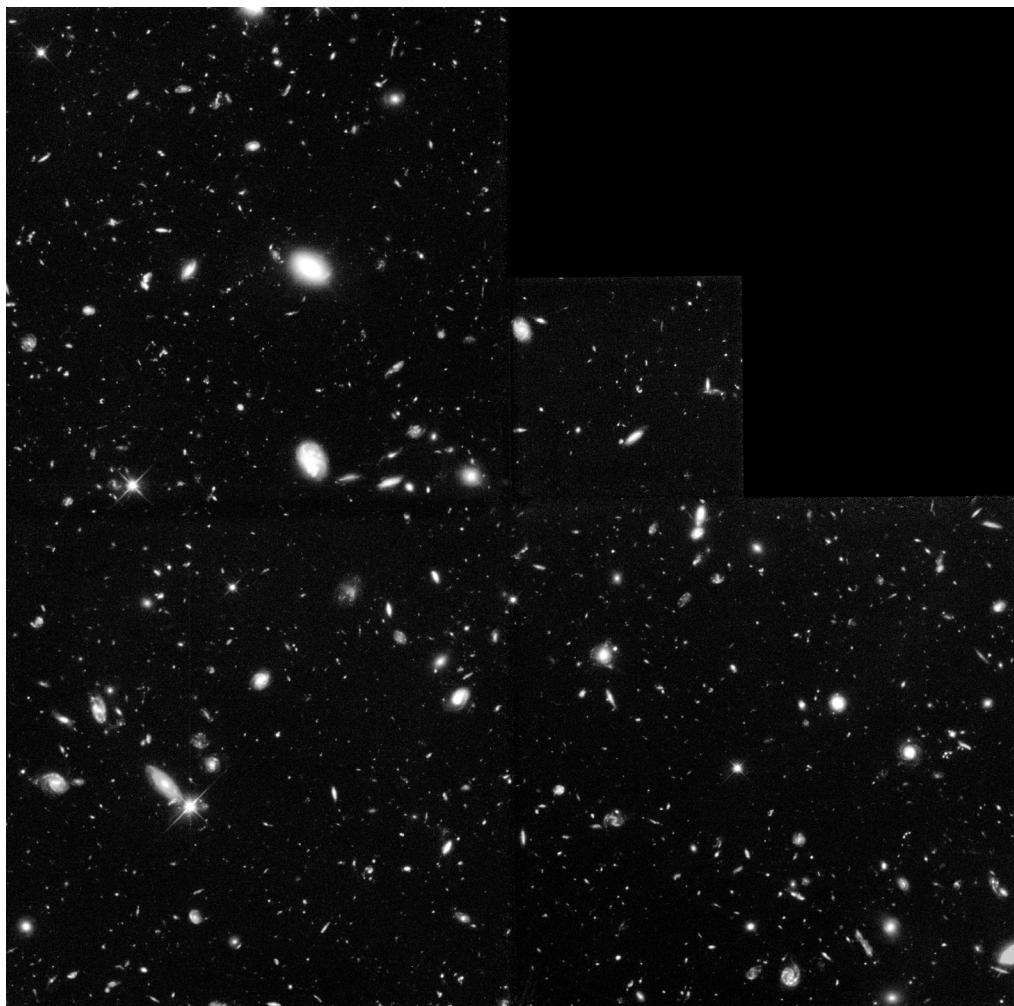




Hubble Deep Field Activity



This booklet contains activities that appear on the back of the HDF poster. The Amazing Space Web site contains an online version of this activity — the “Stellar Statistician” section of the activity titled “Hubble Deep Field Academy.” Go to the “Online Explorations” page of the Web site to find this and many other online resources.

March 2009

Science Introduction

What is the Hubble Deep Field?

The Hubble Deep Field represents a narrow view of the universe, covering a speck of sky. Essentially a narrow, deep “core sample” of sky, the field is similar to a geologic core sample of the Earth’s crust. Just as a core sample represents a history of the evolution of the Earth’s surface, the Hubble Deep Field image contains information about the universe at many different stages in time. Unlike a geologic sample, scientists cannot determine the age of the galaxies because the deep field image does not clearly show their distance from Earth. Hubble’s narrow view shows the galaxies stacked against one another; scientists must disentangle them to determine their ages.

The image was assembled from many separate exposures taken for 10 consecutive days between Dec. 18 and 28, 1995. Three hundred forty-two exposures were taken using the Hubble Space Telescope’s Wide Field and Planetary Camera 2 (WFPC2); 276 have been fully processed and were used for this picture.

Why do we study it?

The Hubble Space Telescope reached back 10 billion years to capture a view of young, never-before-seen galaxies in various stages of evolution. The view shows the dimmest, most distant objects in the universe. Most are about 4 billion times fainter than can be seen by the human eye. Besides uncovering the classical spiral- and elliptical-shaped galaxies, Hubble found a bewildering assortment of other galaxy shapes and sizes that may yield important clues to the evolution of the universe. Some of the galaxies may have formed less than 1 billion years after the Big Bang, the initial cosmic explosion that many scientists believe jump-started the universe.

“Words from the scientist”

by Ray Lucas, Astronomer at the Space Telescope Science Institute

The study of the Hubble Deep Field is typical of 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, we try to classify them based on their observable traits. We first have to see which traits are the most important ones to be measured or counted, and second, we have to decide what procedure we will follow in our classification system. Sometimes the most important characteristics or methods are also the easiest to see, but sometimes nature is more subtle, and sometimes we find that our ways of studying a problem are unwieldy or somehow

unsuitable. Sometimes even our fundamental 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 by 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 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!



Activity Overview

In this activity, students will examine the Hubble Deep Field image and simulate the process astronomers have gone through to count the objects in the image. This is one of four activities in the Amazing Space “Online Exploration” called “Hubble Deep Field Academy,” found at: <http://amazing-space.stsci.edu/resources/explorations/hdf>

For other resources, follow the links to the Hubble Deep Field Academy Lesson Plan “Grab Bag,” in the “Teaching Tips” section of “Hubble Deep Field Academy.”

Activity objectives

After completing this activity, students will be able to:

- Generate questions that can be answered using scientific inquiry
- Collect and interpret scientific data
- Apply estimation skills to scientific data
- Begin to conceptualize the vastness of the universe

Warm-up activities

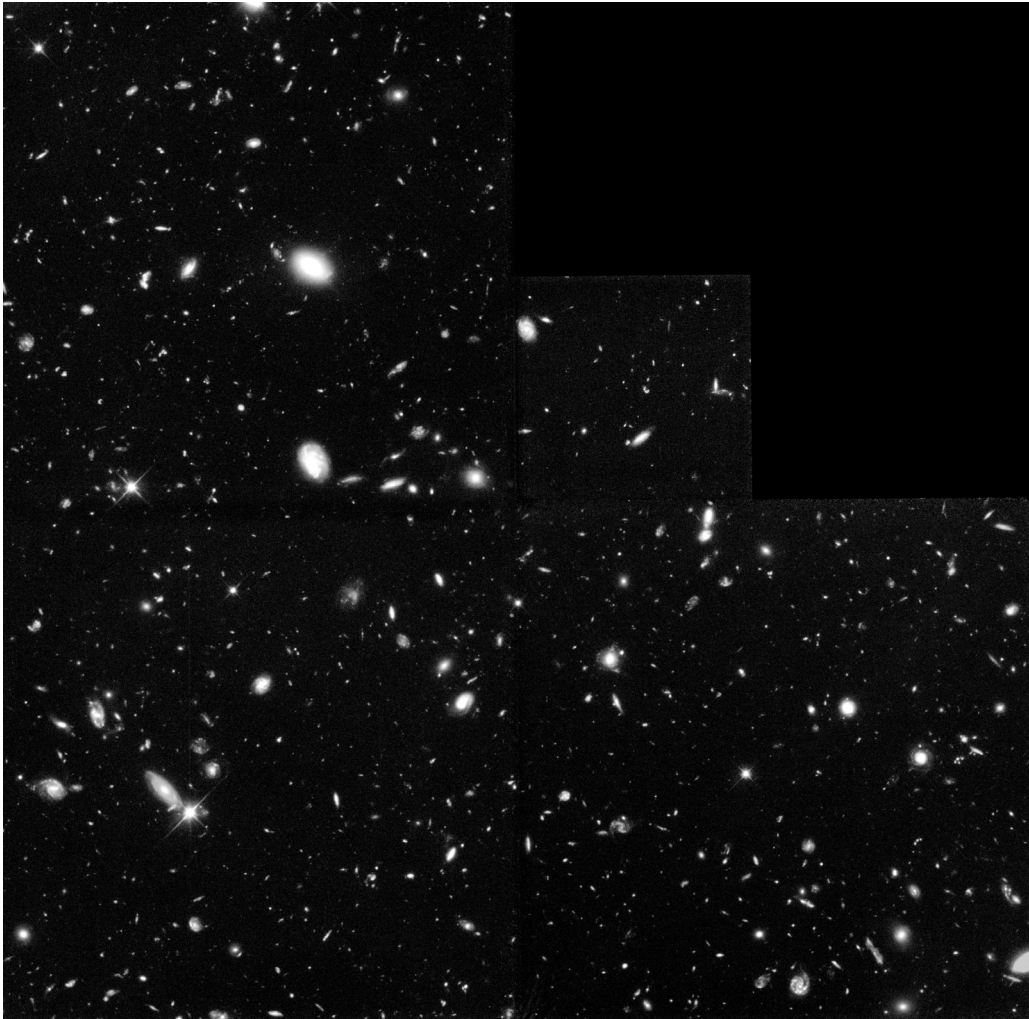
- Describe a possible method for estimating the number of objects in the Hubble Deep Field image.
- Think about and then write down several questions that you would like to have answered about the objects on this poster.
- Devise different ways to classify the objects in the Hubble Deep Field image.

Suggestions for more ways to use the poster

- Use the poster as a learning station for small groups of students.
- Label objects with post-it notes and ask students to classify them based on color and shape.
- Have students guess which objects are close and which are far away. Teachers should point out that the size of an object in the Hubble Deep Field is not necessarily related to its distance.
- Ask students to create their own classification system for the objects in the Hubble Deep Field.
- Ask students to research the varying colors and shapes of the objects and present their information to the class.

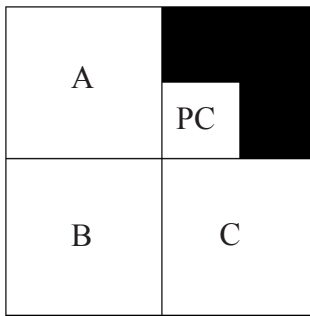
Hubble Deep Field Activity

How Many Objects Are There?



One of the questions astronomers ask is “How many objects are there?” Scientists often have to come up with rough estimates, which they will later verify with further investigations. Using this activity, students can derive their own estimates.

1. Ask students to estimate the number of objects in the Hubble Deep Field (shown above) and record their estimate on a worksheet.
2. Assign each group one camera (“A,” “B,” or “C”) from the Hubble Deep Field to use for representative sampling. Reproducible copies of the three cameras are provided on pages 7, 8, and 9. Each student can count a different section of the camera (12 sections in each). Students then can use this information to calculate a group as well as a class average.



Why is the image chevron-shaped?

The Wide Field and Planetary Camera 2, used to take the deep field image, is actually four cameras that look at adjacent pieces of the sky. The three wide field cameras are labeled A, B, and C. The planetary camera, which provides more detail of a smaller field, is labeled PC. The resulting four separate pictures are combined, like tiles, to create a mosaic. Astronomers prefer to work with reversed images, such as the black on white camera images provided for the student activity, because it makes objects easier to see.

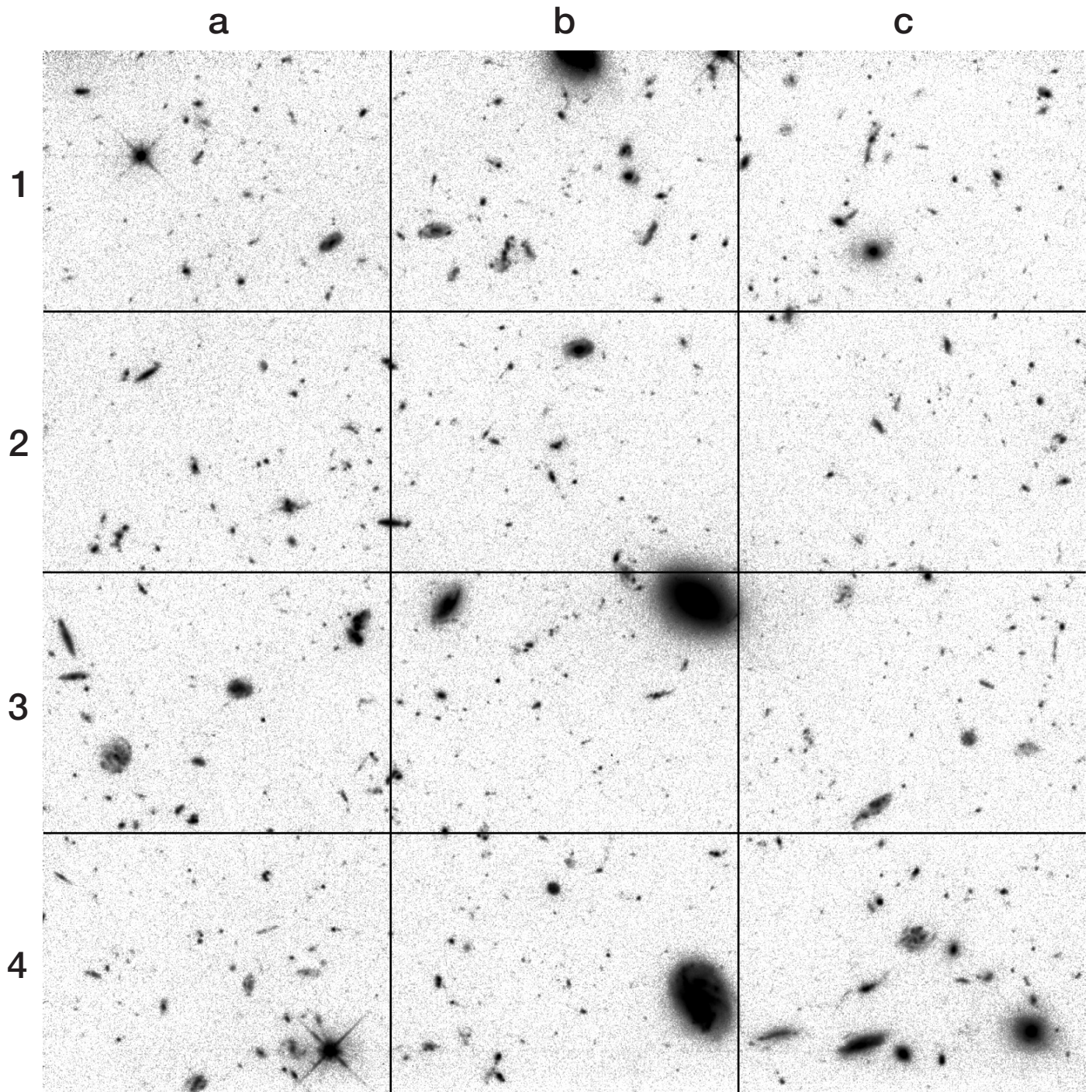
3. The teacher should decide whether to use individual, group, or class estimates to do the following three calculations:

$\frac{\text{Student count from one section of one camera field}}{\text{Student count from one section of one camera field}} \times 12 = X$	where X = objects in one camera field
$X \times 3 = y$	where y = objects in the Hubble Deep Field
$y \times 3 \times 10^7 = Z$	where Z = objects in the Universe

Notes:

1. It would take about 3×10^7 (or, 30 million) WFPC2 images to cover the entire sky.
2. For purposes of this activity, the PC has not been factored into these calculations.
3. To help students comprehend how large a million is, the exercise “What Does a Million Look Like?” is included as part of this activity.

Camera A



Camera B

a

b

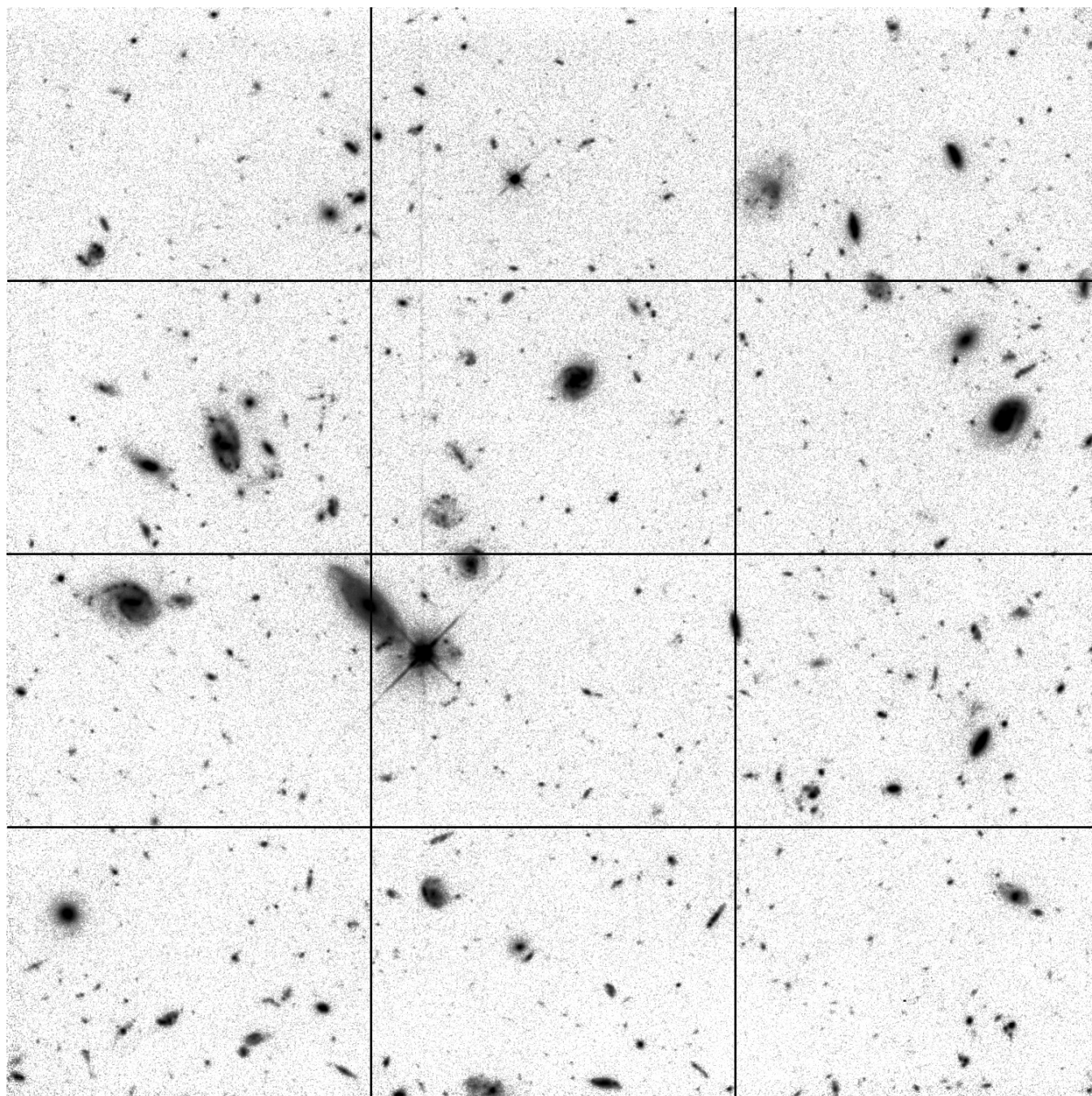
c

1

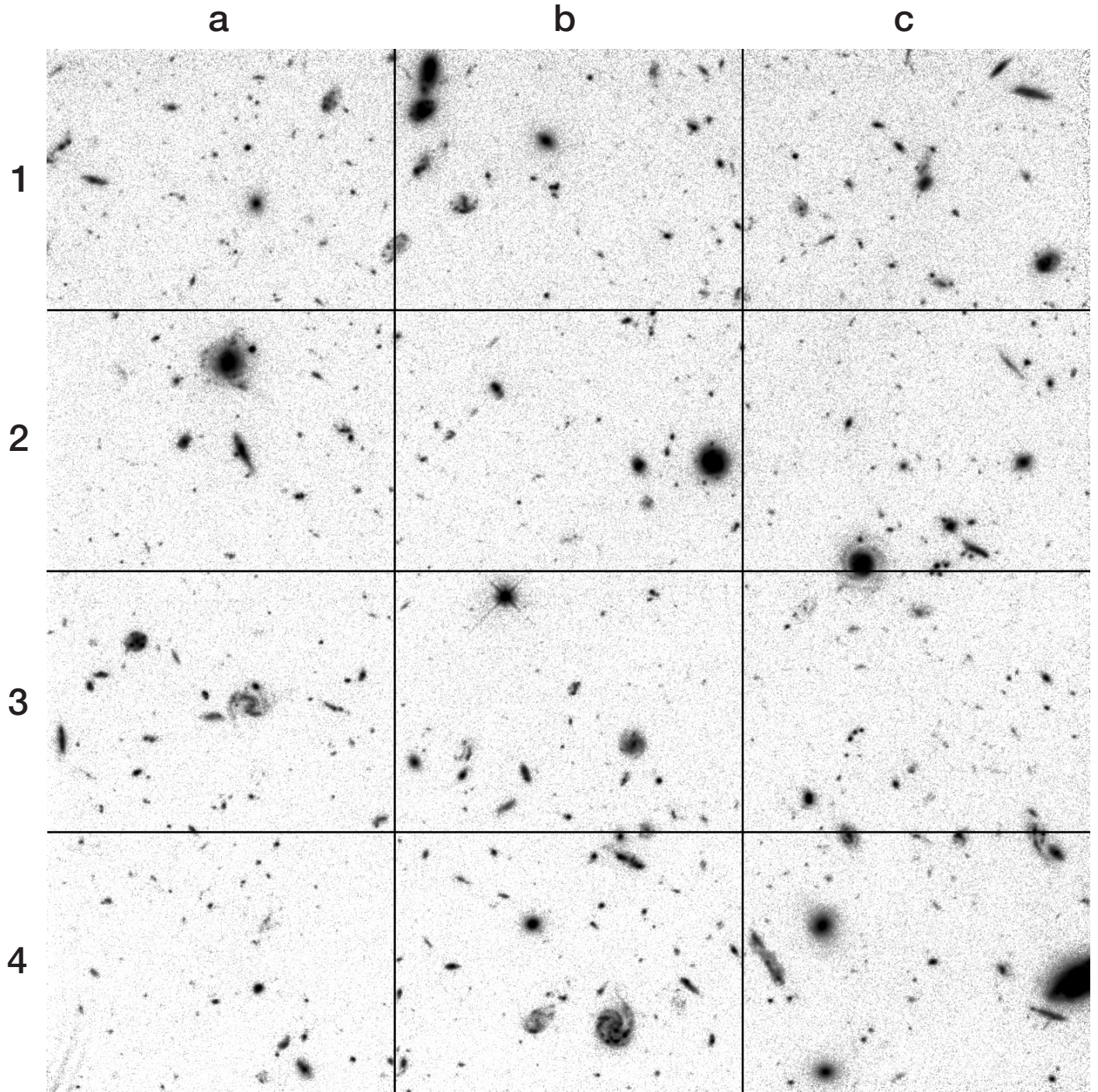
2

3

4



Camera C



Name: _____

Date: _____

What Does a Million Look Like?

When we study the age of the earth, the solar system, and the universe, we are dealing with huge numbers. The size of these numbers is very hard for people to comprehend. To gain a better idea of the magnitude of these numbers, we are going to count dots – millions, billions, and trillions of them.

Please read all questions carefully and show any work necessary to calculate your answers. All questions refer to the number of dots on the worksheet.

1. How many dots are there on the worksheet? _____
2. How many pages would it take to make 1 million (1,000,000) dots? _____
3. How many pages would it take to make 1 billion (1,000,000,000) dots? _____
1 trillion (1,000,000,000,000) dots? _____
4. If 250 stacked pages equals 2.5 centimeters, how many centimeters of paper would it take to make 1 million dots? _____
To make 1 billion dots? _____
To make 1 trillion dots? _____
5. There are approximately 5 billion people in the world. If each dot represented one person, how many pages would be necessary to show the Earth's population?

6. How many centimeters of dotted paper would represent the population of the world?
How many meters?
Compare the height of this stack of papers to a tall office building.
If each story equals 3 meters, how tall would the building be?
Answers: _____ centimeters; _____ meters; _____ stories

“What Does a Million Look Like?” Worksheet

Please show all your work.

A large grid of dots for writing answers, consisting of 30 columns and 30 rows of small black dots.

Science Background

Galaxies

- Galaxies are massive systems made of billions of stars, dust, and gas clouds that are held together by gravity.
- Stars are massive gaseous bodies that undergo nuclear reactions and emit light.

Estimation

- Astronomers have long tried to estimate the number of galaxies in the universe.
- They use a method called “representative sampling” to obtain their estimate. They divide the sky into sections of equal size and count the number of galaxies in one section. They then multiply the count from that one section by the total number of sections in the sky.
- Astronomers have estimated the number of galaxies in the universe to be between 50 and 100 billion.

Shape

- Astronomers use shape to classify galaxies.
- There are three commonly recognized shapes: spiral, elliptical, and irregular.
 - ❑ Spiral galaxies have two or more “arms” winding out from a central disk. When viewed from the side, spiral galaxies look like fried eggs.
 - ❑ Elliptical galaxies appear smooth and featureless, with round or oval shapes, and appear basically the same when viewed from any angle.
 - ❑ Irregular galaxies do not have arms or a uniform appearance. Their stars and gas clouds are scattered in random patches.
- The most difficult part about identifying galaxies by their shape is recognizing them when their orientation is unknown.

Color

- Galaxies come in a variety of colors.
- As a galaxy ages, its color changes.
- Galaxies with young stars would appear blue; galaxies with old stars would appear red.
- Galaxies with stars of varying ages may appear to be a combination of colors. For example, a galaxy with some old and young stars may appear to be a combination of blue and red.
- The presence of dust in a galaxy can make it appear more red than it actually is.
- By studying the light from a galaxy, astronomers can also get information about its chemical composition, its distance from Earth, and the speed at which it is traveling away from us.

Size/Distance

- Determining the distance from Earth for objects in space is a difficult task for astronomers.
- The size of a galaxy is not useful because objects that are nearer to Earth can appear small next to other objects that are extremely large and far away.
- Astronomers use the speed at which a galaxy is moving to determine its distance, measured in light-years.
- A light-year is equal to the distance light can travel in a year, approximately 6 trillion miles.



<http://amazing-space.stsci.edu>