



<http://amazing-space.stsci.edu/resources/explorations/galaxies-galore/>

Name: _____

Background: How Are Galaxies Classified? What Do They Look Like?

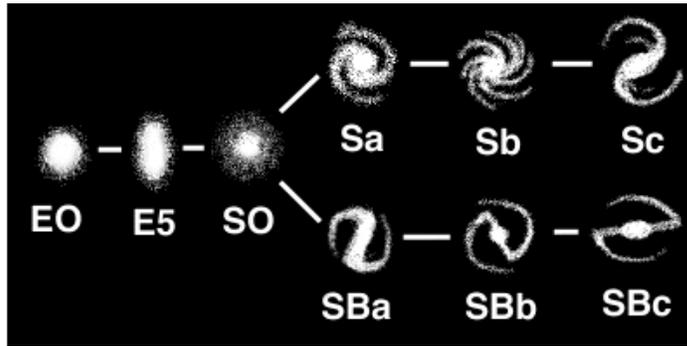
Edwin Hubble classified galaxies into four major types: **spiral**, **barred spiral**, **elliptical**, and **irregular**. Most galaxies are spirals, barred spirals, or ellipticals.

Spiral galaxies are made up of a flattened disk containing spiral (pinwheel-shaped) arms, a bulge at its center, and a halo. Spiral galaxies have a variety of shapes and are classified according to the size of the bulge and the tightness and appearance of the arms. The spiral arms, which wrap around the bulge, contain numerous young blue stars and lots of gas and dust. Stars in the bulge tend to be older and redder. Yellow stars like our Sun are found throughout the disk of a spiral galaxy. These galaxies rotate somewhat like a hurricane or a whirlpool.

Barred spiral galaxies are spirals that have a bar running across the center of the galaxy.

Elliptical galaxies do not have a disk or arms. Instead, they are characterized by a smooth, ball-shaped appearance. Ellipticals contain old stars, and possess little gas or dust. They are classified by the shape of the ball, which can range from round to oval (baseball-shaped to football-shaped). The smallest elliptical galaxies (called "dwarf ellipticals") are probably the most common type of galaxy in the nearby universe. In contrast to spirals, the stars in ellipticals do not revolve around the center in an organized way. The stars move on randomly oriented orbits within the galaxy like a swarm of bees.

Irregular galaxies are galaxies that are neither spiral nor elliptical. They tend to be smaller objects that are without definite shape and tend to have very hot newer stars mixed in with lots of gas and dust. These galaxies often have active regions of star formation. Sometimes the irregular shape of these galaxies results from interactions or collisions between galaxies. Observations such as the Hubble Deep Fields show that irregular galaxies were more common in the distant (early) universe.



How Do You Classify Galaxies Today?

Today we classify galaxies mainly into two major groups following Hubble's examples (*top of next page*). Elliptical galaxies range from round shapes (**E0**) to oval shapes (**E7**). Spiral galaxies have a pinwheel shape and are classified according to their bulge, as well as how tightly their arms are wrapped around the bulge. They range from (**Sa**), which has a large bulge and tight, smooth arms, to (**Sc**), which has a small bulge and loose, lumpy arms.

Barred spiral galaxies classified as (**SB**) are pinwheel-shaped and have a distinct "bar" of stars, dust and gas across their bulge. They range from an (**SBa**), which has a bar across its large bulge and tight, smooth arms, to an (**SBc**), which has a bar across its small bulge and loose, lumpy arms. Irregular galaxies have no definite shape but still contain new stars, gas, and dust. The chart below summarizes the properties of the main classes of galaxies.

	SPIRAL / BARRED SPIRAL (S, SB)	ELLIPTICAL (E)	IRREGULAR (Irr)
Shape and Structural Properties	Disks of stars, gas, and dust containing spiral arms that thicken to central bulge. Sa and SBa have largest bulge. SB galaxies have central bar.	No disk and no arms. Stars distributed evenly from near circular to oval (football).	No structure.
Stellar Content	Have both young and old stars. Halos consist of old stars only.	Contain mostly old stars.	Contain both young and old stars.
Gas and Dust	Disks contain gas and dust. Halos contain little gas or dust.	Little or no gas or dust.	A lot of gas and dust.
Star Formation	Stars form in arms.	No formation seen.	A lot of star formation.
Stellar Motion	Gas and stars rotate around the center of the galaxy.	Stars swarm like bees.	Stars and gas have irregular orbits.

What Are Colliding Galaxies?

When two or more galaxies are close enough to each other, gravitational forces will pull the galaxies toward each other. This gravitational attraction increases as the galaxies travel toward each other. The galaxies may pass by each other or collide. Two galaxies that are interacting or colliding may be referred to as a pair, or one galaxy may be referred to as a companion of the other.

These HST images show how different colliding galaxies can look. The appearance of an interacting system of galaxies depends on many factors, including the number of galaxies involved in the interaction, their masses and types, how close they are, and how they approach each other. The Antennae galaxies are an example of two spirals that are in the process of colliding. We will not see the end result during our lifetimes because this process takes hundreds of millions of years.

Sometimes smaller galaxies plunge into larger galaxies. This type of collision produces a ripple effect, like a rock thrown into a pond. The Cartwheel galaxy is an example of this type of collision. The outer ring of blue stars in this galaxy indicates a ripple of star formation resulting from the collision. The Milky Way and Andromeda are examples of two spiral galaxies that may eventually collide (about 5 billion years in the future).

Galaxy Names Are Identified by a Group of Letters and Numbers. What Do They Stand For?

Scientists classify galaxies in different catalogs. The most common catalog is NGC, which stands for New General Catalog. Other catalogs include M (Messier), ESO (European Southern Observatory), IR (Infrared Astronomical Satellite), Mrk (Markarian), and UGC (Uppsala General Catalog).

The numbers following the letters help scientists to locate the galaxy in its relative position in the sky, such as Mrk 917 (Sc) or NGC1433 (SB). Sometimes a galaxy appears in more than one catalog and can have more than one name.



Here are directions to getting started on the Galaxies Galore Activity!

Step 1: Go to the URL

<http://amazing-space.stsci.edu/resources/explorations/galaxies-galore/index.html>

Step 2: Select "Galaxies Galore"



Step 3: Select "Spiral Shapes"



Step 4: Go ahead and play the game. See if you can match the spiral galaxy classification with its proper picture by dragging the galaxy shape to the picture.

Your Score
(How many pictures did
you make a mistake
classifying?)



Step 5: Select the  button, and answer the questions below:

What classification do you think these galaxies are?

M104 _____ M100 _____ M65 _____

Whirlpool Galaxy _____ NGC _____

Step 6: Select the  button, and read what it has to say.

Step 7: Click the  button.

Step 8: Select “Elliptical Slide” for the next activity. Go ahead and move the slide. Let the slide rest at EO or E7 and it will give you a definition of either an EO or E& galaxy. Write those definitions below.



Elliptical Slide

EO galaxy is _____

E7 galaxy is _____

Step 9: Select the  button, and answer the questions below:

What classification do you think these galaxies are?

M87 _____ M49 _____ M32 _____

NGC 3377 _____

Step 10: Select the  button, and answer the questions below.

What size is a Dwarf Elliptical Galaxy? _____

What size is a Giant Elliptical Galaxy? _____

How many stars are in a Giant Elliptical Galaxy? _____

Step 11: Click on the  button.

Step 12: Select “Irregular Slide” for the next activity. Go ahead and start the game they have for introducing you to irregular galaxies.



Imagine Irregulars

Step 13: Select the  button, and take a look at some Irregular Galaxies.

Step 14: Select the button, and answer the questions below.

What is the definition of an Irregular Galaxy? _____

What is the Large Magellanic Cloud?...and where is it located? _____

Step 15: Click on the “Press Release” picture.



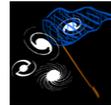
Write a summary on what LBV's are, and how unique it is that we are able to see them.

Step 16: Select the  button twice.

Step 17: Select the Galaxy Games button.



Step 18: Select the Galaxy Hunt button.



Your Score
(How many points did
you earn?)

Step 19: Now select the  button.

What is the Hubble Deep Field?

How far above the Earth is the Hubble Telescope located?

Step 20: Read the information on the next page:

Who is Edwin P. Hubble and what has he to do with galaxies?

Edwin P. Hubble revolutionized cosmology by proving that galaxies are indeed "island universes" beyond our Milky Way galaxy. His greatest discovery was in 1929, when he identified the relationship between a galaxy's distance and the speed with which it is moving. The farther a galaxy is from Earth, the faster it is moving away from us. This is known as Hubble's Law. He also constructed a method of classifying the different shapes of galaxies with the Hubble Tuning Fork.

Edwin Powell Hubble was born in Kentucky where he grew up observing the habits of birds and animals. In 1910 he received his undergraduate degree from the University of Chicago and studied law under a Rhodes Scholarship at Oxford University. Later he changed his mind and completed his Ph.D. in astronomy at Chicago's Yerkes Observatory in 1917. He had several other interests, and for a while he thought of becoming a professional boxer. He also enjoyed basketball, and even answered a call in World War I to serve in the infantry.

He once said that he "chucked the law for astronomy," knowing that even if he was second-rate or third-rate, it was astronomy that mattered.

What is the Hubble Space Telescope?

The Hubble Space Telescope (HST) is a space-based telescope that was launched in 1990 from the space shuttle. From its position 380 miles above the Earth's surface, the HST has expanded our understanding of the universe, in particular star birth, star death, galaxy evolution, and black holes.

The telescope's instruments are the astronomer's eyes to the universe. Its instruments include the Wide Field Planetary Camera 2, Space Telescope Imaging Spectrograph, Near Infrared Camera and Multi-Object Spectrometer, Faint Object Camera, and the Advanced Camera for Surveys.

When first launched, the HST's lens was out of shape on the edges by 1/50 of a human hair. This very small defect made it difficult to focus faint objects being viewed by Hubble. Because the HST is in low Earth orbit, it can be serviced by a shuttle. The defect was corrected in the first servicing mission. The Hubble Space Telescope is scheduled for one more servicing mission before its planned retrieval in 2010. You may one day be able to visit the Hubble Space Telescope at the National Air and Space Museum.

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.

Step 21: Hit the  button, and return to the Galaxy Games main page.

Step 22: Now play the "Galaxy Concentration" Game.



How many clicks did it take you to get all the cards right?

Step 23: Now go  and play the "Galaxy Trading Card" Game.



How many times did you get the wrong galaxy?

Step 24: Now if you have time go back  to and "Build a Galaxy."

