

Overview:

Galaxies are classified by their morphology.

Objectives:

The student will:

- classify 15 images of distant galaxies using a galaxy classification table;
- sketch, classify and describe the morphology of galaxy NGC 1097; and
- write a paragraph describing the attributes of a black hole.

Targeted Alaska Grade Level Expectations:**Science**

[10] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[10] SD4.1 The student demonstrates an understanding of the theories regarding the origin and evolution of the universe by recognizing phenomena in the universe (i.e., black holes, nebula).

Vocabulary:

black hole – an extremely dense celestial object that has a gravitational field so strong that nothing can escape, not even light; a black hole is formed by the collapse of a massive star's core in a supernova

galaxy – and of numerous large-scale collections of stars, gas and dust that make up the universe; a galaxy may range in diameter from 1,500 to 300,000 light years

nebula – a thinly spread cloud of interstellar gas and dust; it will appear as a bright patch in the night sky if it reflects light from nearby stars, emits its own light, or re-emits ultraviolet radiation from nearby stars as visible light; if it absorbs light, the nebula appears as a dark patch

galaxy morphology- Classification system to group galaxies based on their visual appearance

Whole Picture:

A galaxy is an enormous cluster of stars and remnants of stars, intermingled with gas and dust, bound by gravity. Galaxies can contain as few as ten million stars and up to a hundred trillion stars. All the matter in a galaxy orbits its center of mass.

Galaxies come in a wide array of forms. Astronomers use a morphological classification system to divide galaxies into groups. This lesson uses three basic divisions – elliptical, spiral and irregular – each with its own further divisions.

Materials:

- VISUAL AID: "Galaxy Observation"
- VISUAL AID: "Coiled Galaxy"
- STUDENT INFORMATION SHEET: "Galaxy Classification"
- STUDENT INFORMATION SHEET: "What in the World is a Black Hole?"
- STUDENT OBSERVATION SHEET: "Coiled Galaxy"
- STUDENT WORKSHEET: "Galaxy Observation"
- STUDENT WORKSHEET: "Galaxy Observation Table"

NOTE: This activity can be done in two ways.

Option 1: If you have access to a color printer, print enough copies of STUDENT INFORMATION SHEET: "Galaxy Classification" for students to work in pairs to classify galaxies.

Option 2: If no color printer is available, use VISUAL AID: "Galaxies" instead of STUDENT INFORMATION SHEET: "Galaxy Classification".

Activity Preparation:

1. Determine Option 1 or Option 2. See Activity Procedure 4 for more information.
2. Find and bookmark the website Hubble Site for access to images of distant galaxies: <http://hubblesite.org/gallery/>.

Activity Procedure:

1. Divide the class using a "classification" system. Do not tell students the criteria, but direct them to different groups based on your own predetermined criteria. You may start with something very easy, like dividing boys and girls. (John, please go to the right side, Carol to the left, etc.) Ask students what categories they observe. Choose more difficult classification criteria for the next division, based on clothing or hair color, etc. Try to make up to four groups, if possible (Say, boys with glasses, boys without glasses, girls with glasses, girls without glasses) and see if students can determine the criteria.
2. Explain scientists use certain criteria to classify galaxies. Visit the website Hubble Site and show students images of galaxies. (<http://hubblesite.org/gallery/>) Ask student if they notice any patterns in the shape (morphology) of different galaxies. Ask the following:
 - a. How could galaxies be grouped by shape/morphology?
 - b. How could galaxies be grouped by color?
3. Hand out STUDENT INFORMATION SHEET: "Galaxy Classification". Explain this is the system astronomers use to classify galaxies. Review the information. Review images from Hubble Site to see if students can identify the classification of previously viewed images.
4. Option 1: (See Activity Preparation.) Divide students into pairs. Hand out STUDENT WORKSHEETS: "Galaxy Observation" and "Galaxy Observation Table". Explain students will work together using the information sheet on galaxy classification to determine the classification for the galaxies pictured.

Option 2: (See Activity Preparation.) Display VISUAL AID: "Galaxy Observation." Hand out STUDENT WORKSHEET: "Galaxy Observation Table". Explain students must use the information sheet on galaxy classification to determine the classification for the galaxies pictured on the visual aid.
5. Display VISUAL AID: "Coiled Galaxy". Ask students to record the following in a science journal or on the observation sheet provided:
 - a. Sketch the general morphology of galaxy NGC 1097.
 - b. Use the classification chart to provide the appropriate classification for this galaxy.
 - c. In a summary paragraph, explain the reasoning for choosing the classification.
 - d. Choose a name for the galaxy (just for fun).
6. Hand out STUDENT INFORMATION SHEET: "What in the World is a Black Hole?" Choose a reading strategy best suited for the class. Once students have had an opportunity to read the information, ask them to copy then answer the following critical thinking question in their science journal or on a piece of lined paper. Ask students to write a complete paragraph describing the attributes of a black hole as they answer the question. "Based on the knowledge that a black hole sits at the center of the coiled galaxy (pictured earlier), what is keeping the stars orbiting the black hole from being drawn in? Why can we see the stars, yet we cannot see the black hole?"

INSTRUCTIONS

Answers:

STUDENT WORKSHEET: "Galaxy Observation Notes"

1 E0	2 SBb	3 Sb
4 SBc	5 Sb	6 E0
7 So	8 SBb	9 E0
10 E5	11 Irr	12 E0
13 Irr	14 Sb	15 Sb

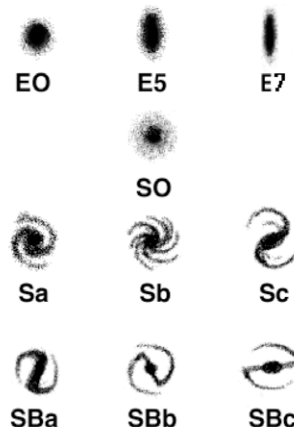
STUDENT WORKSHEET: "Coiled Galaxy"

Answers will vary.

A galaxy is an assembly of between a billion (10⁹) and a hundred billion (10¹¹) stars. There is often a large amount of dust and gas intermingled, all held together by gravity. The Sun and Earth are in the Milky Way Galaxy.

Galaxies have many different characteristics, but the easiest way to classify them is by shape, referred to as morphology. In 1925 astronomer Edwin Hubble established a classification scheme for galaxies that, with some modification, is still used today. In general, galaxies are classified by their appearance into one of three major types: spiral (S), elliptical (E), or irregular (Irr).

Elliptical galaxies make up about one-third of the observed galaxies and are generally found in galaxy clusters. The largest elliptical galaxies contain the equivalent of ten trillion stars like the Sun. Astronomers classify elliptical galaxies as E0 through E7 based solely their shape. A fairly rounded elliptical galaxy would be classified as E0, while a very elongated elliptical galaxy would be denoted as E7. These galaxies are dominated by older stars and contain little (if any) gas and dust, the raw materials needed for stars to form.



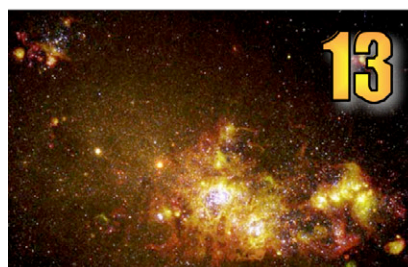
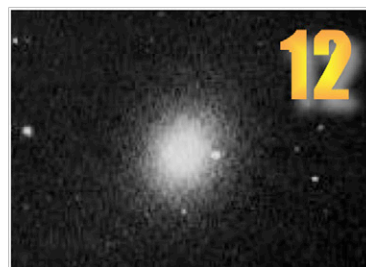
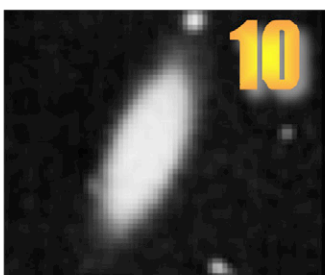
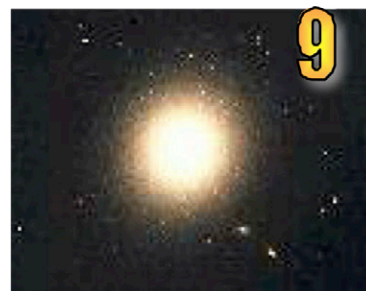
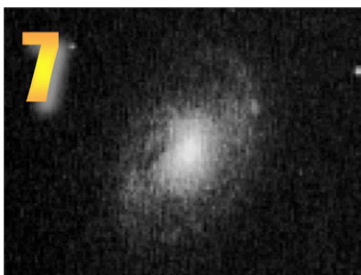
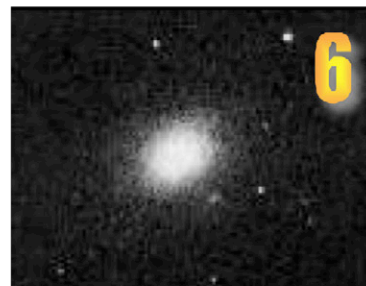
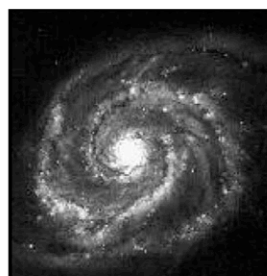
Spiral galaxies account for the majority of the remaining galaxy population and are responsible for many remarkable astronomical images that have been captured. Spirals typically contain the equivalent of a billion to a trillion Sun-like stars. In addition, spiral galaxies have substantial amounts of gas and dust. This reservoir provides the materials needed for ongoing and future star formation. Spiral galaxies feature a central bulge of intense starlight, surrounded by a thin disk of stars, gas and dust. These disks hold the winding spiral arms that characterize the group.

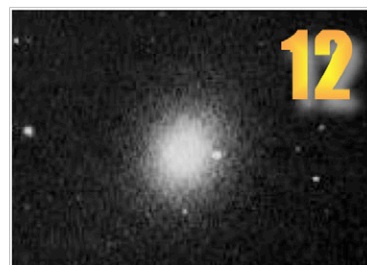
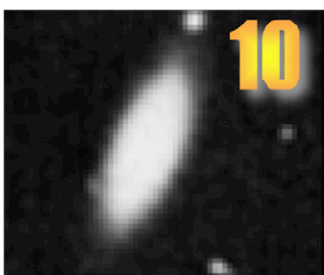
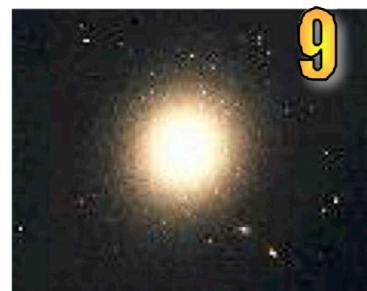
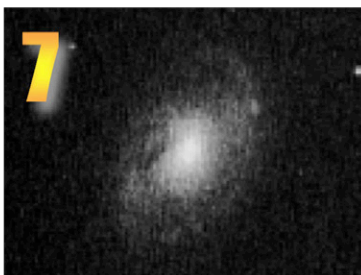
The simplest classification of spiral galaxies uses the terms Sa, Sb, and Sc. The difference between these galaxy types is summarized in the table below.

	Sa	Sb	Sc
<i>Bulge Prominence</i>	Most	Intermediate	Least
<i>Winding of Spiral Arms</i>	Tight	Intermediate	Loose
<i>Amount of Gas/Dust</i>	Least	Intermediate	Most
<i>Star Formation Rate</i>	Least	Intermediate	Most

Earth resides in the Milky Way Galaxy. Being right in it makes it difficult for scientists to determine an accurate classification for the galaxy. The latest imaging suggests that the Milky Way is a slightly barred spiral, like Sb, but with a slight barring at the core.

Irregular galaxies comprise only a small percent of the cataloged galaxies. They are fuzzy blobs lacking any geometrical order, hence irregular, and are typically very faint. Irregular galaxies contain little dust, but produce modest amounts of star formation. The most famous examples of irregular galaxies are the Large and Small Magellanic Clouds seen in the southern sky. The LMC and SMC are nearby companions to our Milky Way Galaxy.



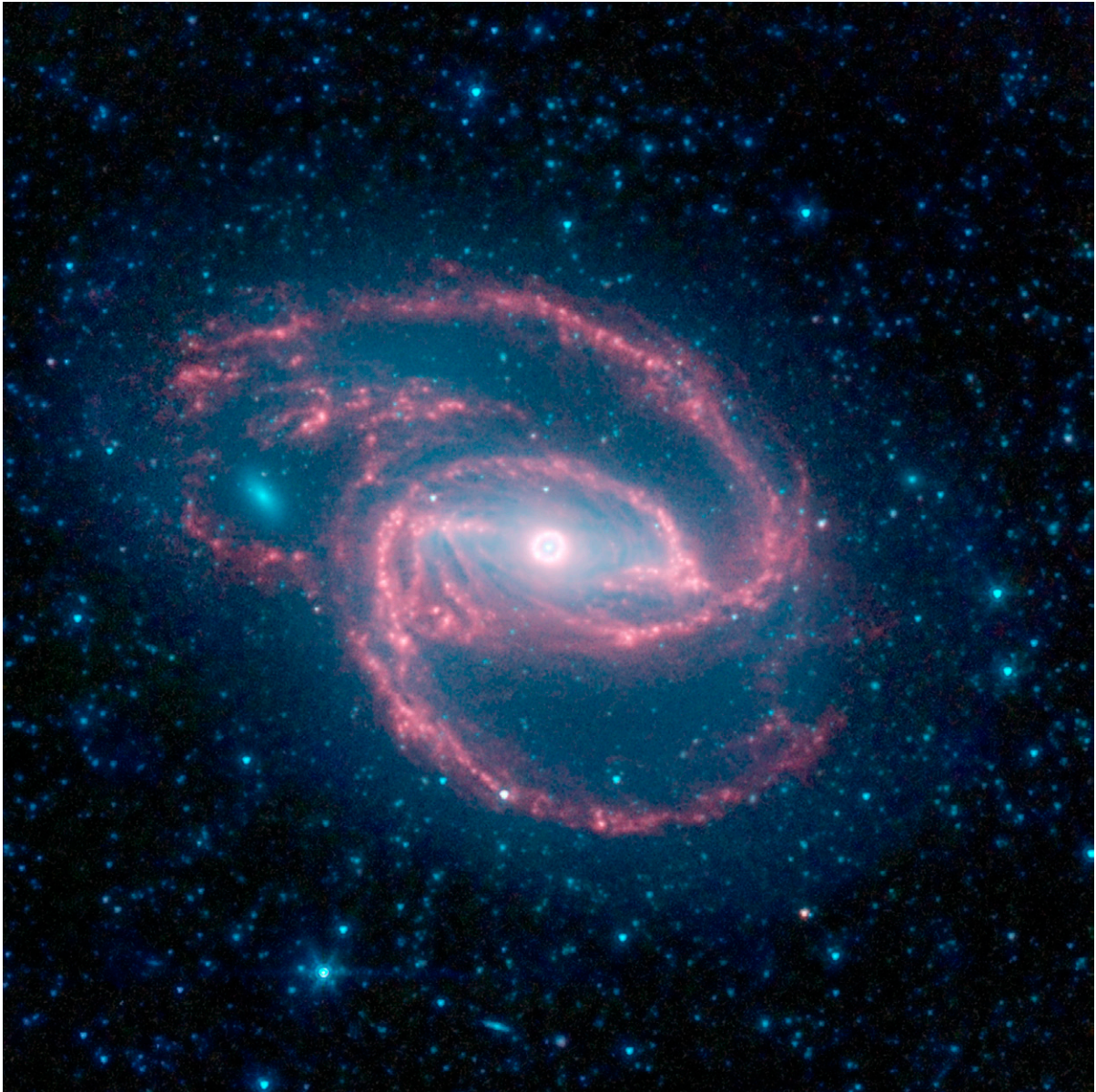


GALAXY OBSERVATION TABLE

STUDENT WORKSHEET

Directions: Use STUDENT INFORMATION SHEET: "Galaxy Classification" to determine the correct classification for galaxies 1 – 15 on VISUAL AID/STUDENT WORKSHEET: "Galaxy Observation". Record your answers. Write E0, E5, E7, S0, Sa, Sb, Sc, SBa, SBb, or SBc.

1	2	3
4	5	6
7	8	9
10	11	12
13	14	15

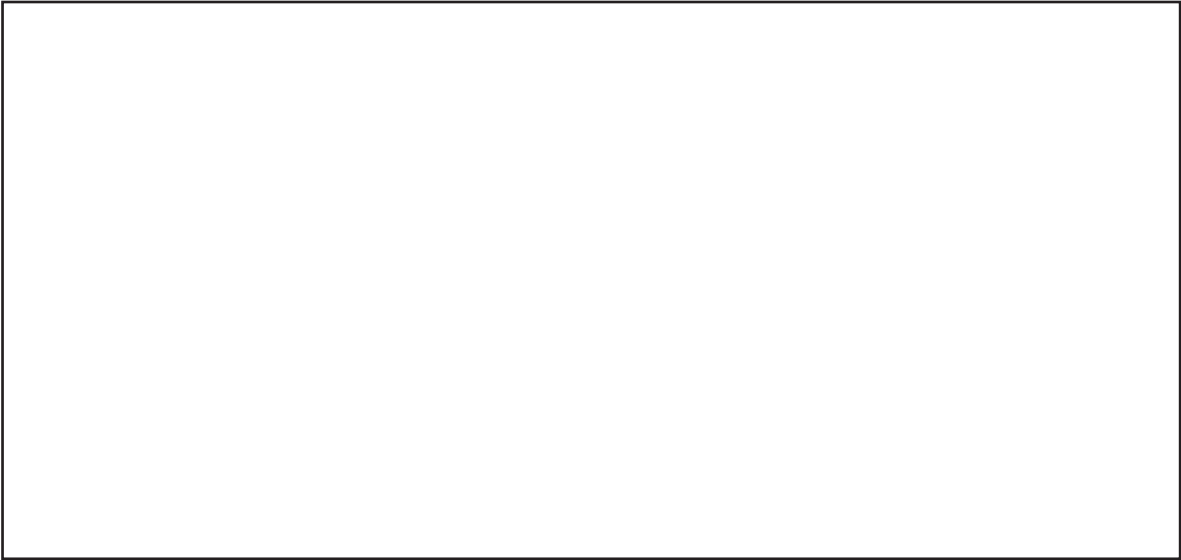


This galaxy, called NGC 1097, is 50 million light years away. This image was retrieved using NASA's Spitzer Space Telescope. The "eye" at the center of the galaxy is a black hole surrounded by a ring of stars. The black hole is estimated to be about 100 million times the mass of the Sun. Image from [Http://commons.wikimedia.org/wiki/File:Coiled_Galaxy.jpg](http://commons.wikimedia.org/wiki/File:Coiled_Galaxy.jpg).

NAME: _____
COILED GALAXY

STUDENT OBSERVATION SHEET

1. Sketch the general morphology of galaxy NGC 1097.



2. The galaxy where Earth is located is called the Milky Way. Choose a name for the coiled galaxy:

3. Use the classification chart to determine the classification for this galaxy. _____

4. In a summary paragraph, explain the reasoning for choosing the classification.

Based on X-ray emission, many galaxies have black holes at the center. A black hole is an extremely dense body of matter, formed by the collapse of a massive star's core, with a gravitational pull so strong nothing can escape.

The study of this celestial phenomenon is somewhat tough. A black hole can't actually be seen because the gravitational pull is so strong that even light can't escape. It's all about escape velocity.

If you launch a model rocket straight up, it will keep going for a while, but eventually, gravity will bring it down. If you put a powerful enough engine on your rocket, you could get it to go fast enough to escape Earth's gravity. That's escape velocity. The Earth's escape velocity is 11.2 kilometers per second, which is about 25,000 miles per hour. In contrast, the escape velocity of the moon is just 2.4 kilometers per second, which is about 5,300 miles per hour. Escape velocity is related to mass. The Earth's mass is greater than the mass of the moon.

Now think about the speed of light. Light travels at 299,792,458 meters per second. (One meter per second equals 2.237 miles per hour.) A black hole has a gravitational pull so strong that the escape velocity is more than the speed of light. That is a clear indication that the mass of a black hole is, well, *massive*.

black hole – an extremely dense celestial object that has a gravitational field so strong that nothing can escape, not even light; a black hole is formed by the collapse of a massive star's core in a supernova

escape velocity – the velocity that a body, such as a rocket, must achieve to overcome the gravitational pull of Earth or another celestial body

light year – the distance that light travels in a vacuum in one year, equal to about 5.88 trillion miles (9.48 trillion kilometers)

speed of light – the speed at which light travels in a vacuum; recognized as 299,792,458 meters per second

Massive versus Extremely Massive

The death of a massive star forms a black hole. A massive star is about 10 times the mass of the Sun. It is assumed the mass of the black hole is the same as the original star.

Some black holes are considered extremely massive. These have a mass a million times that of the Sun.

What is Gravity?

Isaac Newton recognized the force of gravity as the mutual attraction two masses have for each other. The effects diminish as the distance between the objects increase and as the masses decrease.

Albert Einstein expanded on the study of the force of gravity, asserting that all motion is relative. Gravity's effects could not be instantaneous since they would have to travel at infinite velocities, violating his theory of relativity, which states nothing can travel faster than light.

A black hole has what is called an event horizon, which is a theoretical boundary around it beyond which nothing can escape. Objects well away from the event horizon are not in danger of being pulled in. Outside the event horizon a black hole's gravity is not any greater than any other object of the same mass. Stars outside the event horizon will continue their orbital path as usual, similarly to the way Earth continues its orbital path around the Sun.