Other Components of the Universe

9.6

The most common type of celestial object astronomers see in space is a star. Most stars appear to be gravitationally bound together into groups, and some groups are more numerous than others. The following categories describe various types of star groupings.

Star Clusters

All galaxies contain **star clusters**. Star clusters are groups of stars that develop together from the same nebula, are gravitationally bound, and travel together. There are two types of star clusters:

star cluster a group of stars held together by gravity

- Open star clusters are collections of six to thousands of usually young stars.
- Globular clusters are ball-shaped collections of thousands to millions of very old stars (Figure 1).

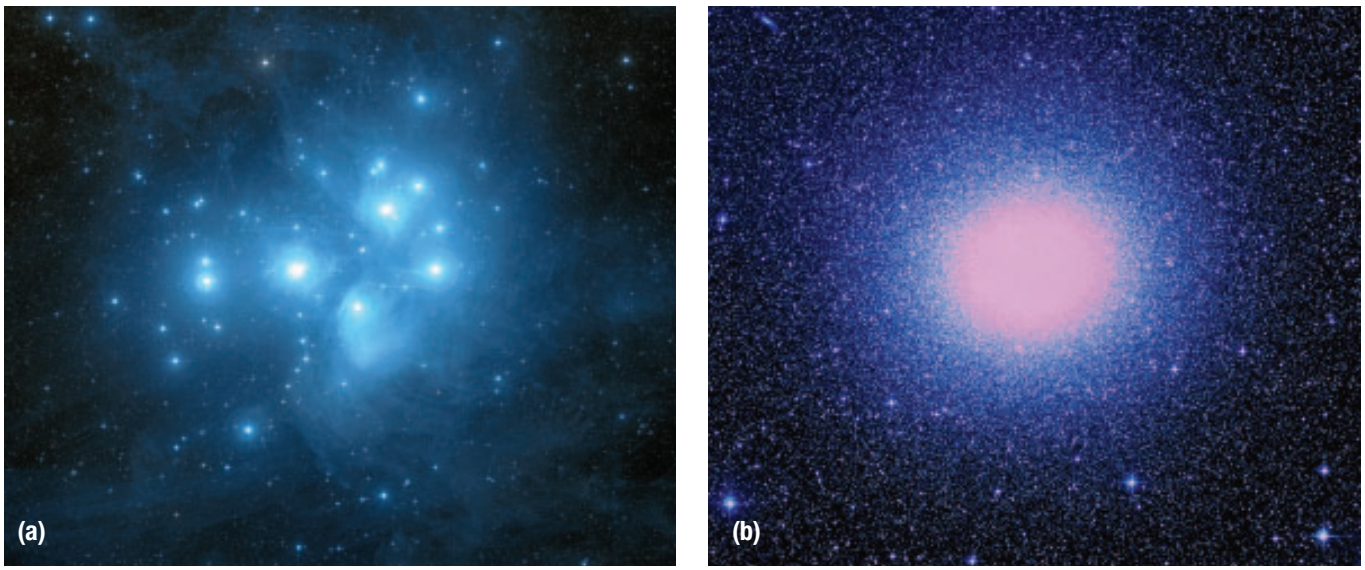

Figure 1 (a) The stars in the open cluster Pleiades can be seen with the unaided eye. (b) Omega Centauri is an example of a globular cluster with a tightly packed group of stars.

Approximately 20 000 open star clusters are found within the main disc of the Milky Way. Globular clusters are scattered like a halo above and below the disc of the Milky Way. Astronomers believe globular clusters date back to the formation of the Milky Way galaxy. The largest globular cluster in the Milky Way is Omega Centauri (Figure 1(b)), which was discovered by Edmund Halley in 1677. This 12 billion-year-old globular cluster orbits the Milky Way at a distance of 18 300 ly from Earth. You will learn more about the Milky Way later in this section.

Types of Galaxies

Galaxies are collections of millions to hundreds of billions of stars, planets, gas, and dust, measuring up to 100 000 ly across. They come in different shapes and sizes and are spread across the Universe. The combined light emitted by the stars in a galaxy defines its size and shape, as observed from Earth.

Figure 2 Edwin Hubble made the key discoveries that the Universe is filled with galaxies and is expanding.

In the 1920s, astronomer Edwin Hubble (Figure 2) changed the way in which scientists view the Universe. Through the use of the most powerful telescope at the time—the Hooker telescope located at the Mount Wilson Observatory in California—he discovered that galaxies besides the Milky Way existed. By 1936, Hubble had created a classification for these new galaxies based on the photographs of the images he saw. He grouped them by shape into four categories: elliptical, spiral, lenticular, and irregular.

elliptical galaxy a large group of stars that together make an elliptical or oval shape

- **Elliptical galaxies** vary in shape from spherical to a flattened oval (Figure 3). We know that they are older galaxies with very little gas, dust, or young stars. Ellipticals account for more than half of all the galaxies we can see.

spiral galaxy a large group of stars that together make a spiral shape, such as the Milky Way

- **Spiral galaxies** look like spinning pinwheels—flattened discs with a central bulge, and two to four spiral arms (Figure 4). The central core is made of old, red stars. The spiral arms contain clouds of gas and dust along with new and young stars. A subclass of spirals are barred spiral galaxies (Figure 5), which are similar to spiral galaxies but have a central bar pattern running down the middle. Spiral arms trail from the ends of these bars. Our galaxy, the Milky Way, is a barred spiral galaxy.

lenticular galaxy a large group of stars that together make a shape that has a central bulge but no spiral arms

- **Lenticular galaxies** have a central bulge surrounded by a flattened disc of gas and dust but have no spiral arms (Figure 6). These galaxies are thought to be spiral galaxies that have lost their gas and dust. Most lenticular galaxies are composed of older, red stars.

irregular galaxy a large group of stars that together make an irregular shape

- **Irregular galaxies** have no definite shape (Figure 7). They contain even more gas and dust than their spiral galaxy cousins. They have no spiral arms or central nucleus and make up at least 10 percent of all galaxies. Irregular galaxies usually contain only 100 million to 10 billion stars.

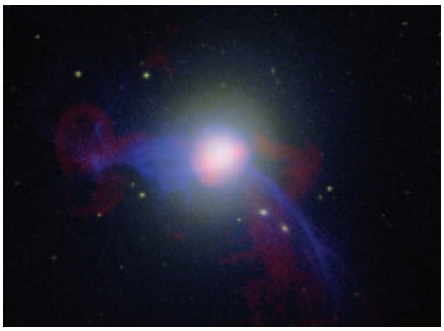

Figure 3 Elliptical galaxy

Figure 4 Spiral galaxy

Figure 5 Barred spiral galaxy

Figure 6 Lenticular galaxy

Figure 7 Irregular galaxy

To learn more about classifying galaxies,
GO TO NELSON SCIENCE

TRY THIS VIEWING GALAXIES

SKILLS: Performing, Observing, Analyzing

SKILLS HANDBOOK 3.B.

Although astronomers can classify galaxies into different types based on their shape, it can be difficult to get clear images of their shape. Galaxies can be blocked by gas and dust or other celestial objects. Even when we get a clear view, the galaxy can be difficult to classify because of the angle we are observing it from.

1. Your teacher will give you four blank overhead projector sheets. Draw one type of galaxy in as much detail as you can on each of the sheets.
2. Have a classmate hold the sheets up one at a time on the other side of the room so they are facing you. Identify each type.
3. Have your classmate tilt each of the sheets at various angles while you try to identify the galaxy types.
4. Finally, have your classmate hold each sheet parallel to the floor while you try to identify the galaxy types.

A. Were the galaxies easy to identify on the other side of the room when they were facing you? T/I

B. As your classmate tilted the sheets, did it become easier or harder to identify the types of galaxies? T/I

C. When the sheets were parallel with the floor, could you see any detail that might help you decide what kinds of galaxies they were? T/I

D. Explain how the angle of observation might make it difficult for astronomers to distinguish spiral galaxies from barred spiral galaxies or lenticular galaxies. T/I

TRY THIS CLASSIFYING GALAXIES

SKILLS: Observing, Evaluating, Communicating

SKILLS HANDBOOK 3.B.3., 3.B.5.

For years, powerful telescopes sitting on mountain tops and spacecraft orbiting Earth have been taking pictures of galaxies found in deep space. To fully understand the structure of these distant galaxies, they first need to be identified and classified based on their appearance.

1. Copy Table 1 into your notebook.

Table 1 Shapes of Galaxies

Galaxy type	Numbers
spiral	
elliptical	
irregular	
lenticular	

A. Look at the shapes of the various galaxies in Figure 8. The illustration is representative of a random sample of galaxies from the Universe. Decide whether each one is a spiral, elliptical, irregular, or lenticular galaxy. Then write its number in the appropriate row. T/I

B. Write one line of description for each type of galaxy, explaining your choice and the features you identified in the picture. T/I

C. How many of each type of galaxy were there? T/I

D. Based on this data, make a prediction about the most common type of galaxy in the Universe. T/I

E. Conduct research to find out if your prediction was correct. T/I

GO TO NELSON SCIENCE

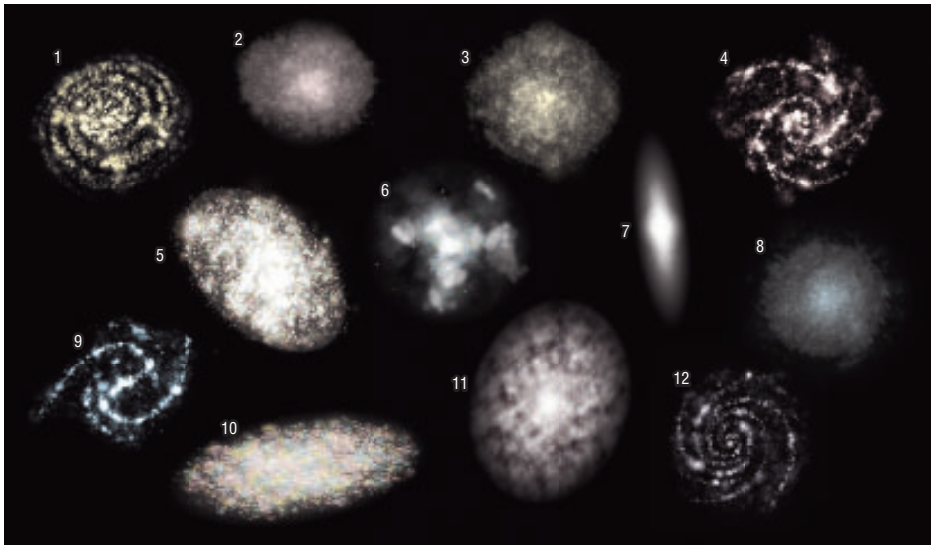

Figure 8

DID YOU **KNOW?**

Orbiting the Milky Way

Our Sun takes about 200 million years to complete one orbit around the centre of the Milky Way galaxy. Dinosaurs roamed Earth the last time we were in the same position as we are today.

The Milky Way Galaxy

Our understanding of the Milky Way comes from many years of research by astronomers. We now know that the Milky Way consists of more than 200 billion stars and is more than 100 000 ly across. In 1935, Canadian astronomer John S. Plaskett conducted the first detailed study of the structure of the Milky Way using the Dominion Astrophysical Observatory in British Columbia. He discovered that the Sun lies about 30 000 ly from the centre of the galaxy.

You can see parts of our galaxy if you look in the moonless night sky away from the city lights during the winter or summer. It looks like a hazy band of light that arches in the dark sky (Figure 9). Legends and stories of various cultures describe the Milky Way as the road to a heavenly palace, a pool of cow's milk, and a giant spine that keeps the stars in place in the sky above.

Figure 9 Seen from Earth, the Milky Way Galaxy appears as an arch of light in the night sky.

DID YOU **KNOW?**

The Spitzer Telescope

Launched in 2003 by the United States, this 900 kg satellite is the largest infrared observatory ever put into space. The Spitzer telescope can detect young stars not visible to optical telescopes because they are hidden behind giant dust clouds.

Astronomers originally believed that the Milky Way had four spiral arms. However, in 2005, astronomers using infrared images from the Spitzer Space Telescope discovered that the Milky Way has just two spiral arms. The Spitzer Space Telescope observes the Universe in the infrared part of the spectrum, which cannot be seen from the ground because it is blocked by Earth's atmosphere. (You will see an infrared image of the Milky Way taken by the Spitzer Space Telescope in Section 10.1.)

The Milky Way consists of stars of all ages. The central bulge is a huge collection of older stars (Figure 10(a) on the next page). The disc of much newer stars spins around the bulge. Young and middle-aged stars, along with clumps of gas and dust, form the bulk of what makes up the spiral arms of the disc. Our solar system is located on the inner edge of one of the spiral arms, about 26 000 ly from the central core of the galaxy (Figure 10(b) on the next page).

At the centre of the Milky Way, a supermassive black hole exists. Astronomers know the black hole is there because they see the effects of its gravitational pull on the movement of stars close to it in the Milky Way.

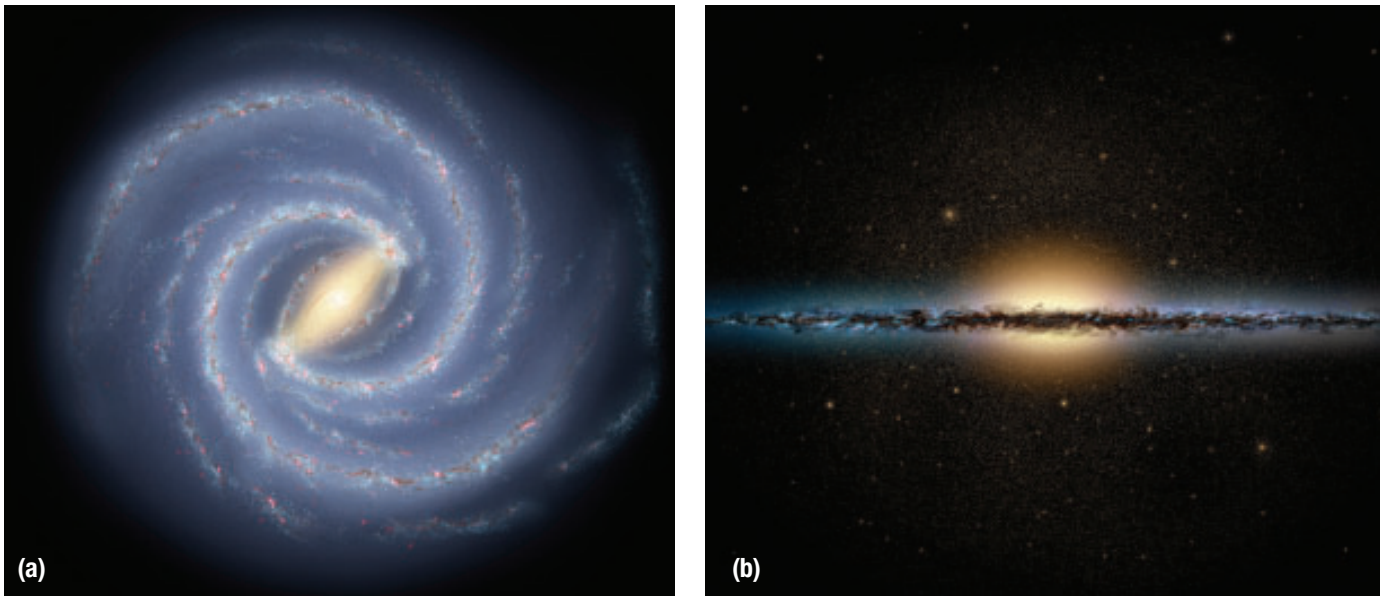

Figure 10 (a) A computer-generated top view of the Milky Way galaxy. (b) This computer-generated image shows that stars in the central bulge of the Milky Way galaxy appear close together because they are so numerous. They are actually very far apart.

Quasars—Powerhouses of Energy

Of all the celestial objects known, **quasars** are considered the most powerful energy producers of all. Their name comes from "**quas**i-stell**ar**" because quasars looked like stars when they were first observed through optical telescopes. In fact, quasars are galaxies with a central region that is more luminous than normal. The large amount of energy emitted by a quasar is in large part caused by a supermassive black hole at its centre. Astronomers observe that matter pulled into these giant black holes by their strong gravity fields is converted into powerful energy waves that are released back out into space (Figure 11). Quasars emit 100 to 1000 times more energy than the entire Milky Way.

quasar a distant, young galaxy that emits large amounts of energy produced by a supermassive black hole at its centre

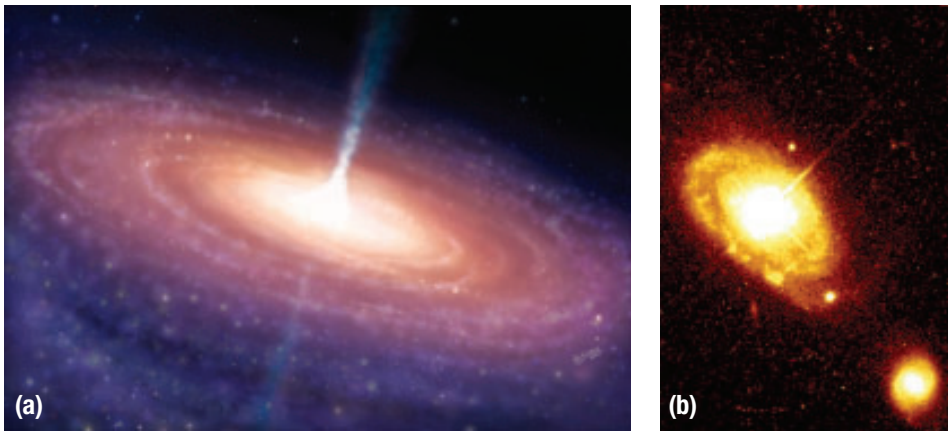

Figure 11 (a) Astronomers think quasars are powered by massive black holes that eject their energy into space from jets located at their top and bottom. (b) A real telescope image of a quasar.

To learn more about quasars,
GO TO NELSON SCIENCE

Astronomers have discovered more than 200 000 quasars. They are all between 2 and 12 billion ly away, so observing them is like looking back in time billions of years. Quasars are thought to be primitive galaxies that formed early in the existence of the Universe.

Galaxy Clusters

The Milky Way is part of a group of more than 35 galaxies called the Local Group (Figure 12). This collection of galaxies is about 10 million ly across. Our largest and nearest galactic neighbour is the Andromeda galaxy—a slightly larger version of the Milky Way. The Andromeda galaxy is a spiral galaxy that contains at least 300 billion stars. Lying about 2.6 million ly away, it is the farthest object the unaided human eye can see. It is amazing to think that the light we see from this galaxy travels for 2.6 million ly before reaching Earth. To put this into perspective, this means that the light we see today left the Andromeda galaxy when our early ancestors were just beginning to use stone tools. Since then, we have refined our tools and developed telescopes powerful enough to view this distant galaxy!

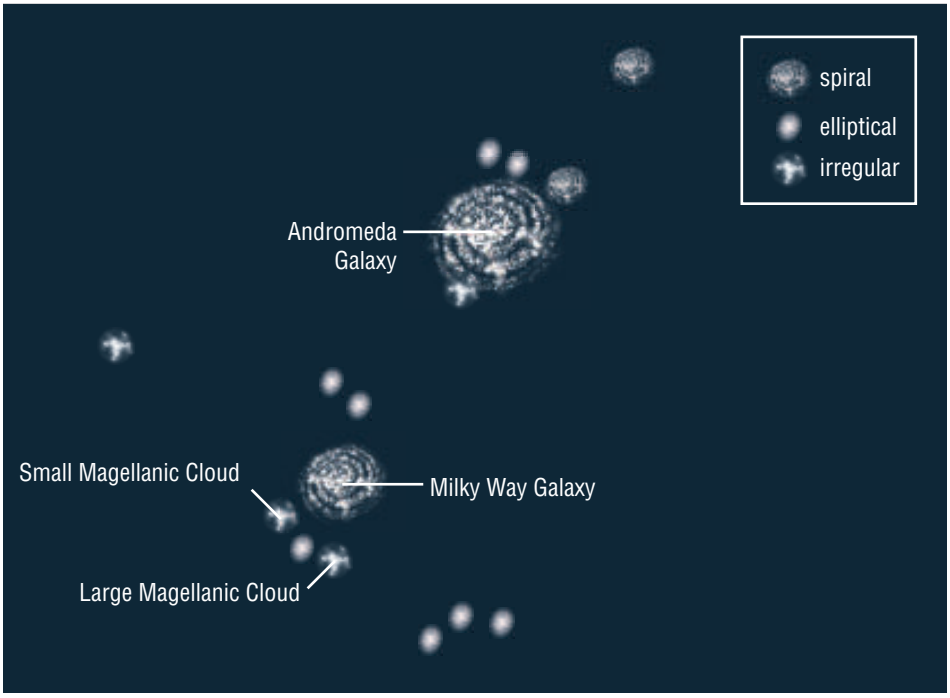

Figure 12 The Local Group, made up of many small irregular and elliptical galaxies, is dominated by two large spiral galaxies—the Milky Way and Andromeda.

Using supercomputer models of galaxy movements, astronomers at the University of Toronto believe that our Milky Way and the Andromeda galaxy are on a collision course with each other. However, this event will not happen for 5 billion years.

Our Local Group belongs to a much larger collection of galaxies called the Virgo Supercluster (Figure 13 on the next page), which is just one of millions of superclusters of galaxies in the Universe.

Figure 13 The Virgo Supercluster is a collection of thousands of galaxies loosely bound together by gravity. It includes our own Local Group. The Virgo Supercluster is just one of millions of superclusters scattered across the Universe.

UNIT TASK Bookmark

How can you apply what you have learned about types of galaxies to the Unit Task described on page 446?

IN SUMMARY

- Stars occur in star clusters and galaxies.
- The Milky Way galaxy contains our solar system and billions of other stars.
- Galaxies can be classified based on their shape as elliptical, spiral, lenticular, or irregular.
- Quasars are extremely high energy galaxies.
- Galaxies occur in clusters and superclusters.
- The Milky Way is part of a galaxy cluster known as the Local Group. The Local Group is part of the Virgo Supercluster.

CHECK YOUR LEARNING

1. Compare and contrast open star clusters and globular star clusters. K/U
2. Create a top view drawing of the Milky Way galaxy. Use the values given in this section for the diameter of the Milky Way and the distance of the Sun from the centre. Label the location of the Sun, old stars, young stars, and supermassive black hole. T/I C
3. What is astronomer Edwin Hubble's contribution to the understanding of galaxies? K/U
4. Astronomers know that the Sun is approximately 30 000 ly from the centre of the Milky Way and that the Milky Way has two spiral arms. K/U
   (a) When were these discoveries made?
   (b) In each case, what technology was used that allowed the discoveries to take place?
5. Create sketches of the following types of galaxies: spiral, barred spiral, elliptical, lenticular, irregular. Be sure to label them. K/U C
6. Where does the term "quasar" come from? Is this an accurate name for these objects? K/U
7. Compare and contrast a quasar with our Milky Way galaxy. T/I
8. What is the name of the galaxy cluster that the Milky Way is part of, and how many galaxies make up this cluster? K/U
9. What is the name of the galaxy supercluster that the Milky Way is part of, and how many galaxies make up this supercluster? K/U