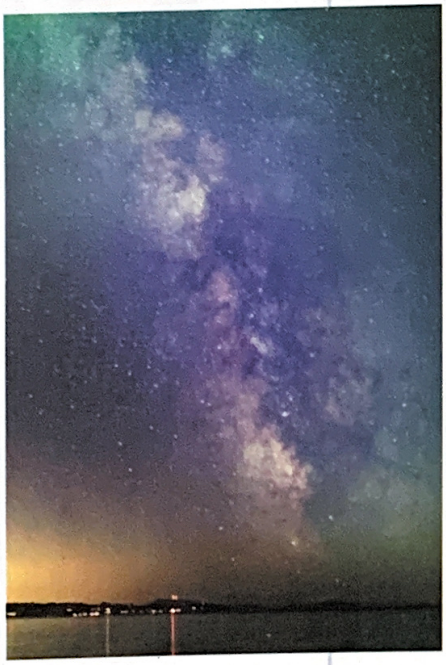
CONCEPT 2

We know that our Milky Way galaxy is just one of many billions of galaxies in the universe.

galaxy a collection of many billions of stars, plus gas and dust, held together by gravity

If you have viewed the night sky in a dark place, far from intruding urban lights, you have likely seen the Milky Way. Brightest in the summer, it appears as a hazy white band extending from the southern horizon and across the sky overhead (**Figure 4.20**). In fact, the band is a vast accumulation of about 400 billion stars that completely encircles Earth. The Milky Way is a **galaxy**—a collection of stars, gas, and dust held together by gravity. (The gas of a galaxy is made up mainly of hydrogen atoms. The dust is not like dust on Earth. Instead, space dust is made up of carbon and silicate particles about 100 nm in size.)



The Discovery of Galaxies

In 1610, using his telescope, Galileo became the first person to realize that the fuzzy Milky Way band was actually a collection of individual stars. It took another 170 years before further understanding of these stars developed. At that time, a British astronomer, William Herschel, was exploring the heavens. He and his sister, Caroline, were famous for building and selling fine telescopes. Together, using their inventions, they discovered that the Milky Way is a gigantic system of stars—what we now call a galaxy. Every star that you see in the sky on a clear night is part of the Milky Way galaxy.

Figure 4.20 In a dark sky, on a clear night, the Milky Way galaxy looks like a band of white in the night sky. The ancient Romans called it the *Via Lactea*, which means "way (or road) of milk." The term "galaxy" also comes from an ancient word (Greek, this time), *galactos*, meaning milk.

Activity

Model Galaxy Motion

Add about 250 mL of water to a 500 mL beaker. Hold it carefully, and swirl it slowly to give the water a circular motion. Put the beaker down, with water still swirling, and add a few drops of food colouring to the centre. Sketch your observations.

Repeat this process with water swirling faster and slower, and with a pinch of light, dry material such as dried oregano or cumin. Compare how the different materials behave in the swirling water. How is this model similar to real galaxy motion? What are the limitations of this model?

The Shapes of Galaxies

A galaxy forms when gravity causes a large, slowly spinning cloud of gas, dust, and stars to contract (draw together). The Sun is one of an estimated 400 billion stars in the Milky Way. All the stars in the universe belong to one of the billions of galaxies that exist.

Galaxies come in different shapes and sizes. Generally, they are classified as either elliptical or spiral, according to their appearance. Galaxies that do not fit into these general classifications are called irregular galaxies.

Elliptical galaxies vary in shape from spherical to a flattened oval (**Figure 4.21A**). They are older galaxies with very few young stars. Ellipticals account for 15% to 20% of all galaxies we can see.

Spiral galaxies look like pinwheels—flattened disks with a central bulge and two to four spiral arms (**Figure 4.21B**). Their central core is made of up old stars. The spiral arms contain clouds of gas and dust along with new and young stars. Our Milky Way is a spiral galaxy. A subclass of spirals are barred spiral galaxies (**Figure 4.21C**). They are similar to spiral galaxies, but they have a central bar pattern across the middle, with spiral arms trailing from the ends of these bars.

Irregular galaxies have no definite shape (**Figure 4.21D**). They contain more gas and dust than their spiral cousins. They have no spiral arms or central core, and they make up at least 10% of all galaxies.

Figure 4.21 Main types of galaxies—an elliptical A, spiral B, barred spiral C, and irregular D.

Understanding the Milky Way

It has taken astronomers many years to learn about the Milky Way galaxy. William Herschel started putting together the pieces of the puzzle. By counting stars, Herschel figured out the approximate shape of the Milky Way galaxy. Herschel proposed that the Milky Way is a huge disk of billions of stars, flattened like a dinner plate, in which the Sun is embedded. He also proposed that the Sun might be at the centre of the Milky Way.

Star Clusters

In the early 20th century, American astronomer Harlow Shapley helped to put together more pieces of the puzzle. While studying the Milky Way, he was also studying **star clusters**. A star cluster is a collection of stars held together by its own gravity. Like individual stars, star clusters are held inside or around galaxies by gravity. **Figure 4.22** shows the two types: open clusters and globular clusters. Open clusters have 50 to 1000 stars and appear along the disk of the Milky Way. Globular clusters have a spherical shape with 100 000 to 1 000 000 stars.

Shapley became interested in globular clusters in particular. He reasoned that globular clusters should be evenly distributed around the galaxy. He noticed, however, that they appear only in the direction of the constellations Hercules, Scorpius, Ophiuchus, and Sagittarius—not all around us. Shapley reasoned that his observations could only be explained if he were observing the globular clusters from a position well away from them. He concluded that if globular clusters were spread out around the Milky Way's centre, the Sun must be nowhere near the centre.

star cluster a collection of stars held together by gravity

The Diameter of the Milky Way

Radio waves can travel through the clouds of Earth's atmosphere. They also can travel through the gas and dust between stars. By mapping the galaxy with radio waves, astronomers have been able to determine that its shape is disk-like and that its diameter is about 100 000 light-years across. (A light-year is the distance that light travels in one year: 9.5×10^{12} km. You will learn more about light-years and distances within and between galaxies in the next Concept.)

Figure 4.22 The Pleiades open cluster A is found in the constellation Taurus. Globular clusters B contain many more stars than open clusters do.

The Centre of the Milky Way Galaxy

Using radio waves as well as infrared radiation, astronomers next confirmed that the centre of the Milky Way galaxy is surrounded by a bulge of stars. Around the bulge, there is a sphere of globular clusters, as shown in **Figure 4.23**. When Shapley was observing globular clusters, he was looking toward the centre of the Milky Way galaxy and the halo of globular clusters that surround the galaxy from a position in the disk well away from the centre.

Figure 4.23 Globular clusters form a sphere around the centre of the Milky Way.

Some other Characteristics of the Milky Way Galaxy

Knowing that the Milky Way galaxy has a disk-like shape, with a central bulge of stars, astronomers have concluded that it is a spiral galaxy.

Using data from the European Space Agency's (ESA's) Gaia space telescope, which is creating a 3D map of our galaxy, astronomers from the University of Toronto have calculated our Sun's distance from the galactic centre to be 24 788 to 26 745 light years. With telescopes that use different parts of the electromagnetic spectrum, astronomers can also image various regions of the Milky Way (**Figure 4.24**).

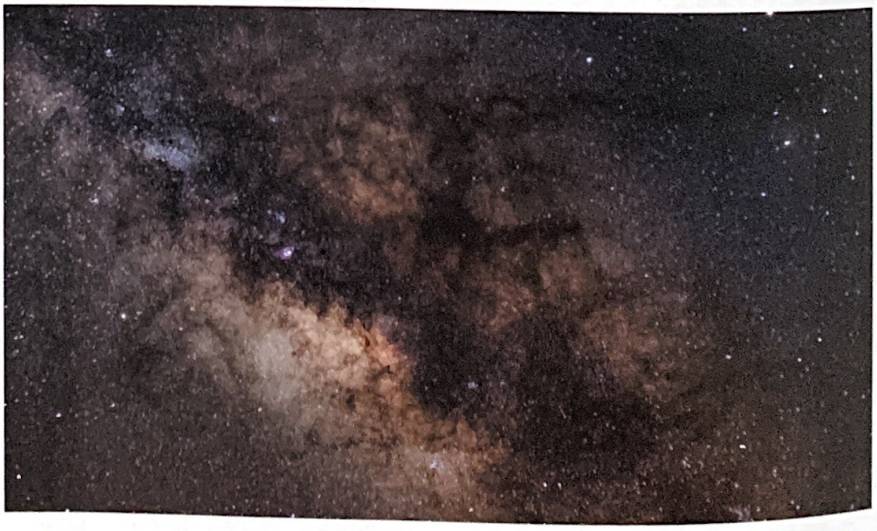


Figure 4.24 The dark, reddish-brown areas across the centre of this image of the Milky Way galaxy are called lanes. This darkened zone is caused by enormous clouds of gas and dust that are blocking the light from the background stars in the galaxy. Using other electromagnetic frequencies enables astronomers to "see through" the lanes.

Galaxy Groups and Clusters

The Milky Way belongs to a group of about 50 galaxies called the Local Group. Some are shown in **Figure 4.25**. The diameter of the Local Group is about 10 million light-years. Our nearest comparable-size galactic neighbour is the spiral-shaped Andromeda galaxy. It lies about 2.6 million light-years away and is the farthest object in the sky that we can see with the unaided eye. The earliest recorded observation of the Andromeda galaxy was made by Persian-Islamic astronomer Abd al-Rahman al-Sufi. He described it as a fuzzy cloud in his famous *Book of Fixed Stars* in the year 964. Our galaxy is estimated to collide with the Andromeda galaxy in about 4 billion years.

Our Local Group belongs to a much larger collection of galaxies called the Virgo Supercluster. And this is just one of millions of superclusters in the universe!

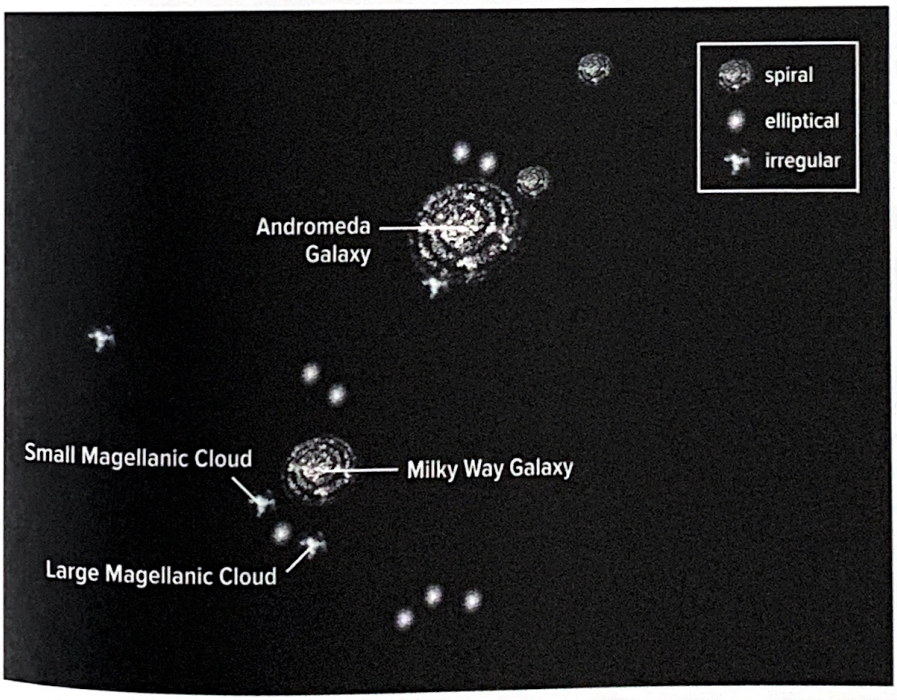


Figure 4.25 The Local Group, made up of many small irregular and elliptical galaxies, is dominated by two large spiral galaxies: our Milky Way and Andromeda.

Before you leave this page . . .

1. Compare the three basic shapes and sizes of galaxies.
2. How did we infer our position within the Milky Way galaxy?
3. How did we infer that the Milky Way is a spiral galaxy?
4. What is the Local Group?