GALAXIES AND THE UNIVERSE | LESSON 7

Our Galaxy

The shape, size and history of the Milky Way, and how we mapped a galaxy we can never leave.

Grades 6-12 | About 15 minutes of narrated flight, plus discussion stops | 9 stops | Start: learn.allseeing.space/our-galaxy

What students will see and do

Students start at the Sun and follow its 230-million-year orbit, visit star clusters and the spiral arms, pull back to see the whole disk, dive to the black hole at the center, meet neighbor galaxies, and finish with how to see the Milky Way themselves.

Learning objectives

- Describe the shape and size of the Milky Way and the Sun's place in it
- Explain how astronomers mapped the galaxy from inside it
- Describe evidence for dark matter from the way stars orbit
- Explain how the Milky Way grew by merging with smaller galaxies

NGSS connections

MS-ESS1-2	Gravity holds the galaxy together and governs the Sun's orbit around the center.
MS-ESS1-3	Scale properties of the galaxy: size, thickness, distances to the center and neighbors.
HS-ESS1-2 (extension)	Galaxies form and grow over billions of years in an evolving universe.
DCI ESS1.A	The Universe and Its Stars.

40-minute class plan

1. 5 min: pre-lesson prompt. Before we fly: have you ever seen the Milky Way? Describe or sketch what you think our galaxy looks like from outside.
2. 18-20 min: run the lesson. Keep discussion stops short (1-2 minutes each) or turn them off in the Lessons menu.
3. 8 min: whole-class discussion using two of the questions below.
4. 5 min: Exit ticket: Where is the Sun in the Milky Way, and how long does it take to go around once?

Full exploration (about 60 minutes)

1. 5 min: pre-lesson prompt, recorded so students can revisit it.
2. 25-30 min: run the lesson with every discussion stop at full length.
3. 15 min: follow-up activity. Galaxy model: draw a spiral galaxy on a paper plate, mark the Sun, the center and the halo.
4. 10 min: revisit the pre-lesson ideas, then the exit ticket.

Before the lesson

Before we fly: have you ever seen the Milky Way? Describe or sketch what you think our galaxy looks like from outside.

Discussion stops: timing and key points

At The spiral arms (4-6 min): We live inside the Milky Way and cannot take a picture of it from outside. What kinds of clues could astronomers use to map its shape?

- Map where star clusters, gas clouds and young stars are.
- Use radio and infrared light that pass through dust.
- Measure how stars move (Gaia) and compare with other spiral galaxies.

At Neighbor galaxies (3-5 min): The Milky Way grew by swallowing smaller galaxies. What evidence could tell astronomers that a group of stars came from another galaxy?

- Stars from another galaxy may move in unusual orbits.
- They may have a different chemical makeup or age.
- They may line up in long streams across the sky.

More questions for after the lesson

1. Why does the Milky Way look like a band across the sky?
2. How did Harlow Shapley find the galaxy's center?
3. Why is light pollution a problem for astronomers and for everyone else?

Vocabulary

galaxy, spiral arm, disk, halo, globular cluster, galactic year, dark matter, dwarf galaxy

Exit ticket

Exit ticket: Where is the Sun in the Milky Way, and how long does it take to go around once?

Follow-up activities

- Galaxy model: draw a spiral galaxy on a paper plate, mark the Sun, the center and the halo.
- Light pollution survey: count visible stars inside a paper tube at home and compare results across the class.
- Galactic year timeline: mark where Earth's history fits in one galactic year.

Full transcript

Introduction

Welcome to Our Galaxy. On a dark night, far from city lights, a pale glowing band stretches across the sky. People in many cultures saw it as a river, a road, or a trail of spilled milk. It is our galaxy, the Milky Way, seen from the inside.

Here is our question. We live inside the Milky Way and can never fly outside it to take a picture. So how did astronomers figure out its shape, its size, and where we are?

1. Our place: the Sun

We start with our own star, the Sun. It is one of a few hundred billion stars in the Milky Way, an ordinary, middle-aged yellow star. Nothing about it is special, except that it happens to be ours.

The Sun is not sitting still. It is orbiting the center of the galaxy at roughly two hundred and thirty kilometers every second, carrying Earth and all the planets with it. Even at that speed, one trip around the galaxy takes about two hundred and thirty million years. Astronomers call that a galactic year.

One galactic year ago, the first dinosaurs were just appearing on Earth. Since the Sun formed, it has circled the galaxy only about twenty times.

As it orbits, the Sun also bobs gently up and down through the disk of the galaxy, like a horse on a carousel, completing one up and down cycle every several tens of millions of years.

2. Star clusters

Stars are born in groups. This is the Pleiades, an open cluster of young stars that formed together about one hundred million years ago. Open clusters like this live in the flat disk of the galaxy, and over time their stars slowly drift apart.

The galaxy also holds a very different kind of cluster. Globular clusters are tight balls of hundreds of thousands of very old stars. About one hundred and fifty of them swarm around the Milky Way in a huge, round region called the halo, far above and below the disk.

In nineteen eighteen, the astronomer Harlow Shapley mapped where the globular clusters are. He noticed they are not centered on the Sun. They are centered on a point far away, in the direction of the constellation Sagittarius. He realized that point must be the true center of the galaxy, and that the Sun lives far out in the disk.

3. The spiral arms

This is the Orion Nebula, a glowing cloud where new stars are being born. Clouds like this trace the spiral arms of the galaxy. The Sun lives in a smaller arm called the Orion Arm, or Orion Spur, between two larger arms.

Spiral arms are not solid structures. They are more like traffic jams. Stars and gas move in and out of them as they orbit, but they crowd together in the arms, where gas is squeezed and new stars form. That is why the arms glow with bright, young, blue stars.

Mapping the arms from inside is hard, because dust blocks our view. Astronomers use radio telescopes, which can see the glow of hydrogen gas through the dust, and the Gaia spacecraft, which has measured the positions and motions of more than a billion stars. Together they show that the Milky Way is a barred spiral, with a long bar of stars across its center.

Discussion stop: We live inside the Milky Way and cannot take a picture of it from outside. What kinds of clues could astronomers use to map its shape?

4. The shape of the galaxy

Now we pull back to see the whole galaxy. It is a flat, spinning disk about one hundred thousand light-years across, but only about a thousand light-years thick in most places. If the Milky Way were the size of a dinner plate, the disk would be only about as thick as two stacked coins.

The Sun is about twenty six thousand light-years from the center, a little more than halfway out. When you look at the Milky Way band in the night sky, you are looking along the disk, through billions of stars. When you look away from the band, you are looking out of the disk, into emptier space.

Most of the galaxy's mass is invisible. Stars in the outer disk orbit much faster than the visible matter alone could explain. Something unseen must be adding gravity. Astronomers call it dark matter, and there

seems to be several times more of it than all the stars and gas combined.

The Milky Way is very old. Some of its stars formed more than thirteen billion years ago, not long after the universe began. The galaxy has been growing ever since, collecting gas and merging with smaller galaxies.

5. The heart of the galaxy

We fly now to the center. Thick dust hides it from ordinary telescopes, but infrared light and radio waves pass through. At the very heart is Sagittarius A star, a supermassive black hole about four million times the mass of the Sun.

Around it is a crowded region where stars are packed far more tightly than near the Sun. If you lived there, the night sky would blaze with thousands of stars brighter than any you have ever seen.

In twenty twenty two, the Event Horizon Telescope released the first image of this black hole: a glowing ring of hot gas around a dark shadow.

Scientists first proved the black hole was there by watching stars race around it. One star, called S2, completes an orbit every sixteen years. Tracking those stars for decades earned Reinhard Genzel and Andrea Ghez the Nobel Prize in Physics in twenty twenty.

6. Neighbor galaxies

The Milky Way has companions. This is the Large Magellanic Cloud, a small galaxy about one hundred and sixty thousand light-years away, visible to the naked eye from the southern hemisphere. Nearby is its partner, the Small Magellanic Cloud.

In nineteen eighty seven, a star in the Large Magellanic Cloud exploded as a supernova bright enough to see without a telescope, the closest observed supernova in nearly four hundred years.

These galaxies are being tugged by the Milky Way's gravity, and streams of gas have been pulled out of them. Some studies suggest the Large Magellanic Cloud may eventually merge with the Milky Way, billions of years from now.

This has happened before. Gaia found groups of stars moving in strange orbits, the leftovers of smaller galaxies the Milky Way swallowed long ago. Our galaxy is still eating one right now, a small galaxy called the Sagittarius Dwarf, which is being stretched into long streams of stars around us.

Discussion stop: The Milky Way grew by swallowing smaller galaxies. What evidence could tell astronomers that a group of stars came from another galaxy?

7. The galaxy's family

Pull back once more. The Milky Way, Andromeda, the Triangulum Galaxy, and dozens of smaller galaxies form a group called the Local Group, about ten million light-years across. The Milky Way and Andromeda are the two biggest members, and most of the others are small dwarf galaxies orbiting one or the other.

New members are still being found. Some dwarf galaxies are so faint that they contain only a few thousand stars, and they were discovered only recently by careful surveys of the sky.

8. Seeing ourselves from outside

Finally, we visit the Andromeda Galaxy, two and a half million light-years away. It is a large spiral like ours, and looking at it helps us imagine what the Milky Way would look like from outside.

About a hundred years ago, many astronomers believed the Milky Way was the whole universe. Then Henrietta Leavitt discovered that certain pulsing stars, called Cepheids, could be used to measure distances. In nineteen twenty three, Edwin Hubble found Cepheids in Andromeda and proved it was far

outside our galaxy. Suddenly the Milky Way was just one galaxy among many.

Today astronomers estimate there are hundreds of billions of galaxies in the observable universe. The Milky Way is our home, but it is one island in a vast ocean of galaxies.

Andromeda and the Milky Way are moving toward each other. For years, astronomers predicted a collision in about four to five billion years. Newer measurements suggest a merger is less certain, and might happen much later, if at all. Even if the galaxies do merge, stars are so far apart that they would almost never collide.

9. Seeing the Milky Way yourself

Let us come home. Here is the sad part of this story. Most people alive today have never seen the Milky Way with their own eyes. Light from cities, streetlights, and buildings brightens the night sky and washes it out. In North America, about eight out of every ten people cannot see the Milky Way from where they live.

But you can still find it. On a clear, moonless night, travel away from city lights, let your eyes adjust to the dark for twenty minutes, and look up. In summer, the brightest part of the Milky Way lies toward the constellation Sagittarius, the direction of the galaxy's center.

Dark skies are a natural resource worth protecting. Some towns and parks now use shielded lights that point down, so people can still see the stars.

Wrap-up

So how did we learn the shape of a galaxy we can never leave? By mapping where clusters and gas clouds are, by watching how stars move, by using radio and infrared light to see through dust, and by comparing ourselves with galaxies like Andromeda.

Next time you see the Milky Way's glow, remember: you are looking along the disk of your own galaxy, from the inside. Press L to choose another lesson.

Positions are computed live from real orbits. Narration is checked against public scientific sources; full credits at learn.allseeing.space/credits.html. Standards are listed as connections to NGSS, not formal alignments. Report an issue: info@allseeing.space