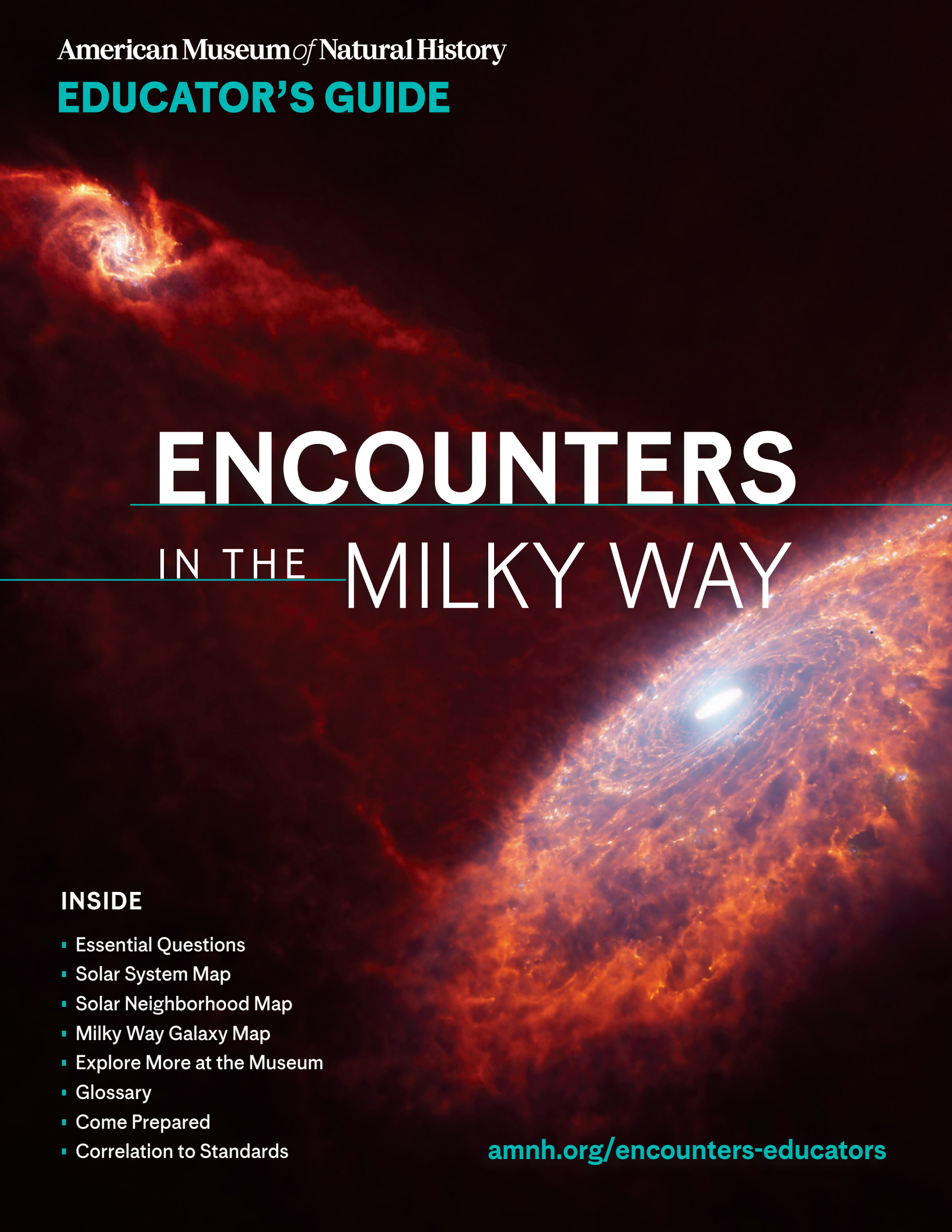
American Museum *of* Natural History

EDUCATOR'S GUIDE



ENCOUNTERS IN THE MILKY WAY

INSIDE

amnh.org/encounters-educators

Essential Questions

1. What is moving in the night sky?

When you look up on a clear night, you might see all kinds of objects: the Moon, airplanes, satellites, planets, and stars. Some of these will appear to be moving; some will appear stationary, but they're not. Ever since the Big Bang—the explosive dynamic event that occurred when the universe began—everything in the cosmos has been constantly in motion. Stars orbit the center of our Milky Way Galaxy, some fast, some slow, each following its own path. Our own star, the Sun, completes an orbit of the **galaxy** every 230 million years, making it 20 **galactic years** old. Clouds of gas and dust surround the stars, moving with them. Scientists think that like our Sun, most stars have systems of planets and other material orbiting around them. Every single one of those objects, from galaxies, stars, and planets down to gas and dust, is moving.

2. What happens when objects in space get close to each other?

When cosmic objects like comets, stars, and galaxies come close together, they interact through the force of **gravity**, getting pulled, nudged, swung, and pushed around, changing their courses. The strength of their gravitational interaction depends on their masses and distance apart. The more massive the objects and the closer they are, the stronger the gravitational interaction. Sometimes two objects will brush past each other in an encounter, exchanging material or merely altering each other's paths. Other times they will merge gradually or collide violently.

Scientists are observing cosmic encounters at many scales of both space and time.

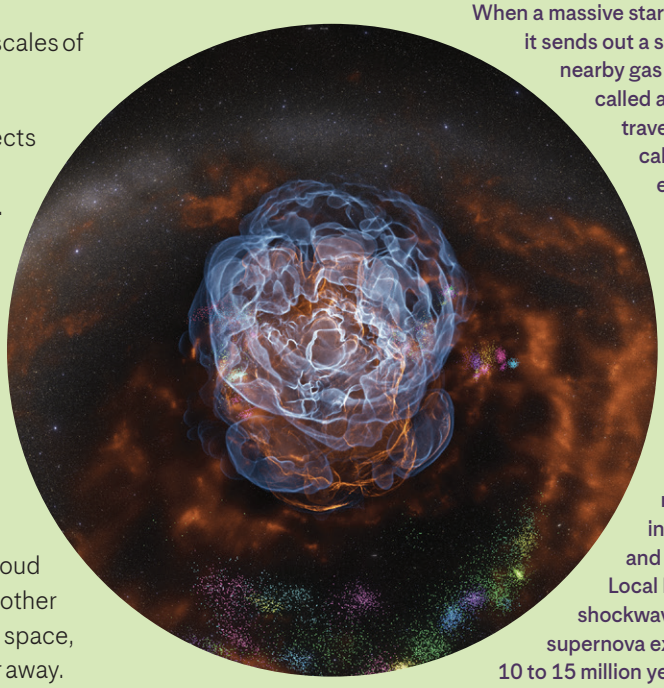
In our Solar System: Scientists are investigating objects that have wandered into our Solar System, such as **comets** and **asteroids** flung out of other star systems. Such interstellar interlopers might even carry the building blocks of life!

In our stellar neighborhood: In about a million years, another star system will come near enough to interact with ours. The two star systems will not collide, but we will pass each other so closely that our Sun and the other star will attract material from each other's **Oort cloud**—the vast outer region of a star system, made up of icy material left over from the birth of the star. Some objects dislodged from each Oort cloud during this stellar flyby will be captured and stay in the other star system, and some will be flung out into interstellar space, perhaps going on to encounters in star systems far, far away.

In our galaxy: Over the past 5 to 6 billion years, the Milky Way Galaxy has been interacting with another galaxy, the **Sagittarius Dwarf Galaxy**, absorbing it as the smaller galaxy circles and intersects the Milky Way Galaxy again and again. Scientists expect the encounter to continue for several billion years longer. Despite its small size, the Sagittarius Dwarf Galaxy has enough gravitational force to compress gas and dust in the Milky Way Galaxy each time the galaxies intersect, driving up star formation. More **supernovas** form, creating **bubbles** when they explode. Could the Sun have formed during a gravitational punch from the Sagittarius Dwarf Galaxy? Astrophysicists aren't sure, but they think it's possible.

3. How do scientists investigate the movement of objects in space?

The galaxy is full of objects that are very far away and events that unfold over billions of years, which makes them difficult for us to observe with the naked eye. To study them, scientists use powerful instruments on Earth and in space. For a dozen years, the Gaia Space Telescope recorded the exact location of nearly 2 billion of the 200 to 300 billion stars in the Milky Way Galaxy and measured the direction and speed at which they're traveling. The James Webb Space Telescope collects light from distant galaxies with a giant mirror. Scientists use the data from these missions to build maps and computer models that help us understand cosmic encounters throughout our galaxy and across the universe.



When a massive star explodes as a supernova, it sends out a shockwave that clears out nearby gas and dust, forming a cavity called a bubble. Our Sun has been traveling through what scientists call the **Local Bubble** (outer edges shown in bluish-white, surrounded by gas and dust shown in orange and clusters of young stars shown as colored dots) for the past 5 million years and will continue to do so for another 4 million years. That's been great for astronomy, allowing scientists to see much farther than we would in a stellar region full of gas and dust. Scientists think the Local Bubble was formed by shockwaves from a series of supernova explosions starting 10 to 15 million years ago.

Solar System Map

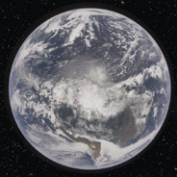
The Hayden Planetarium space show takes visitors on a journey through our Solar System and beyond. Check out the sights you and your students will encounter.

Sun

Our star is the center of our Solar System and holds it together. Scientists think the Sun was part of a star cluster when it was born 4.5 billion years ago. If so, encounters with other stars must have knocked it on a separate path from its stellar siblings, because the Sun is now traveling alone.

Earth

We call this planet home. It's one of eight: the four terrestrial planets, Mercury, Venus, Earth, and Mars; the gas giants, Jupiter and Saturn; and the ice giants, Uranus and Neptune. The lines represent their orbits around the Sun. Earth has completed about 4.5 billion orbits, which we call years.

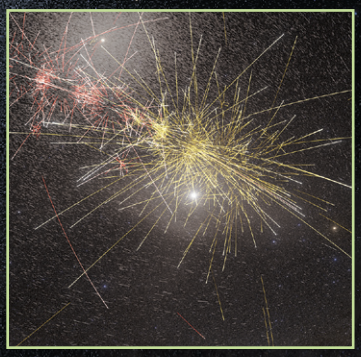


Kuiper Belt

This region of comets and asteroids is home to the dwarf planet Pluto. It takes Pluto approximately 248 Earth years to complete one orbit around the Sun.

Asteroid Belt

This ring of rocky and metallic objects lies between the orbits of Mars and Jupiter. When the objects collide, debris can form meteoroids that sometimes enter Earth's atmosphere. Of the 50,000 meteorites found on Earth, 99.8% may have originated in the Asteroid Belt.



Coming in a Million Years!

A star called Gliese 710 will pass through our Oort Cloud and the two will trade icy comets (shown here as yellow and red trails).

Interstellar Interlopers

In 2017, astronomers spotted Oumuamua, a 400-meter-long asteroid-like object (left). In 2018, they noticed Comet 21/Borisov (right), an unusually fast comet. The speed and angles of entry of these two objects meant they must have come from other star systems.

EXPLORE MORE AT THE MUSEUM

Dorothy and Lewis B. Cullman Hall of the Universe

Lower Level

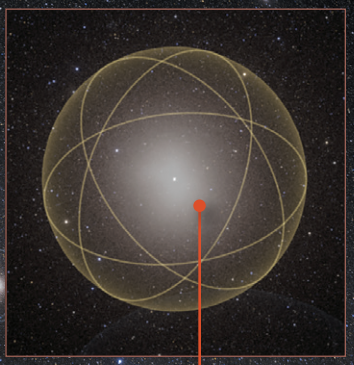
Gravity keeps everything in motion. Students can visit the four zones of the Cullman Hall of the Universe (Universe Zone, Galaxy Zone, Stars Zone, and Planets Zone) to investigate how gravity influences the formation and interaction of cosmic objects. They can also visit the big screen and the kiosks to investigate space missions that explore our Solar System and beyond.

Solar Neighborhood Map

Our solar neighborhood is a diverse collection of star systems lying within a 25 light-year radius of our Sun. Check out what you and your students will encounter here.

Our Oort Cloud

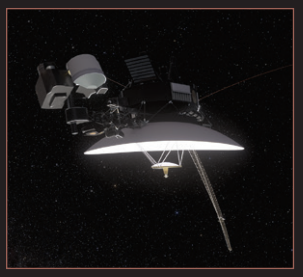
Our Oort Cloud is the vast outer region of our Solar System that is made up of icy material left over from the birth of the Sun. It extends one-and-a-half light years in every direction, meaning light from our Sun takes a year and a half to reach the edge of the Solar System. The yellow sphere indicates its reach. The small white dot in the middle represents our Sun and the eight planets.



Other Oort Clouds

Each star has its own Oort cloud—the more massive the star, the larger its Oort cloud. When two stars encounter each other, their Oort clouds can intersect and exchange material.

Voyager 2



Launched in 1977 to study the outer Solar System, Voyager 2 has passed the eight planets and the Kuiper Belt and is now traveling through the Oort Cloud on a track to leave the Solar System in about 30,000 years. It carries a copy of the Golden Record, a small metal disk encoded with terrestrial images and greetings in many languages, for any intelligent extraterrestrials who might encounter it.

EXPLORE MORE AT THE MUSEUM

Louis V. Gerstner, Jr. Collections Core

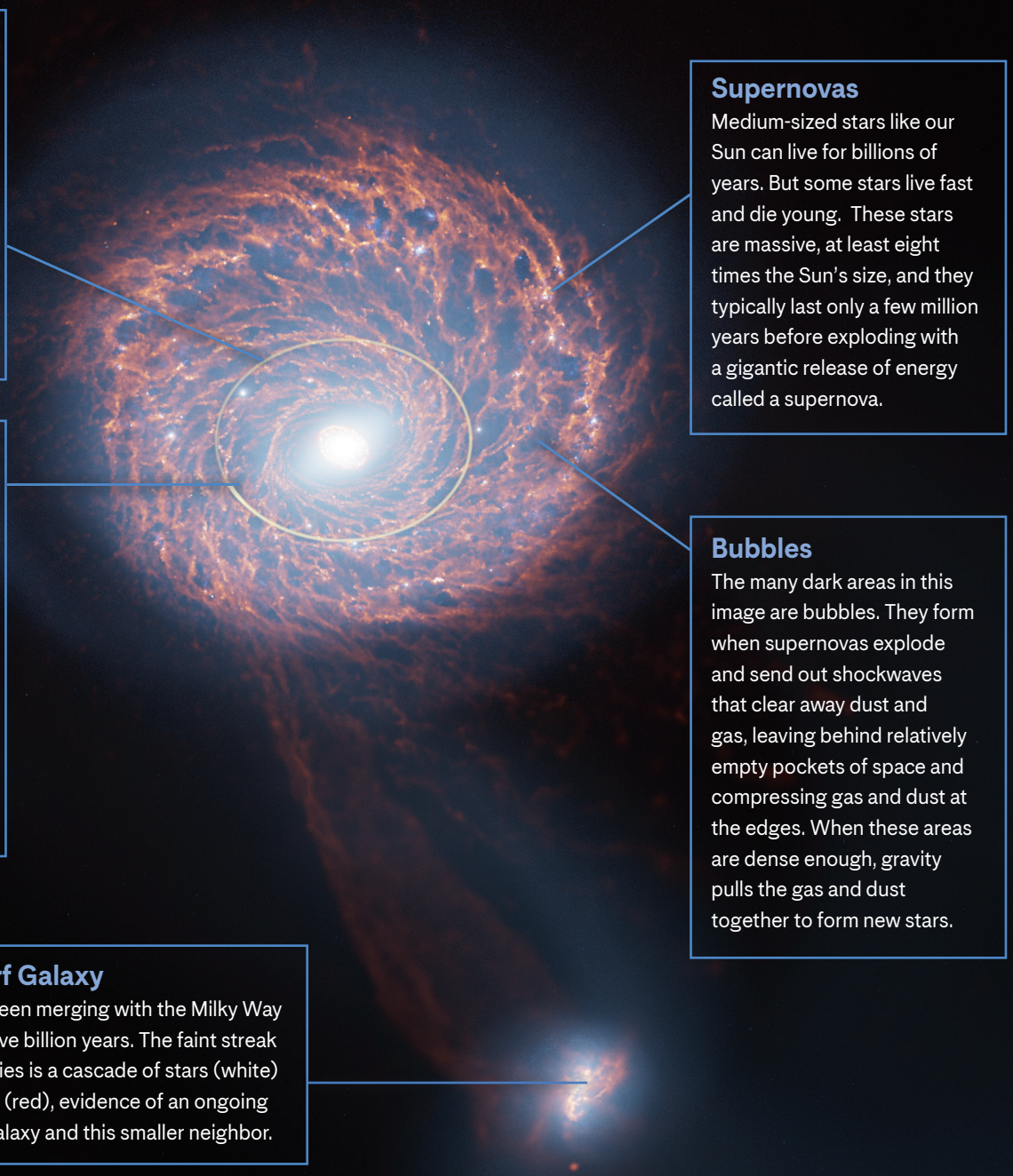
The Macaulay Family Foundation Collections Gallery

2nd floor, Richard Gilder Center for Science, Education, and Innovation

Students can examine an image called The Milky Way Galaxy Star Density Map, generated by the Gaia Space Telescope, one of the instruments featured in the space show. They can use a large touchscreen nearby and select the Gaia Astronomical Data tab to explore discoveries in astronomy arising from Gaia's data. The touchscreen sections include Uncovering Stellar Flybys, Revealing Stellar Nurseries, and Stellar Change Above NYC.

Milky Way Galaxy Map

This scientific visualization of our galaxy from the outside offers a different perspective from our usual Earth-bound view. Check out what you and your students will encounter here.



Orbit of Our Sun

Our Sun is orbiting the Milky Way Galaxy at 500,000 miles per hour, taking our Solar System along with it. It takes about 230 million years for the Sun to complete a circuit, indicated by the yellow ellipse. We've completed 20 orbits, which makes us 20 galactic years old!

Our Local Bubble

This cavity surrounded by gas and dust is called our Local Bubble. It was formed by supernova explosions starting about 10 to 15 million years ago. Our Solar System entered the bubble about five million years ago—around the time our early human ancestors were starting to walk upright—and will exit in about four million years.

Sagittarius Dwarf Galaxy

This small galaxy has been merging with the Milky Way Galaxy for more than five billion years. The faint streak between the two galaxies is a cascade of stars (white) as well as gas and dust (red), evidence of an ongoing merger between our galaxy and this smaller neighbor.

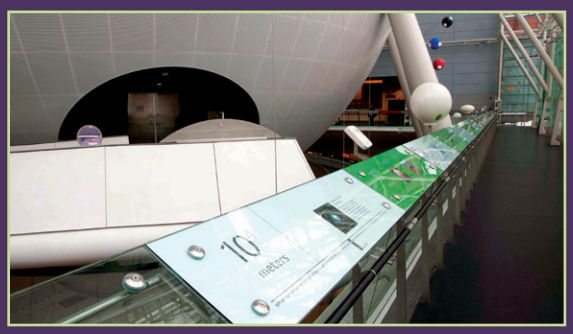
Supernovas

Medium-sized stars like our Sun can live for billions of years. But some stars live fast and die young. These stars are massive, at least eight times the Sun's size, and they typically last only a few million years before exploding with a gigantic release of energy called a supernova.

Bubbles

The many dark areas in this image are bubbles. They form when supernovas explode and send out shockwaves that clear away dust and gas, leaving behind relatively empty pockets of space and compressing gas and dust at the edges. When these areas are dense enough, gravity pulls the gas and dust together to form new stars.

EXPLORE MORE AT THE MUSEUM



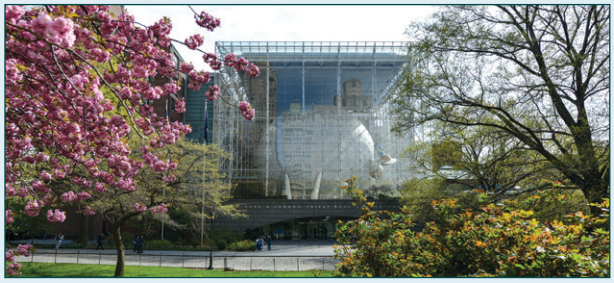
Scales of the Universe

2nd floor, Frederick Phineas and Sandra Priest Rose Center for Earth and Space

The space show features objects of vastly different sizes. Students can investigate concepts of scale by comparing the relative sizes of cosmic objects—from galaxies to atoms—using the central Hayden Sphere as a reference. As students walk along the walkway, they will encounter panels that explore the following concepts: Size Scale Measures (distances); 10^{24} (observable universe and the Virgo Supercluster of galaxies); 10^{16} (Oort Cloud of comets); 10^{13} (Kuiper Belt of comets).

COME PREPARED CHECKLIST

- ☐ **Plan your visit**. For information about reservations, transportation, and lunchrooms, plus videos to help prepare for your trip, visit **amnh.org/field-trips**.
- ☐ **Read the Essential Questions** to see how themes in the space show connect to your curriculum. Identify the key points that you'd like students to learn.
- ☐ **Review the maps** of the Solar System, our solar neighborhood, and the Milky Way Galaxy for an advance look at what your class will encounter in the space show.
- ☐ **Review the Explore More at the Museum** sections for ideas of other places to visit before or after the space show.



CORRELATION TO STANDARDS

A Framework for K-12 Science Education

Disciplinary Core Ideas ▪ ESS1.A: The universe and its stars ▪ ESS1.B: Earth and the solar system ▪ ESS1.C: The history of planet Earth ▪ PS2.A: Forces and motion ▪ PS2.B: Types of interaction ▪ PS4.B: Electromagnetic radiation

Crosscutting Concepts ▪ 1. Patterns ▪ 2. Cause and effect: mechanism and explanation ▪ 3. Scale, proportion, and quantity ▪ 4. Systems and system models ▪ 7. Stability and change

Scientific & Engineering Practices ▪ 2. Developing and using models ▪ 3. Planning and carrying out investigations ▪ 4. Analyzing and interpreting data

GLOSSARY

asteroid: a relatively small rocky or metallic object orbiting the Sun; the **Asteroid Belt** is a region of asteroids orbiting the Sun between the orbits of Mars and Jupiter

bubble: a cavity within vast clouds of gas and dust, formed by shockwaves from an exploding supernova; the **Local Bubble** is the bubble through which the Sun is currently traveling

comet: a relatively small ball of frozen gas, rock, and dust orbiting the Sun

galactic year: the time it takes a star to complete an orbit of a galaxy it is moving within

galaxy: a huge system of objects and materials such as stars, planets, dust, gas, dark matter, and even black holes, all bound together by gravity

gravity: the fundamental force between objects that have mass or energy; the strength of the gravitational interaction between two objects depends on both their masses (or energy) and the distance between them

Kuiper Belt: a region of comets and asteroids that lies beyond the orbit of Neptune and contains the dwarf planet Pluto

Oort cloud: the vast outer region of a star system that is made up of icy material left over from the birth of the star; when two stars encounter each other, their Oort clouds can interact and exchange material; our Solar System's **Oort Cloud** reaches far beyond the Kuiper Belt

Sagittarius Dwarf Galaxy: a small galaxy that has been orbiting and intersecting the Milky Way for billions of years, triggering star-formation events in the Milky Way; eventually our galaxy will absorb it

star system: a group of planets and other objects orbiting a star; our **Solar System** is a star system of eight planets and their moons orbiting our Sun, along with asteroids, comets, dust, gas, and other objects

supernova: an extremely bright, powerful, sudden explosion of a massive star (at least eight times the mass of our Sun) that occurs when the star runs out of fuel and collapses

CREDITS

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