Mission 5
A Model of the Milky Way Galaxy

What Does Our Home Galaxy Look Like?

Notes

In Mission 4, students learned of the enormous distance to the star Sirius. Still, Sirius is the seventh closest star to Earth! Most stars are considerably farther away, and there are about 500 billion stars in our Milky Way Galaxy. There are billions of galaxies even farther away, each one with hundreds of billions of stars.

Overview

In this mission, students realize that the existence of billions of stars means billions of chances that life exists somewhere else in the universe. In Mission 5.1, students see the video image show "Wonders of the Milky Way Galaxy" and then map our immediate cosmic vicinity (out to a few hundred light-years distance) by plotting the locations of some stars, nebulae, and globular clusters. In Mission 5.2, students see the video image show "Galaxies: Billions Upon Billions of Stars" and then make a model of the entire Milky Way Galaxy. They show the size of their vicinity diagram from Mission 5.2 in comparison to the entire galaxy and compute the distance to the center and to the opposite side of the Milky Way Galaxy.

Mission 5.1
Materials

For a Class of 30

- Data projector, computer, PowerPoint file
- "Wonders of the Milky Way Galaxy" segment from the *Project Haystack* PowerPoint file
- "Wonders of the Milky Way Galaxy" script (pages xxxx)
- Overhead projector
- "Celestial Mapping" transparency (page xx)
- Transparency markers or grease pencils

For Each Team

- Butcher paper (roughly 1m by 1m)
- Meter stick with mm markings
- Protractor (360° recommended)

For Each Student

- "Making a Celestial Map" directions (page xx)

- “Celestial Map Data” worksheet (page xx)
- “Celestial Map Questions” worksheet (pages xx)
- Pencil

Getting Ready

1. Copy the “Celestial Map” directions and the two “Celestial Map” worksheets for each student.

2. Set up the data projector.

3. Start the *Project Haystack* PowerPoint file “Wonders of the Milky Way Galaxy.” Have the script handy.

Classroom Action

1. **PowerPoint Presentation.** A PowerPoint script has been provided. It can be used as is to accompany the slide show, or its information can be paraphrased. Introduce students to a few of the spectacular wonders of the Milky Way Galaxy in this segment. They will see open clusters of stars, globular clusters of stars, and nebulae, many of which they will plot on a map, showing their distance from Earth.

   (Optional): Have students draw a picture of the object on their map and plot its position. Students should do a quick sketch of each image as it is shown in the video. Or, provide additional pictures of these objects.

2 **Demonstration and Transparency.** Divide the class into teams of four to five students each. Hand out the “Making a Celestial Map” directions and the “Celestial Map Data” worksheet to each student. Teams will use a piece of butcher paper about one meter long. They should draw a line down the center vertically and a line across the center horizontally. The center, where these lines intersect, is the location of our Sun. Students should label the diagram with degree markings: 0°, 90°, 180° and 270°. By definition, zero degrees is the direction toward the galactic center of the Milky Way. Show them these coordinates on the “Celestial Mapping” transparency.

   Teacher's Note: *Astronomers map the galaxy beginning with 0° at the bottom of the square, which places the center of the galaxy at the center of the image. This is different than classical geometry (see page xx).*

   Anticipate that your students will have trouble seeing how a rectangular map can have 360°. Many students think that only circles have 360°. Ask students to envision an imaginary circle inside their rectangle. Students will only need two pieces of information to plot each object: how far it is from the Sun, and on which angle it is located. Go over these two terms with the class.

   Distance in light-years = distance from our Sun
   Galactic longitude = Degrees from zero

The galactic longitude of an object is the angle between the center of the galaxy, our Sun, and the object as seen by someone looking down on the galaxy from a great distance.

It is crucial to realize that this figure does not give students a sense of the depth (or the third dimension) of the Milky Way Galaxy. This especially affects globular clusters because they are considerably above or below the plane of the Milky Way Galaxy.

Anticipate that students may have trouble using a 180° protractor to plot objects between 180° and 360°–they may flip the 180° protractor to the other side and not know whether they need to add or subtract to find the correct angle. We recommend using a 360° protractor.

The map scale is 1 cm = 15 light-years. At this scale, most of the closest stars actually fit on the diagram. Most nebulae are considerably farther away than the stars, and most globular clusters are farther away still, so they will *not* fit on the paper! Students should still plot how far away these objects would be if they could be placed on a bigger map (*e.g.*, out in the schoolyard, across the street, or even farther away). They should write this information on the edge of their vicinity map.

Demonstrate how to plot an object on the “Celestial Mapping” transparency. Plot at least two objects. One should be between 0° and 180° and the second between 180° and 360°. One object should fit on the map and the second should not; for the second, demonstrate how to write data on the edge of the paper.

3. **Activity.** Have students graph various celestial objects on a celestial map to get a better sense of their general distribution and direction from Earth in our immediate area of the Milky Way Galaxy. It may take two (or more) class periods to ensure that all students are able to plot all the objects on their “Celestial Map Data” worksheets.

4. **Homework.** Hand out the “A Celestial Map Questions” worksheet to each student. Have students complete this worksheet in class or as homework.

Mission 5.2
Materials

For a Class of 30

- Data projector, computer, PowerPoint file
- “Galaxies: Billions Upon Billions of Stars” segment from *Project Haystack* PowerPoint
- “Galaxies: Billions Upon Billions of Stars” script (pages 81-84)

For Each Team

- Thin pieces or sheets of plastic (lids from plastic containers are ideal)
- Compasses
- Scissors
- Glue or paste

- Cotton balls (or other cotton)
- White paint
- Brushes
- Meter sticks with mm markings
- *(optional)* Graph paper

For Each Student

- "Our Home Galaxy" directions
- Pencil

Getting Ready

1. Copy the "Our Home Galaxy" directions for each student.

2. Set up the data projector Start the *Project Haystack* PowerPoint file"Galaxies: Billions Upon Billions of Stars." Have the script handy.

Classroom Action

1. **Review.** Reassemble the class into their teams from Mission 5.1. In Mission 5.1, students plotted several objects that are all found in the near vicinity of our Sun, all within the Milky Way Galaxy. Tell students that they will see how their Vicinity Chart relates to the entire Milky Way Galaxy by making a scale model that shows both where in the galaxy we are and how much space the Vicinity Chart takes up compared to the entire Milky Way Galaxy.

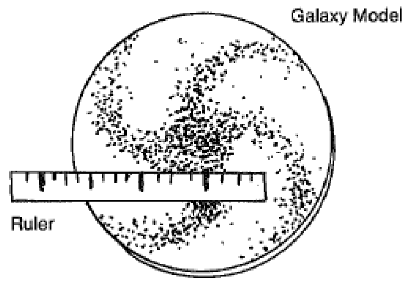
2. **Data Projector.** A script has been provided. It can be used as is to accompany the PowerPoint presentation, or its information can be paraphrased. This segment will show the variety of galaxies in the universe and how our own Milky Way Galaxy is believed to look.

   Today students will be artists! They will refer to the poster (optional) drawings of the Milky Way and/or images of galaxies that are thought to look like our home galaxy. They then will draw a nice sketch that looks something like the Milky Way–an open spiral. We do not know exactly what our galaxy looks like from the outside. It has only been in the last five years that astronomers have figured out that the inner part of our galaxy probably contains a "bar" of stars, and they are still trying to puzzle out whether the very center of our galaxy contains a massive black hole, or millions of ordinary stars packed close together.

   Our best guess is that it looks something like the Andromeda Galaxy, but the spiral pattern of Andromeda is not clearly visible on photos. An open spiral pattern will be used to depict our Milky Way Galaxy. Students will see that, on a top-view diagram of our galaxy, we are toward the inside edge of one of the spiral arms. Remind students that the Milky Way is roughly 100,000 light-years across, 5,000 light-years thick at its center, and 2,000 light-years thick everywhere else. The length of the bar is about 20,000 light-years. Write these numbers on the whiteboard.

3. **Activity.** Hand out the “Our Home Galaxy” directions to each student. Ask students to create a model of our galaxy using the pictures and diagrams that they have just seen as models. Pass out pieces of plastic, white paint, brushes, cotton balls, glue, compasses, and scissors. Plastic will make the three-dimensional model of our galaxy. Ask students to measure the thickness of their piece of plastic. The real Milky Way Galaxy has an overall diameter to thickness ratio of 50 (except for the bulge in the middle). Because we know that the real Milky Way Galaxy is about 100,000 light-years across, students can compute the diameter that would be appropriate for their piece of plastic (given its thickness) and draw a circle of that diameter. Students should cut out their plastic circle and paint an open spiral pattern on it, as shown in Figure 5.l. Encourage the use of many dots, depicting stars rather than lines, especially near the edges of the spiral arms. The transparency of the plastic shows the open space that exists between the stars. At this scale, the stars in the center are so dense that they blur together.

Figure 5.1–A Model Milky Way Galaxy.



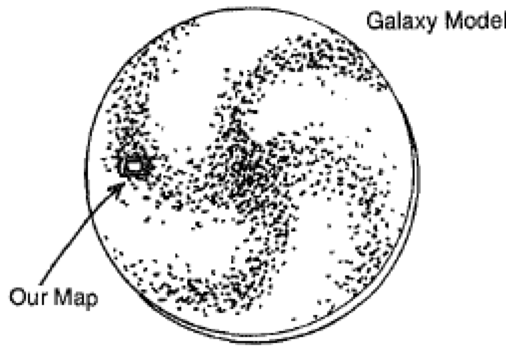
To represent the bulge at the center of the Milky Way Galaxy, have students use a cotton ball. Knowing that the Milky Way is roughly 100,000 light-years across, and 5,000 light years thick in the middle, they can compute about how much cotton to glue to the center to show the bulge. Glue the cotton on both sides of the disk. Wisps of this cotton should be pulled out toward each spiral arm, becoming more tenuous farther from the center.

Teacher's Note*: It is clear now that the Milky Way is a strongly barred galaxy, so the cotton ball is only a rough representation. However, it does add a third dimension to the model.*

Optional: If it is too difficult to obtain pieces of plastic, use graph paper, which will produce a flat map with no third dimension. The white paint, brushes, cotton balls, and glue will not be necessary. Just have students draw an open spiral galaxy extending to the edges of the graph paper. Have them cut out the map as a circular shape (see fig. 5.1).

4. **Activity.** Tell students that the challenge is to draw in a rectangle representing the diagram that they constructed in Mission 5.1 (the Vicinity Chart) that is to scale on this new model of the entire Milky Way Galaxy, as shown in figure 5.2.

Figure 5.2–Our Map and the Milky Way Galaxy.



Ask students to remember their rectangular vicinity map. Ask them to guess where this rectangle would appear on their new model of the entire Milky Way Galaxy. Ask them to guess how big this rectangle would appear on their new model of the entire Milky Way Galaxy. Students pencil their best guess on their new model. *(Students' best guesses will probably be much too big!)*

Have students follow the “Our Home Galaxy” directions for calculating the distance to the center and to the opposite edge of the Milky Way Galaxy at the scale of 1 cm = 15 light-years. Try to provide a place where students can actually walk off or measure off this distance, which will be roughly 20 meters away along the 0' line to the center and 55 meters to the opposite edge! If possible, have students mark off these distances in the schoolyard.

Going Further

Activity: 3·D Constellation Models

This activity is completely described in appendix B as an enrichment lesson. It is highly recommended. These models show students that constellations only look familiar from one viewpoint: our own, here on Earth!

Activity: The Milky Way *x* 10!

Students make a second model/map of the Milky Way Galaxy, with the second map scale being 1 cm = 150 light-years. At this scale, the nebulae fit on the diagram, but the globular clusters still do not. This will give students a sense of how far away these objects actually are. At this scale, all the stars still fit, but they are now bunched up very close to the Sun. They are difficult or impossible to plot clearly.

Activity: How Big Is It?

Give students photographs of various objects, or show them to the class as a whole. Ask students how big each is. How can they tell? If the objects are familiar to students, they will rely on past experience and knowledge. Point this out to them, and ask for clues to sizes and scales that could be used if they had never seen such an object. Some of the pictured objects should be unfamiliar to students.

Activity: Mapping and Scale

Students use graph paper to conduct a resolution mapping exercise. Students make maps of the classroom or schoolyard at various scales. For each scale, they record only what can be seen at that scale, or only the dominant objects for that scale.

Activity: Calculation Challenges

Challenge # 1

Students calculate the exact size of the rectangle representing the diagram that they constructed in Mission 5.2 (the Vicinity Chart) to scale on their new model of the *entire* Milky Way.

First, the distance across the Galaxy just drawn must be measured (in millimeters). This distance represents 100,000 light-years, so dividing 100,000 by the total distance in millimeters gives the number of light-years that one millimeter represents. For example, if a galaxy is 200 mm across, the scale would be 1 mm = 500 light-years.

To calculate the appropriate size of the rectangle for the entire Milky Way Galaxy, the scale just computed for the entire Galaxy must be applied to the measurements of the rectangle from Mission 5.2. For instance, a rectangle of butcher paper measuring 92 cm x 60 cm becomes 1,380 light-years by 900 light-years. Dividing each of these figures by 500 gives the dimensions of the rectangle for the new diagram-it would be slightly smaller than 2 mm x 3 mm!

The next step is to draw this rectangle on the new diagram of the Milky Way, out toward the inside edge, about two-thirds of the way from the center on one of the spiral arms. Students should be quite startled to discover how little space their first diagram takes up within the entire Milky Way Galaxy.

Challenge # 2

Students calculate how many times larger the Milky Way Galaxy is than each Vicinity Chart. Students should use the formula for the area of a circle, $a = \pi r^2$, to find the area of the Milky Way Galaxy. Multiplying length by width, students will find the area of the rectangle used in mission 5.1. Dividing the area of the circle (the area of the Milky Way Galaxy) by the area of the rectangle (the Vicinity Chart) will provide the answer.

Show and Tell: Scale Models

Students make or buy scale models all the time. Have them bring some of these models to school. They should know the scale involved (*e.g.*, doll-house furniture at a scale of 1 inch = 1 foot; HO trains at a 1/87 scale). Some models should be larger than life (*e.g.*, plastic fly), some should be smaller than life (*e.g.*, plastic dinosaur), and others should be life-size. Have students estimate the scales of each other's models.

Activity: Seeing Another Galaxy

The Andromeda Galaxy can be seen with the naked eye. It appears as a white, fuzzy area. With binoculars, or with a simple, small telescope, the image becomes much larger and clearer. The Andromeda Galaxy is easy to locate, assuming the constellation of Andromeda will be overhead at a time when students will be looking for it–this means that you must be somewhere in the northern hemisphere on a dark night. Consult a star map to determine when and from where the constellation Andromeda can be seen in your geographic location. *(For students in the southern hemisphere, consider finding the Magellanic Clouds, two very nearby dwarf galaxies.)* Give students a star map, or have them do library research to find a star map. The darker the night sky, the better the chance of observation; accordingly, if your school is in a heavily light-polluted city, perhaps have students try this activity during a weekend camping trip.

Activity: Stories from the Stars

Mythology and religion are rich in tales about the stars. Many constellations have elaborate stories explaining their existence. Do all peoples see the same constellations when they look at the sky? Students may research other cultures and present pictures of how other peoples see the sky. Students may then read or tell stories about the stars from cultures around the world. Create a “campfire” at the center of the room, put out the lights, and have students take turns telling the stories. Ask students whether constellations in the southern celestial hemisphere are different from those in the northern hemisphere. Do any southern constellations have Greek or Roman names?

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Celestial Map Data–Teacher's Key

Table 5.1.

Name of Celestial Object	Right Ascension	Declination	Galactic Longitude	Distance in Light-Years	Distance in Centimeters (1 cm = 15 light years)	Distance in Centimeters (1 cm = 150 light-years)
Aldebaran (Star)	4h 33m	16° 25’	183°	68.0	4.53	0.45
Altair (star)	19h 48m	8° 44’	47°	16.6	1.1	0,10
Alpha Centauri (Star)	14h 36m	-60° 38’	315°	4.3	0.3	0.03
American Nebula	20h 52m	43° 54’	84°	2,600.0	173.0	17.30
Antares (Star)	16h 29m	-26° 26’	354°	326.0	21.7	2.17
Arcturus (Star)	14h 16m	19° 11’	15°	36.0	2.4	0.24
Barnard’s Star	17h 55m	4° 33’	30°	5.9	0.4	0.04
Beehive Open Cluster	8h 38m	19° 52’	208°	500.0	33.3	3.33
Betelgeuse (Star)	5h 55m	7° 24’	202°	651.0	43.4	4.34
Capella (Star)	5h 17m	46° 00’	165°	42.4	2.8	0.28
Crab Nebula	5h 31m	21° 59’	185°	6,552.0	436.0	43.60
Cygnus Loop Nebula (Veil)	20h 49m	30° 30’	78°	1,630.0	109.0	10.90
Deneb (Star)	0h 44m	-17° 59’	110°	68.5	4.6	0.46
Epsilon Eridani (Star)	3h 31m	-9° 38’	195°	10.8	0.7	0.07
Hercules Globular Cluster	16h 40m	36° 33’	59°	25,000.0	1,666.6	166.60
Horsehead Nebula	5h 39m	2° 32’	204°	12,000.0	800.0	80.00
Lagoon Nebula	18h 01m	-24° 22’	7°	3,900.0	260.0	26.00
Mizar (star)	13h 24m	54° 56’	112°	58.7	3.9	0.39
Omega Centauri Globular Cluster	12h 24m	47° 13’	132°	17,000.0	1,133.0	113.0
Orion Nebula	5h 35m	-5° 27’	208°	1,600.0	107.0	10.70
Pleiades Open Cluster	3h 47m	24° 07’	168°	415.0	27.7	2.77
Polaris (North Star)	2h 32m	89° 16’	130°	1,080.0	72.0	7.20
Rigel (Star)	5h 14m	-8° 12’	210°	913.0	60.9	6.09
Ring Nebula	18h 54m	33° 02’	63°	4,100.0	273.0	27.30
Sirius (Star)	6h 43m	-16° 39’	228°	8.6	0.6	0.06
Spica (Star)	13h 25m	-11° 10’	315°	155.0	10.3	1.00
Tau Ceti (Star)	1h 42m	-16° 12’	175°	11.7	0.8	0.08
Trifid Nebula	17h 58m	-23° 24’	8°	3,260.0	217.0	21.70
Vega (Star)	18h 37m	38° 47’	68°	26.4	1.8	0.18

SETI INSTITUTE

Mission 5
A Model of the Milky Way Galaxy

Celestial Map Questions–Teacher's Key

1.

a. The galactic center is *2,000* centimeters (20 m) away.

b. The far edge of the Milky Way Galaxy is 5,333 centimeters (53.3 m) away.

c. The near edge of the Milky Way Galaxy is 1,333 centimeters (13.3 m) away.

2.

a. All stars less than 100 light-years from the Sun on the Milky Way Galaxy Object List: Aldebaran, Altair, Alpha Centauri, Arcturus, Barnard's Star, Capella, Deneb, Epsilon Eridani, Mizar, Sirius, Tau Ceti, and Vega.

b. The SETI Target List includes many stars that are less than 200 light-years away because these are the stars that we will have the greatest chance of detecting a signal from. An extraterrestrial signal would be easier to detect from a close star than from a far-away star, in the same way that it is easier to see a dim light if you are closer to it. The signal will probably be weak because of limitation on transmitter power.

3.

a. The data tells the directions that the *Voyager* spacecraft are headed, and the speed at which they are traveling. The directions are equivalent to the galactic longitude; first draw the two trajectory lines. One method of showing locations: on each trajectory line mark off every 150 light-years (10 cm at map scale), and label each mark with the number of years it will take for the *Voyager* spacecraft to get to those marks.

b. Each *Voyager* takes *19,400* years to go 1 light-year.

c. How long will it take for a *Voyager* to go 150 light-years? *2,900,000* years.

Script for PowerPoint Slides

“Wonders of the Milky Way Galaxy”

Introduction

The Milky Way Galaxy, our own home galaxy, is filled with wonders. If you know where to look, many are visible to the unaided eye, but when seen through a telescope, their splendor is a joy to behold! This video will show you a few of the wonders of the Milky Way Galaxy: mammoth star clusters, multicolored nebulae of glowing dust and gas. In class today, you will make a map showing where these wonders are in relation to Earth, and to our solar system, which are very small in comparison to the universe.

Image # 5.23: The Beehive (Praesepe) Open Cluster (M44)

Stars are often born in groups called *open clusters*. This image shows an open cluster named the Beehive. Do the stars remind you of a swarm of bees? Open clusters are groups of hundreds of stars. Our own Sun was probably born within such a group. In these open clusters, the individual stars are slowly drifting apart from each other. The Beehive is one of the closest open clusters, being only about 500 light-years away!

If you wanted to see the Beehive, you would look in the constellation Cancer, the Crab. If you knew exactly where to look, and went out on a dark night during winter or spring, you would be able to see the Beehive with your unaided eye. You would see a fuzzy white patch. With binoculars, some of the individual stars would become visible. Galileo was impressed to see over 40 individual stars in the Beehive with his small telescope. With a modern telescope, we can see over 350 individual stars there.

Image # 5.24: The Pleiades Open Cluster (M45)

There are many open clusters in our galaxy. This one is called the Pleiades, or the Seven Sisters. You may have seen the Pleiades, or heard stories about how the Seven Sisters went to live in the sky and became stars. If you have seen them, you have looked at something that is 415 light-years away from Earth. How long would it take you to visit the Seven Sisters if you rode your “space bike”? *(It would take 18 billion years! The universe itself is only expected to have been in existence for about 15 billion years.)*

If you have never seen the Pleiades, you can look in the constellation of Taurus, the Bull, one of the signs of the zodiac, on a dark winter's night. They are easily seen with the naked eye. Can you see all Seven Sisters? To be able to do so was the “eye exam” required to get into the Roman army 2,000 years ago!

Image # 5.25: Globular Cluster in Hercules (MI3)

Not all star clusters are open clusters. This is *a globular cluster* located in the constellation Hercules. You are looking at several hundred thousand stars packed into a very compact area. Globular clusters become denser as you approach the center. Near the center of this cluster, there are about 1,000 stars in every cubic light-year! The neighborhood is so crowded that you cannot distinguish the individual stars.

Globular clusters are very old objects. At a distance of 25,000 light-years, M13 is one of the closest. Amazingly, even at this distance, you can see the globular cluster in Hercules with the unaided eye. The constellation Hercules is almost straight overhead in midsummer. Try finding this globular cluster when school's out.

Image # 5.26: The Trifid Nebula (M20)

Deep in the constellation Sagittarius, the Archer, toward the center of our galaxy lie enormous glowing red and blue clouds of gas and dust that dim and hide the light of any stars that may be beyond them. Deep within these clouds, new stars are being born. These glowing gas clouds are called *nebulae.* This particular gas cloud is the Trifid Nebula, a typical stellar nursery—a *big* nursery. The Trifid measures 40 light-years in diameter. And what big babies. The Trifid is lit with the glow from its newborn stars. This glow comes from 3,260 light years away.

Image # 5.27: The Great Nebula in Orion (M42)

Perhaps the most famous nebula of all is the Great Nebula in Orion. It is visible to the unaided eye as a misty patch in the sword of Orion, the Hunter, one of the most familiar constellations in the world. But photographed through a telescope, it becomes a glorious, multicolored object. Look for it in the night sky in winter.

Like the Trifid Nebula, the Great Nebula is a glowing cloud where stars that have just been born reside. But the Great Nebula is a good deal closer to us than the Trifid Nebula. It is only 1,500 light years away from Earth. Hop on your "space bike"!

Image # 5.28: The Horsehead Nebula

What would you name this nebula? People everywhere like to see "pictures" of familiar objects in cumulus clouds, in rock formations or flames in a fire, or in a distant glowing cloud of dust and gas. Yes, this is called the Horsehead Nebula. Its shape is a pure coincidence. The black horse's head is just part of a larger dark cloud, which is opaque enough to block the light of the stars that lie behind it. The red background that outlines the horse's head is the ruddy glow of hot hydrogen gas.

You could see the Horsehead Nebula if you looked in the constellation of Orion, the Hunter. In fact, this nebula is only a few degrees away from the Great Nebula in Orion, but it is much smaller and much harder to find, even with a telescope. Like the Great Nebula, it is about 1,500 light-years away from Earth.

Image # 5.29: The Ring Nebula (M57)

About 20,000 years ago, a star blew off its outer layers and created this expanding shell of glowing gas and dust. Ultraviolet light emitted by the central star causes the gas and dust to glow. What would you name this nebula? That's right. It is named the Ring Nebula! It is 4,100 light-years away from Earth. Someday the space around the Sun will look like this as the sun begins to age and die.

The Ring Nebula can be found in the summer constellation Lyra, the Lyre. A lyre is an ancient Greek musical instrument.

Image # 5.30: The Crab Nebula Supernova Remnant (M1)

The Crab Nebula is the wreckage of an exploded star, a *supernova.* The light from this super explosion reached Earth about July 5, 1054. The stellar display was recorded by the Pueblo Indians in Arizona and by Chinese astronomers. The Crab Nebula is 6,552 light-years away from Earth. Can you calculate when the star exploded?

The Crab Nebula is located in the constellation of Taurus, the Bull, which is visible in spring and winter. This dust cloud is still expanding at the rate of 1,000 miles per second. Inside the Crab Nebula is a super dense *neutron star* that spins around its axis 30 times a second. Because this neutron star emits pulses of light, x-rays, and radio waves, it is called a *pulsar:* It is the remnant core of the exploded star.

Image # 5.31: The Veil Nebula Supernova Remnant (NGC 6960, 6992)

There may be a pulsar near the center of this supernova remnant, the Veil Nebula. It is all that is left of a once great star. This wispy Veil Nebula is the visible manifestation of a shock wave that has been traveling toward us for over 100,000 years, ever since a minor star in the constellation Cygnus exploded. This insignificant star suddenly blazed 100 million times as brightly as before! It became a supernova. The initial explosion would have made the star shine as brightly as our moon. The star would have even been visible in daylight for several weeks before fading. Today the Veil Nebula surrounds the old explosion site.

Stop and Assess “Wonders of the Milky Way Galaxy”

1. Back up and take a second look at various images if students would like to study them.

2. Ask: What have you learned about these beautiful celestial objects?

3. Ask: Can *you* make a map that shows the location of these objects?

Script for Video Images

“Galaxies: Billions Upon Billions of Stars”

Introduction

As huge as it is, the Milky Way Galaxy, including its hundreds of billions of stars, its star clusters and glowing nebulae, is only one galaxy in the universe. And there are tens of billions of other galaxies, each one filled with billions of stars! This number of stars is almost impossible to imagine. There are more stars than there are grains of sand on all of the beaches in the world.

In today's image show, you will see what some of these other galaxies look like, and then see how our own Milky Way Galaxy looks from the inside, and how it is believed to appear from the outside. After the show, you will make a three-dimensional model of our home galaxy.

Image # 5.32: Spiral Galaxy in Virgo

Astronomers know that stars are organized into huge systems called galaxies. Each galaxy contains billions of stars. Our Sun is just one star out of about 500 billion stars in our own Milky Way Galaxy. Galaxies are classified by their basic shapes as spirals, ellipticals, and irregulars. Which shape do you think this galaxy is?

This is a *spiral* galaxy seen nearly face on. It can be seen through a telescope, if you look in the constellation of Virgo. It is about 50 million light years away from Earth. Can you imagine what a huge piece of butcher paper you would need to include another galaxy on your map?

Image # 5.33: Andromeda Galaxy (M31)

The Andromeda Galaxy is one of the galaxies that is nearest to us. It is only about 2.2 million light-years away from Earth! Amazingly, this galaxy can actually be seen as a “fuzzy blob” with the unaided eye, if you know where to look in the fall or winter sky in the constellation Andromeda. The actual shape of the Andromeda Galaxy is a spiral of stars, dust, and gas.

The Andromeda Galaxy is thought to be quite similar to the shape of our own Milky Way Galaxy. The Andromeda Galaxy also has two small elliptical *companion* galaxies. Is this unique in the universe?

Image # 5.34: The Virgo Cluster of Galaxies (M84)

Actually, although photographs often focus on single galaxies, isolated galaxies are quite rare in space. Most galaxies are found in clusters, or groups. This is only part of a cluster of galaxies seen when looking at the constellation Virgo. How many galaxies can you see in this picture? How many do you think might be in the whole cluster?

There are eight galaxies easily seen in this image. In fact, the entire Virgo cluster contains several thousand individual galaxies. And astronomers classify this region as only moderately rich. Some clusters have even more galaxies. Can you tell what shape most of these galaxies are? Are they spirals, ellipticals, or irregulars?

Image # 5.35: Edge-on Spiral Galaxy in Leo (NGC 3628)

This is one galaxy in the Leo Triplet of galaxies named because the stars in the constellation of Leo the Lion are in the same part of the sky. It is one of the “Local Group” of galaxies, all of which lie within two or three million light-years of Earth. These are almost next-door neighbors. What shape is this galaxy? Is it a spiral, an elliptical, or an irregular?

Actually, it is a spiral galaxy. It looks so different from the other spirals that we have seen because we are viewing it from the edge instead of face-on. Think of a spiral galaxy as if it were a dinner plate with a spiral pattern painted on it. From one view, you would see the whole spiral pattern. What would the plate look like if you turn it so that you are looking at the edge? It would look like this galaxy.

Image # 5.36: Large Magellanic Cloud, an Irregular Local Galaxy

This galaxy is called the Large Magellanic Cloud. It is even closer to home than the Leo Triplet. Although the stars and star clusters that we see in our own Galaxy are within 150,000 light-years of us, other galaxies are usually millions of light-years away. This is about 10 times as far away as the farthest individual stars that we can see. What shape galaxy is the Large Magellanic Cloud? It is an irregular galaxy.

The Large Magellanic Cloud is one of our two companion galaxies. It is only 170,000 light-years away. It is clearly visible to the unaided eye. Have you ever seen it? Not unless you have traveled to the southern hemisphere in summer. The Large Magellanic Cloud is never seen from North America. f you go to Australia, look for it, and for our other companion galaxy, the Small Magellanic Cloud.

Image # 5.37: The Milky Way: Horizon Shot with Trees

Have you begun to wonder what our own galaxy looks like? Have you ever seen the “Milky Way,” the band of light that crosses the night sky? What you were looking at is part of the galaxy that we live in. Like other galaxies, ours has billions of stars in it. These stars can be so dense in some regions of the sky that their light blends into a bright band: the well known Milky Way.

Image # 5.38: The Milky Way Within Sagittarius in Visible Light

The Milky Way is best seen on the darkest nights. When you use a telescope to look more closely at a section of the Milky Way on a dark night, many individual stars can be seen. However, in some places the stars are still too dense for us to see more than a cloud of light. This is a telescopic view of an area of the Milky Way Galaxy that is quite densely populated; it is filled with stars. The stars are densest towards the direction of the galactic center, the center of the Milky Way Galaxy. This image was taken in visible light, in the constellation Sagittarius.

Astronomers know that the Milky Way is a spiral galaxy. Why don't we see the spiral shape of our galaxy when we look up into the night sky? Why do we only see a band of light? The shape of our own galaxy is impossible for us to see as we can for other galaxies, because we are inside it! We are in a celestial forest, so all we can see are the trees. Because we are within the Milky Way Galaxy, our views can only be from within, in just the same way that you can't see the shape of a forest if you are inside of it. This image was taken in visible light. The light areas are shining with starlight. The dark areas are clouds of dust that block the light from still other stars.

Image # 5.39: Galactic Center of the Milky Way in Infrared Light

Astronomers can view our Milky Way Galaxy with different kinds of light. This image shows our Milky Way Galaxy from within, in a photograph taken in infrared light. Have you heard of infrared light? In our next mission, we will learn about the electromagnetic spectrum, which includes all types of radiation, including all types of light. One third of the light from our galaxy is emitted in infrared, which is invisible to our eyes. If infrared is invisible, how can we see it? With special cameras, we can take photographs that show us this otherwise invisible light. Infrared light is able to pass through the dust clouds, so the picture is no longer patchy with dark areas.

Image # 5.40: Artist's Conception of the Milky Way Galaxy

As you have calculated, the distances to the stars are so great that we can't travel outside of the Milky Way Galaxy to the view that we see in diagrams like this one, created by artists. There are no photographs of the Milky Way Galaxy taken from the outside. Only extraterrestrials from another galaxy could take that photograph.

Stop and Assess “Galaxies: Billions Upon Billions of Stars”

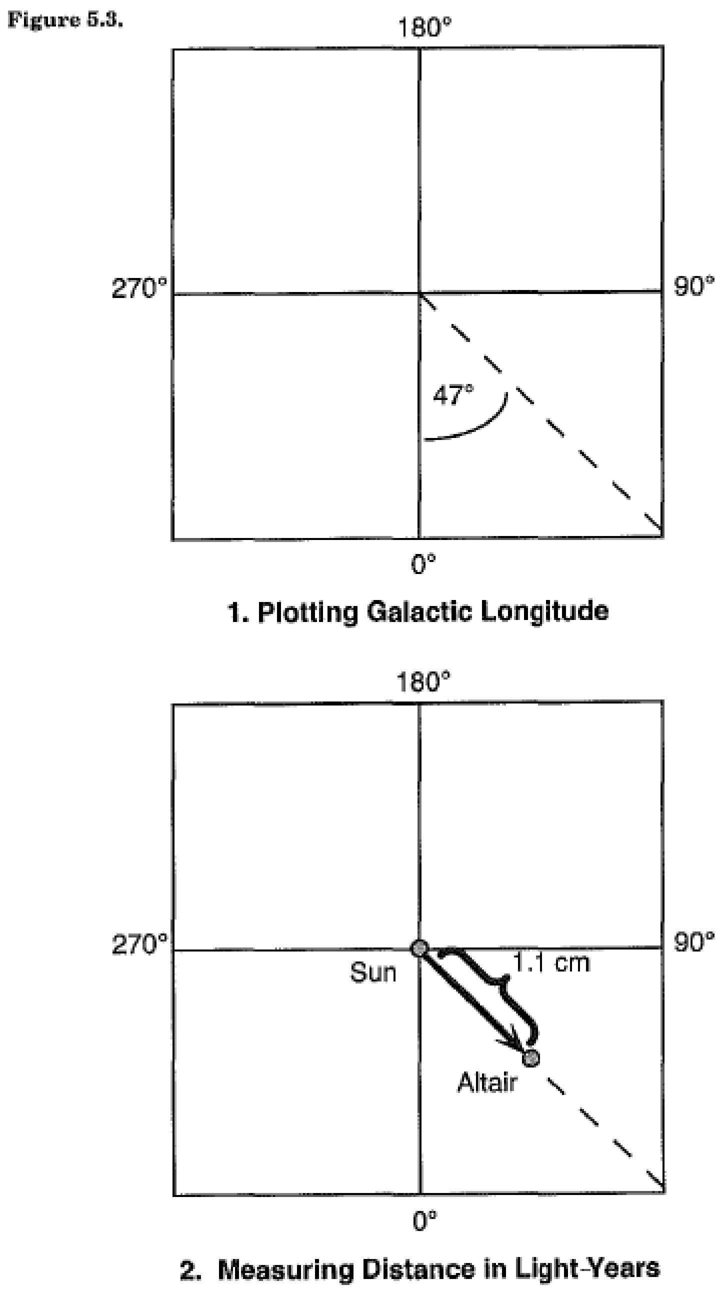
1. Back up and take a second look at various images if students would like to study them.

2. Ask: Can *you* make a model that shows the shape of our home galaxy? All right, you will get a chance to try now.

Mission 5
A Model of the Milky Way Galaxy

Celestial Mapping–Transparency or PowerPoint Slide

Figure 5.3.



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