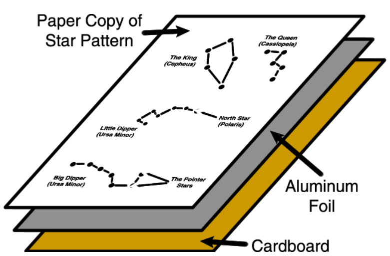
What's Your Latitude?

One of the most important tasks of a navigator is to determine where she is at all times. The height of the North Star above the horizon is affected by where you are on the Earth. The altitude angle of the North Star is a very good approximation (within 1˚ or better) for your latitude on Earth. In this activity, your students review how to find the Big Dipper and the North Star. Then they build a quadrant and practice using it to tell latitude.

Before the Lesson

Using an overhead projector to show stars creates a very nice "planetarium effect." Following are instructions to make a simple star frame for the constellations needed in this program.



Materials for a Star Projector

- 1 copy of star pattern, page 2
- 1 piece of aluminum foil large enough to cover the star pattern copy
- 1 piece of corrugated cardboard to protect surface of table or desk
- 1 pushpin and a sharp pencil
- 1 file folder or tag board to make a frame
- 1 roll of transparent tape
- 1 yellow paper star of your design to mark the position of the North Star on the wall
- 1 overhead projector

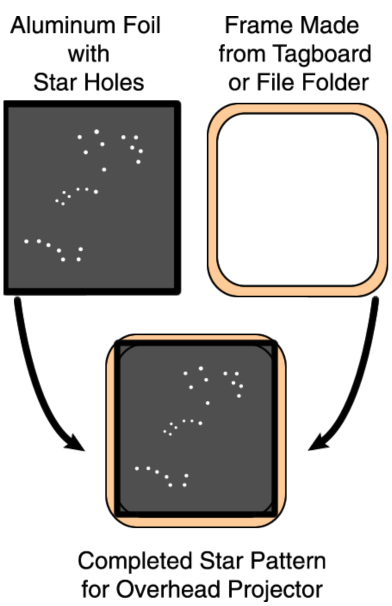
1. Make Star Holes in the Aluminum Foil

a. Place the paper copy of the star pattern on top of the aluminum foil and the cardboard.

b. Use the pushpin to poke a hole through the paper and the aluminum foil for each star.

c. Remove the paper copy, and use the pencil to slightly enlarge the stars of the Big Dipper and the Polaris, the North Star. The larger the hole, the brighter the star appears.

d. Test the aluminum foil star pattern on your overhead projector.



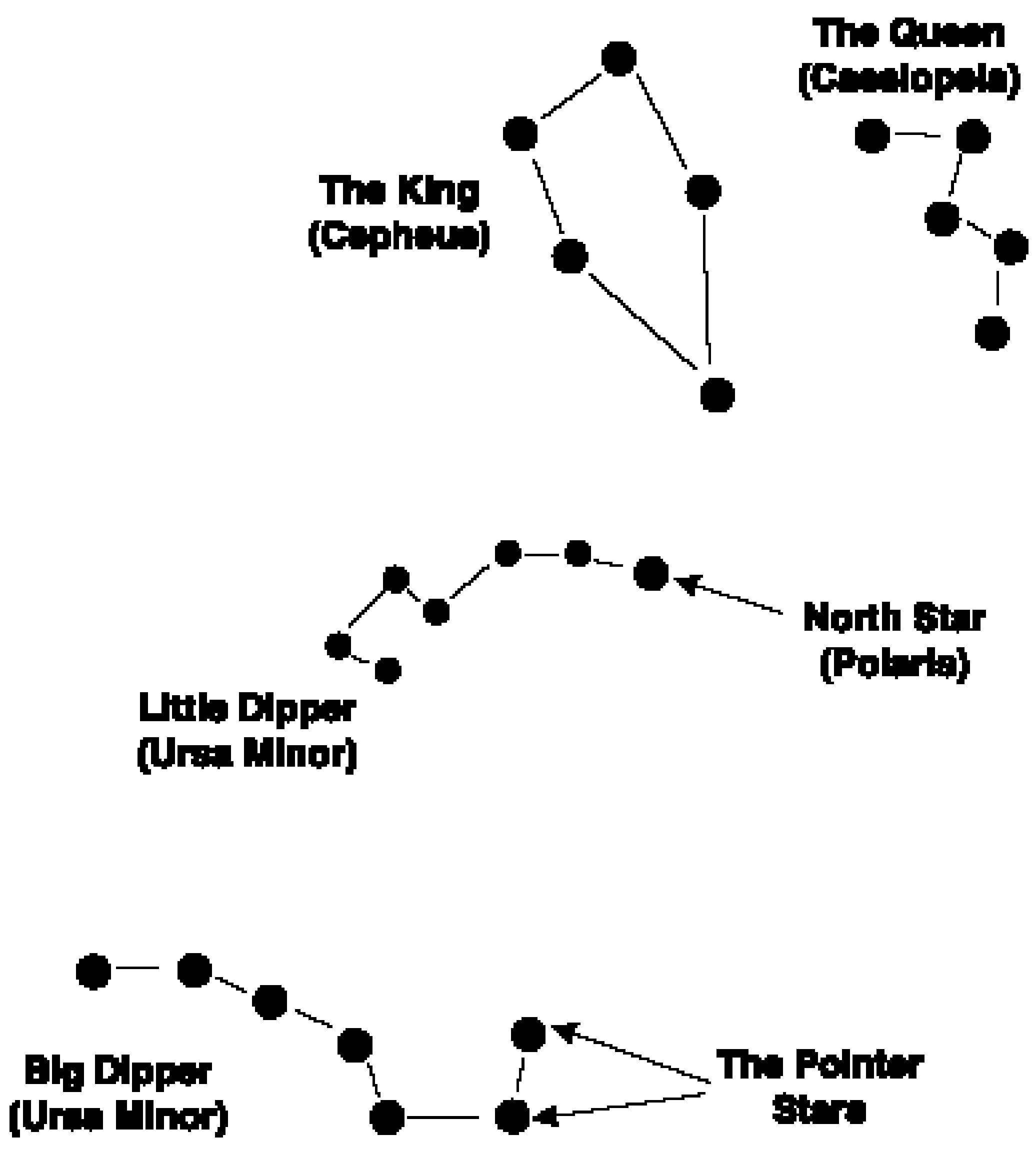
2. Make a Frame for the Foil

a. Make a frame for the aluminum foil from a file folder or tag board so that the entire surface of your overhead projector is covered by the framed star pattern.

b. Mark the front side of the star pattern so that when you use it during the presentation, the star patterns are correct. If the frame is flipped over front-to-back, all of the star patterns will appear backwards.

Star Pattern for Projecting Stars in the Classroom

Use this pattern to make the framed aluminum foil star pattern, and use this diagram as a reference to teach your students the northern constellations that surround Polaris, the North Star.



In Class

Part A. Finding the North Star

Set up the overhead projector using the star pattern frame. Ask your students the following questions. Encourage the students to use the star projector in their explanations as well. You can supplement their answers as well. Sample answers are given after each question.

1. What is the North Star?

The North Star, Polaris, is used as a navigational star in *Who “Discovered” America?* and by real-life navigators for finding true north. All of the other stars appear to circle around the North Star once every 24 hours.

2. How Can You Find the North Star in the Sky?

First find the Big Dipper (also called Ursa Major, the Big Bear.) The two front stars in the bowl of the Big Dipper point to the North Star. You can then find the much fainter Little Dipper (also called Ursa Minor, the little Bear), since the North Star is the end of the handle of the Little Dipper.

3. Why does the North Star seem to stay in one place?

As the Earth spins rotates on its axis, the Sun, Moon, planets, and stars appear to rise and set, creating the cycle of day and night. The North Pole of the Earth points toward the same place in space throughout the year. We call the place in space where the Earth’s North Pole points the *north celestial pole*. The North Star is within 1˚ of the north celestial pole, and we call it *Polaris* which means “pole star.”

Part B. Make a Quadrant

A quadrant is a quarter of a circle. It is also the name of an instrument, shaped like a quarter of a circle, used by navigators in Columbus’s day to determine latitude—how far north or south of the equator the navigator was located.

Instructions for making and testing a Do-It-Yourself Quadrant

1. Have the students glue the quadrant sheet to the cardboard and cut it out.
2. Demonstrate how to assemble the quadrant according to the directions printed on the student copy of each quadrant. Have the students assemble their quadrants.
3. When assembled, check the pointer on each student’s quadrant: it should swing freely.
4. To measure the altitude or height or an object, look along the top edge of the quadrant, aligning the back and front of that edge with the object. Wait until the pointer stops swinging.
5. Pinch the pointer against the scale; then read the angle from the quadrant.

Materials for Making Quadrants

- 1 copy of “‘Do-It-Yourself’ Quadrant” for each student (master from #2 of the “Materials” section in the script document for *Who “Discovered” America?*)
- push pins, one per student quadrant
- pencil eraser tip, small piece of cork or soft wood, one per student
- cardboard or file folder, 20 x 21.5 cm (8” x 8.5"), one per student
- glue stick, one for every two students
- scissors, one for every two students

To insure that students know how to use their quadrants correctly, take your students outside and measure the height of the school flag pole or a tall building from a distance. If the students stand close together, or in a line, their angular measurements should be very close to the same number. Any student who has a measurement more than 10° from the average probably needs some help in holding and sighting the quadrant correctly.

Emphasize that quadrants measure the altitude in *degrees*. They do not measure directly the distance of something above the ground.

Demonstrate this by having your students measure the altitude angle of a distant object, like the top of a flag pole, and then go about half of the distance towards the object and measure it again.

Is the altitude angle higher or lower? [Higher.]

As they get closer and closer to the pole, the angle will get higher and higher, up to the limit of 90°. When they stand right next to the flag pole, and look up at the top, they will measure very nearly 90°. When they measure an object at eye level, such as the horizon, they will measure 0°.

Although the quadrant does not measure distance directly, you can calculate the distance above the ground if you know your distance from the object and use geometry or trigonometry.

Part C. Measuring the Altitude Angle of the North Star

1. Using the North Star overhead projector setup, challenge the students to measure the altitude angle of the North Star with their quadrants.
2. Switch off the overhead projector and tilt the projection lens so that the North Star will appear higher on the wall. Have students measure the altitude angle again. Ask,

   “Has the altitude angle increased or decreased?” [Increased.] “Would this mean that we are further north or further south on the Earth?” [Further north.]
3. Repeat step 2, but adjust the North Star lower than its first position.
4. ***How does my place on Earth affect where I see the North Star?***

If you were to stand on the North Pole of the Earth, you would see the North Star at the zenith. As you walk south from the North Pole the only way to go!, you would see the North Star at a lower and lower altitude. By the time you trek to the equator, the North Star is on your horizon at an altitude of 0˚—the same as the latitude of the equator. Below the equator you would not see the North Star at all. Unfortunately, there is no South Star, since the Earth’s south pole does not point to a visible star. South of the equator, navigators used other stars or the sun, and had to make more complicated calculations.

The North Star makes a very small circle around the north celestial pole. Serious navigators have to make adjustments for this, but the North Star seems to stay in one place for the ordinary stargazer.

Going Further

1. Geography Game

Using a large world map or globe, explain that latitude is the number of degrees north or south of the equator that a place is located. Its longitude is the number of degrees east or west it is of the prime meridian. The *prime meridian* is a north-south line that runs through Greenwich England.

a. Each team of 2 students picks a secret geographic location on a world map or globe that has latitude and longitude marked.

b. They write down on a piece of paper the word *Polaris*, their names, and the longitude of their secret place.

c. Each team labels a particular chair with a second piece of paper with their names on it

d. Using a quadrant, viewing from that chair, they find a particular spot on a wall which is the altitude angle that Polaris would be from their secret geographic place. This will require some trial and error to accomplish.

f. They tape their Polaris paper from step 2 to that spot on the wall.

g. Teams challenge each other to figure out their secret places by reading the longitude on the Polaris paper on the wall, and using a quadrant to determine the latitude by measuring the altitude angle of Polaris as viewed from the designated chair. It is important that chairs not be moved.

2. What's Your Latitude at Home?

When your students have learned to locate the North Star from the activities in *Who "Discovered" America?* they can take their quadrants home, and measure the altitude of the North Star in the real night sky. Their measurement will vary ± 5°, but the class average will probably be close to the latitude of your school. You may obtain your latitude from a local airport, an atlas, your city planning office, or a United States Geological Survey map at the local library. The GEMS Teacher's Guide, *Height-O-Meters*, published by Lawrence Hall of Science, offers additional lessons focused on angular measurement for grades 6–10.

Background for Teachers

Why Does the Height of the North Star Tell Us Our Latitude?

What is the North Star?

The North Star, Polaris, is used as a navigational star in *Who "Discovered" America?* Real-life navigators use it for finding true north. All of the other stars appear to circle around the North Star once every 24 hours.

Where is the North Star in the sky?

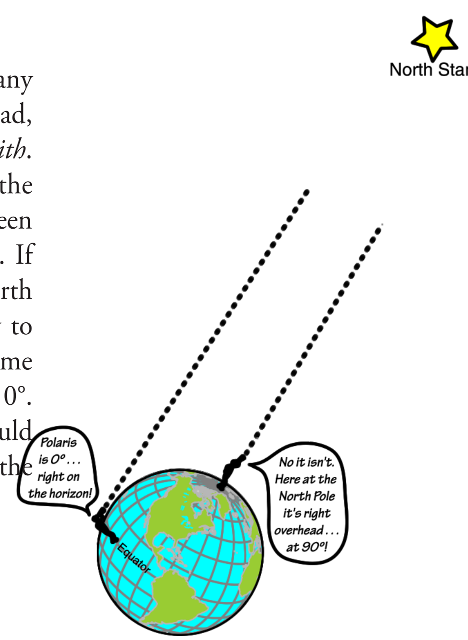
First find the Big Dipper. It is also called Ursa Major, the Big Bear. The two front stars in the bowl of the Big Dipper point to the North Star. You can then find the much fainter Little Dipper. It is also called Ursa Minor, the little Bear. The North Star is the end of the handle of the Little Dipper.

Why does the North Star seem to stay in one place?

As the Earth spins (rotates) on its axis, the Sun, Moon, planets and stars appear to rise and set. This creates the cycle of day and night. The North Pole and South Pole of the Earth point toward the same place in space throughout the year. We call the place in space where the Earth's North Pole points the *north celestial pole*. The Earth's South Pole points toward the *south celestial pole*. The North Star is within 1° of the north celestial pole. We call that star *Polaris* which means "pole star." The North Star makes a very small circle around the north celestial pole. Serious navigators in the days of Columbus had to make adjustments for this. But the North Star seems to stay in one place for the ordinary star gazer.

How does my place on Earth affect where I see the North Star?

Using an instrument called a quadrant, you can measure the altitude of any star in the sky to measure from the horizon, 0°, to the point directly overhead, 90°. The point in the sky directly over each observer's head is called the *zenith*. Your students can easily make one from a copy of the master in #2 of the "Materials" secton of PASS: *Who "Discovered" America?*. A star halfway between the horizon and the point directly overhead would have an altitude of 45°. If you were to stand on the North Pole of the Earth, you would see the North Star at your zenith. As you walk south from the North Pole (the only way to go!), you would see the North Star at a lower and lower altitude. By the time you trek to the equator, the North Star is on your horizon at an altitude of 0°. This is the same as the latitude of the equator. Below the equator you would not see the North Star at all. Unfortunately, there is no South Star, since the Earth's South Pole does not point to a visible star.



How does the North Star help you to navigate?

One of the most important tasks of navigators is to determine where they are at all times. As mentioned above, the height of the North Star above the horizon is affected by where you are on the Earth. In fact, the altitude of the North Star is a very good approximation for your latitude on Earth. If you measure the North Star's altitude to be 90° then you must be at the North Pole. If you measure the North Star's altitude to be 0°, you must be at the equator.

How accurately did Columbus read the North Star?

Details about the accuracy of using the North Star to determine latitude are not discussed in this program. However, you may be interested to know that the Earth's axis does not point precisely at the North Star, but about 1° off. Over a very long period of time—about 25,800 years—the axis of the Earth slowly drifts in a giant circle, like the slow wobble of a spinning top. This motion is called *precession*. Because of precession, in the time of Columbus the North Star was $3^1/_2°$ away from the north celestial pole, which is an important difference if you depend on it for your life. Like other navigators of his day, Columbus knew about this and used the positions of other stars in the Little Dipper to determine when the North Star was just to the left or right of the celestial pole (and not above it or below it), so that he could use his quadrant to determine his latitude accurately. When using the North Star to adjust the direction of his compass, Columbus made certain that it was just above or below the north celestial pole (and not to the left or right.)

Transparent modern magnetic compasses are available for classroom demonstration on the overhead projector. They are available from many sources (see #1 in the "Materials" section of PASS: *Who "Discovered" America*).

How Does a Compass Work?

A compass needle is a tiny magnet that is suspended so that it can turn very easily. Since the Earth itself acts like a giant magnet, the needle lines up with the Earth's magnetic field. In the northern hemisphere, the needle points towards the Earth's magnetic north pole. In most places on Earth, compass needles do not point to true north. True north refers to the Earth's geographic North Pole, around which the entire Earth turns. The difference in direction between magnetic north and true north is called *magnetic variation*. It is caused by the fact that the north magnetic pole of the Earth is not in the same place as the north geographic pole defined by the Earth's axis of rotation, and because iron in the Earth can cause local variations in the direction of the Earth's magnetic field. It is the Earth's north geographic pole that points toward the North Star.

As the ship's navigator on the Santa Maria, Columbus had to adjust the compass so that it would point true north. He did that by attaching a paper card to the needle. The needle pointed towards magnetic north. When he could see the North Star, he would adjust the card so it pointed towards the North Star or, more precisely, the north celestial pole. He then attached the card to the needle with something like tape, just as your students will do. The compass is then turned over to the helmsman, whose job it is to use the compass to steer the ship. The compass now indicates true directions so the ship's prow can be aligned with the direction they want to go. From Spain, Columbus directed the helmsman to sail southwest to the Canary Islands and then due west across the great Ocean Sea.

Your class may want to obtain the magnetic variation for your geographic area by checking a topographic or navigational map of your area. These are available from your local map shop, airport, or the United States Geological Survey.

You can also demonstrate a modern compass to show the deflection of the needle caused by a small magnet. Compass needles respond to the small magnet just as they do to the giant magnet, the Earth, where we live. You can use a regular compass and pass it around the room with a magnet for students to experiment.