ANCHORAGE MUSEUM

STARS: INTERDISCIPLINARY EXPLORATION UNIT 4. STAR NAVIGATION

BACKGROUND INFORMATION

For centuries, humans have studied star motion to reveal more about where they are and where they are going. Throughout this unit, you will use the Stellarium online tool to traverse the world, learning about how stars help us understand our location on Earth.

STUDENTS WILL:

- Observe how star movement varies depending on your location on Earth
- Discover how to tell latitude and longitude based on star observations

MATERIALS

- Computer or tablet with internet connection
- Star Navigation Challenge Activity Sheet

RECOMMENDED GRADE LEVEL

- Sixth through eighth grade

KEY TERMS

Latitude: used as a global coordinate system to help locate a position on Earth; latitude lines wrap horizontally around the Earth, are parallel, and measure distance, give in degrees north or south from the equator; lines of latitude form circles of different sizes; the largest circle is the equator (latitude = 0), while at the poles (latitude = 90), the circles shrink to a point

Longitude: used as a global coordinate system to help locate a position on Earth; longitude lines extend from pole to pole, like the segment boundaries on a peeled orange; longitude lines are a measurement of distance, given in degrees east or west of the prime meridian (longitude = 0)

ACTIVITIES

This lesson provides three activity sets and explains each of them in detail on the following pages. Activities should be completed in order. Challenge questions are listed under each activity. You can also print the Challenge Activity sheet, which follows the Stellarium Appendix.

1. **Activity 1:** Star Motions
2. **Activity 2:** Polaris Observations
3. **Activity 3:** Earth Locations

ACTIVITY 1

Star Motions [15-20 minutes]

Open Stellarium online tool: https://stellarium-web.org/

Follow these steps:

Go to the 'Location on Earth' menu. Turn off 'autolocation'. Set location to Anchorage, Alaska. Make sure to click the 'use this location' button. You are now seeing how the sky looks from Anchorage. Turn 'atmosphere' off ('cloud with sun' button at bottom of screen). This lets us see how stars move regardless of whether the sun is up. Make sure 'landscape' is on ('hill with trees' button at bottom of screen). This lets us see the horizon line.

Challenge Questions:

Move the cursor so you look East. Open the 'Date/Time' menu and move the blue slider all the way to the left. Now, slowly move the slider to the right to move forward through time. Observe the stars' motion.

1. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

Move the cursor so you are looking West. Move time forward again and observe the stars' motion.

2. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

Move the cursor so you are looking North. Move time forward again and observe the stars' motion.

3. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

Go to the 'Location on Earth' menu and set location as Portland, Oregon. You are now seeing how the sky looks from Portland.

4. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
5. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
6. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

ACTIVITY 1 CONTINUED

Change your location to Honolulu, Hawaii

7. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
8. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
9. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

Change your location to Quito, Ecuador

10. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
11. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
12. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

Finally change your location to North Pole (NOT North Pole, Alaska)

13. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
14. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
15. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.
16. For a new perspective, zoom out and move your cursor so you see a 'planetarium view' of the entire sky (a circle showing the entire sky). Move forward through time. What is unique about how stars move at the North Pole compared to all the other locations you tried?

ACTIVITY 2

Polaris Observations [15-20 minutes]

Using Stellarium change location to Anchorage. Use the search box to locate the star Polaris. Zoom out enough to see what happens to Polaris as you move forward through time.

Challenge Questions:

1. As we move forward in time, how does Polaris move?
2. How do the stars around Polaris move?

Observe Polaris and the stars around Polaris for each of the previous locations. At each location, compare the position of Polaris in the sky and note if it is similar or different from the previous location. Move forward in time to see if the stars around Polaris change how they move.

Portland, Oregon

3. Polaris observations
4. Other stars observations

Honolulu, Hawaii

5. Polaris observations
6. Other stars observations

Quito, Ecuador

7. Polaris observations
8. Other stars observations

North Pole

9. Polaris observations
10. Other stars observations

Polaris is the North Star for the northern hemisphere of Earth. As the Earth rotates, the area directly overhead the North Pole does not seem to move. Polaris is close to the Earth's axis of rotation, so Polaris appears to stay stationary and other stars appear to move in a circle around Polaris because the Earth is rotating.

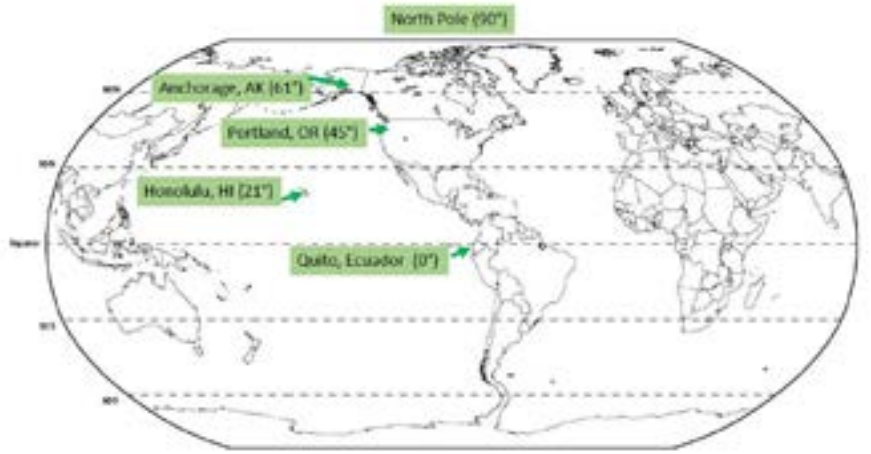
ACTIVITY 3

Earth Locations [15-20 minutes]

You will continue to use Stellarium to connect your star observations for how stars can be used for navigation.

Challenge Questions:

1.
   a. What happened to Polaris as we moved from Anchorage to Portland to Honolulu and finally Quito?



Latitudes for these locations:
Anchorage, AK = 61.17458°
Portland, OR = 45.52025°
Honolulu, HI = 21.30455°
Quito, Ecuador = -0.22016°
North Pole = 90°

b. Find the altitude of Polaris at each location. *Hint: Search for Polaris at each location and look for Az/Alt in the information box. The second number listed in degrees (°) is the Alt or altitude.* Write down the altitude for Polaris at each location.

Anchorage, AK =
Portland, OR =
Honolulu, HI =
Quito, Ecuador =
North Pole =

2. Are there any similarities between the latitudes of the locations and the altitudes of Polaris at each location?

As you have observed, the altitude of Polaris matches very closely with the latitude on Earth. Early explorers used many different instruments to measure the angles of different stars, including Polaris, to figure out where they were on Earth.

3. How would using stars like Polaris help in navigation around the world?
4. Can you think of any potential problems with navigating this way?

This method helps with locating your latitude on Earth but still does not address figuring out your longitude. For this, use the website below to explore the seas and learn about longitude. Click 'set sail' on the homepage:

https://www.pbs.org/wgbh/nova/longitude/find/

The below website provides a sample calculation to help you find your longitude:
https://www.pbs.org/wgbh/nova/longitude/find/samplea.html

5. How many degrees does the Earth rotate in 12 hours?

This product is supported by NASA's Universe of Learning, in partnership with Smithsonian Affiliations.
This product is based upon work supported by NASA under award numbers NNX16AC65A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

STELLARIUM APPENDIX

Stellarium is a free, open source planetarium for your computer. Stellarium works on multiple computer operating systems including Windows, Mac and Linux, as well as through an online interactive, stellarium-web. The below How To Guide offers basic instruction for how to utilize the online softward and an introduction to the different interactive elements.

1. GETTING STARTED

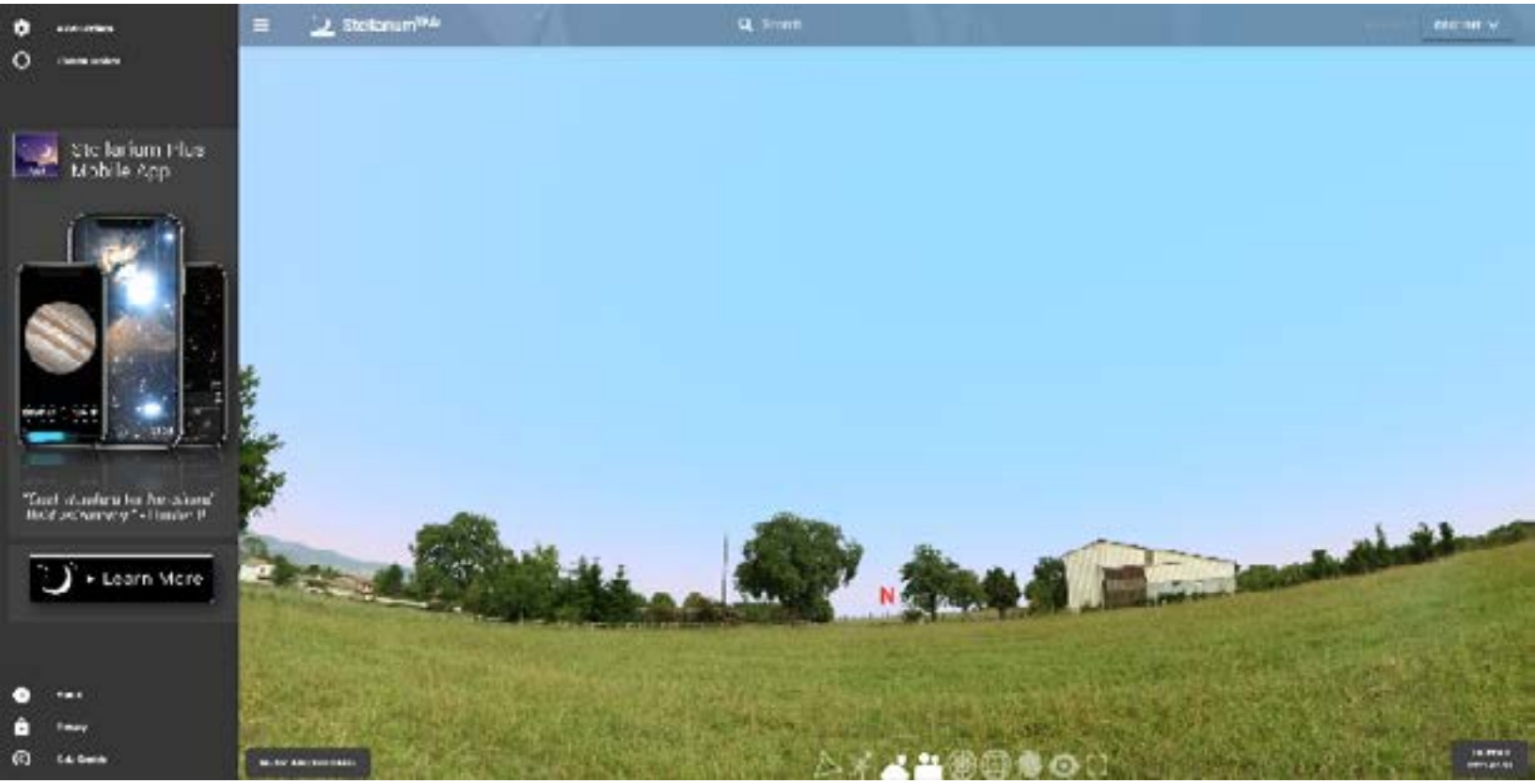
This is the home screen for stellarium-web. There are five main menus and a search box visible at all times. The following images go through each menu and interactives for each.

STELLARIUM APPENDIX

2. SETTINGS MENU

View Settings
Turn on/off milky way, deep sky objects, meridian line, ecliptic line and if you want to simulate the atmosphere's refraction (bending) of light.

Planets Tonight
See which planets are visible and what time they will rise and set.



STELLARIUM APPENDIX

3. OBSERVER TOOLS

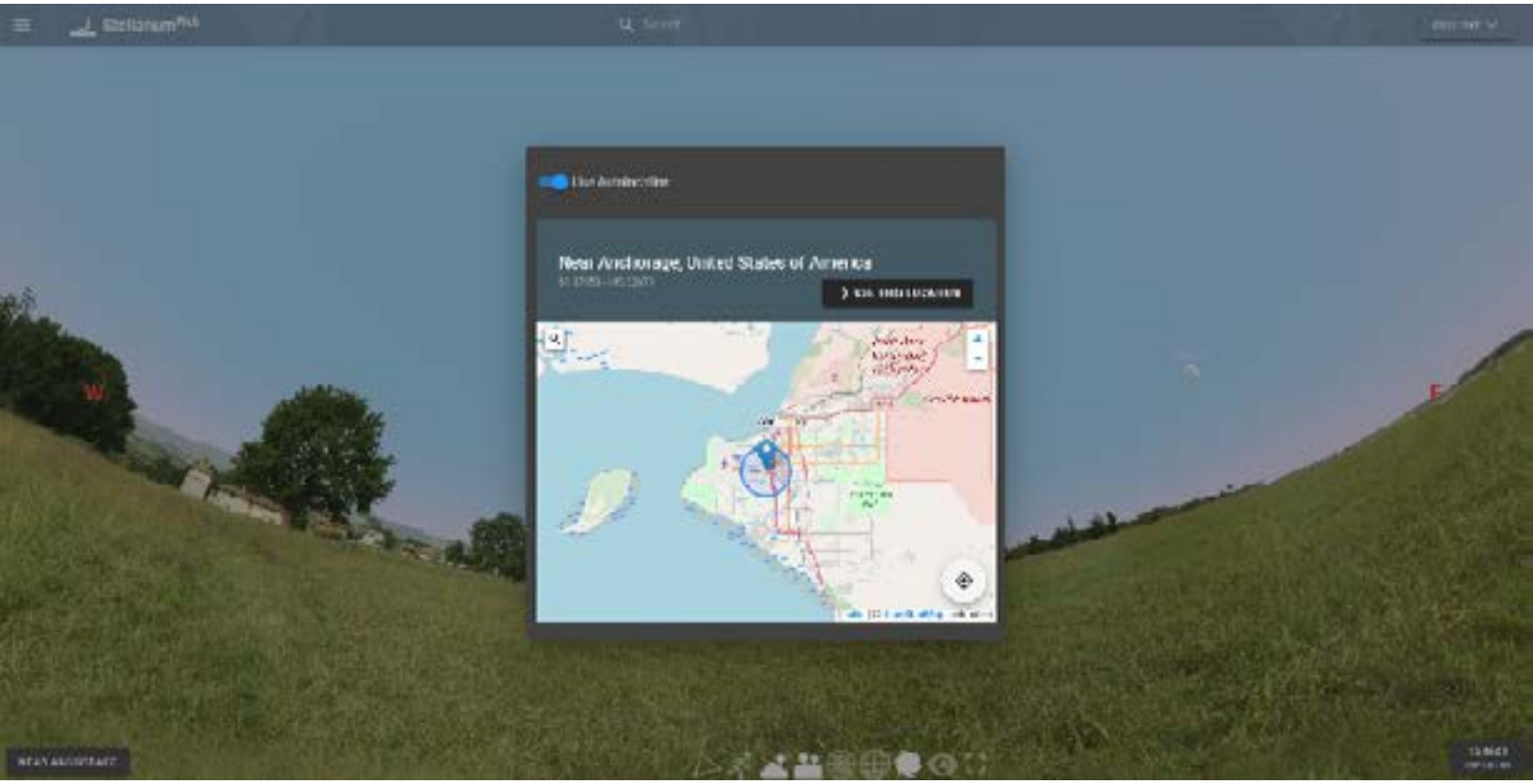
My Observations
Option to use NoctuaSky to keep a journal of night observations.

Calendar
Displays a list of night sky events to look forward to including moon phases and locations of planets in their orbits.

STELLARIUM APPENDIX

4. LOCATION ON EARTH

Location on Earth
Pick your location on Earth or choose to use autolocation.



STELLARIUM APPENDIX

5. DATE/TIME MENU

Date
Change the date by clicking the up or down arrows.

Time
Change the time by clicking the up or down arrows, or by dragging the blue slider bar. Stellarium uses the 24-hour clock.

Pause/Now
The center buttons can either pause time or go back to the current time.

STELLARIUM APPENDIX

6. MOUSE ZOOM IN/OUT AND CHANGING PERSPECTIVES

Zoom in
Use the scroll wheel on the mouse to zoom in to an object, or make the ground/horizon flat.

Zoom out
Use the scroll wheel on the mouse to zoom out and get 'planetarium' perspective.

Zoomed out all the way looking straight up ('planetarium')

Zoomed in looking North

Zoomed in looking East

Zoomed in looking South

Zoomed in looking West

STELLARIUM APPENDIX

7. LEARNING MORE ABOUT OBJECTS: INFORMATION BOX

Left mouse click

Use the mouse to select objects like stars, planets, and deep sky objects to learn more. Once an object is selected, an information box appears in the upper left corner of the screen. In this box, there are facts about the object and helpful links to discover more information.

Bullseye icon

The bullseye button, located below the lower right corner of the information box, centers the object that you have selected.

STELLARIUM APPENDIX

8. BOTTOM CENTER TOOLBAR: NINE TOGGLE BUTTONS

1. Constellations
Turns all constellation lines on/off

2. Constellations Art
Turns all constellation art on/off

3. Atmosphere
Turns Earth atmosphere on/off

4. Landscape
Turns Earth landscape on/off

5. Azimuthal Grid
Turns azimuthal grid on/off

6. Equatorial Grid
Turns equatorial grid on/off

7. Deep Sky Objects
Turns DSO (i.e. galaxies) on/off

8. Night Mode
Turns a red light on/off

9. Fullscreen
Covers entire screen

1 2 3 4 5 6 7 8 9

STAR NAVIGATION
CHALLENGE ACTIVITY SHEET

ACTIVITY 1. Star Motions

How the sky looks from Anchorage, Alaska.

1. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

2. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

3. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

How the sky looks from Portland, Oregon.

4. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

5. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

6. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

How the sky looks from Honolulu, Hawaii.

7. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

8. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

9. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

STAR NAVIGATION
CHALLENGE ACTIVITY SHEET

ACTIVITY 1 CONTINUED

How the sky looks from Quito, Encuador.

10. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

11. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

12. What are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

How the sky looks from the North Pole (NOT North Pole, Alaska).

13. Looking East, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

14. Looking West, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

15. Looking North, what are the stars doing? Describe how they are moving or draw a picture to represent a star's path.

16. For a new perspective zoom out and move your cursor to see a 'planetarium view' of the entire sky (a circle showing the entire sky). Move forward in time. What is unique about how stars move at the North Pole compared to all the other locations we have tried?

ACTIVITY 2. Polaris Observations

How the sky looks from Anchorage, Alaska.

1. As we move forward in time, how does Polaris move?

STAR NAVIGATION
CHALLENGE ACTIVITY SHEET

ACTIVITY 2 CONTINUED

2. How do the stars around Polaris move?

How the sky looks from Portland, Oregon.

3. As we move forward in time, how does Polaris move?

4. How do the stars around Polaris move?

How the sky looks from Honolulu, Hawaii.

5. As we move forward in time, how does Polaris move?

6. How do the stars around Polaris move?

How the sky looks from Quito, Ecuador.

7. As we move forward in time, how does Polaris move?

8. How do the stars around Polaris move?

How the sky looks from the North Pole.

9. As we move forward in time, how does Polaris move?

10. How do the stars around Polaris move?

STAR NAVIGATION
CHALLENGE ACTIVITY SHEET

ACTIVITY 3. Earth Locations

1.

a. What happened to Polaris as we moved from Anchorage to Portland to Hawaii and finally to Quito?

b. Write down the altitude for Polaris at each location:

Anchorage, AK =
Portland, OR =
Honolulu, HI =
Quito, Ecuador =
North Pole =

2. Are there any similarities between the latitudes of the locations and the altitudes of Polaris at each location?

3. How would using stars like Polaris help in navigation around the world?

4. Can you think of any potential problems with navigating this way?

5. How many degrees does the Earth rotate in 12 hours?

STAR NAVIGATION
ANSWERS SHEET

ACTIVITY 1. Star Motions

Anchorage, Alaska

1. Stars are rising and moving diagonally up to the right.
2. Stars are setting and moving diagonally down to the right.
3. Stars move in a counterclockwise motion. Stars near the horizon move diagonally up to the right.

Portland, Oregon

4. Stars are rising and moving diagonally up to the right. The movement up is a little steeper than in Anchorage.
5. Stars are setting and moving diagonally down to the right. The movement down is a little steeper than in Anchorage.
6. Stars move counterclockwise but more stars rise and set than in Anchorage.

Honolulu, Hawaii

7. Stars rise and move slightly up to the right, but almost straight up. The movement is steeper up than in Portland.
8. Stars set and move slightly down to the right, but almost straight down. The movement is steeper down than in Portland.
9. Stars move counterclockwise but even more stars rise and set than in Portland.

Quito, Ecuador

10. Stars rise straight up with no rightward movement.
11. Stars set straight down with no rightward movement.
12. Stars move counterclockwise and almost all of them rise and set.

North Pole

13. Stars move completely sideways to the right. Nothing rises.
14. Stars move completely sideways to the right. Nothing sets.
15. Stars move completely sideways to the right.
16. At the north pole, stars do not rise and set. Everything stays above the horizon throughout the entire day.

STAR NAVIGATION
ANSWERS SHEET

ACTIVITY 2. Polaris Observations

Anchorage, Alaska

1. Polaris does not seem to move.

2. Stars move counterclockwise around Polaris.

Portland, Oregon

3. Polaris moved closer to the horizon (ground) but still does not seem to move.

4. Stars move counterclockwise around Polaris.

Honolulu, Hawaii

5. Polaris moved closer to the horizon and does not move.

6. Stars move counterclockwise around Polaris.

Quito, Ecuador

7. Polaris moved just above the horizon. Here you can tell it moves a little, making a small counterclockwise circle.

8. Stars move counterclockwise around Polaris.

North Pole

9. Polaris is directly above us and it is hard to see if you do not zoom all the way out to see the entire sky ('planetarium' view).

10. Stars move counterclockwise around Polaris.

11. Stars move completely sideways to the right.

12. At the north pole, stars do not rise and set. Everything stays above the horizon throughout the entire day.

ACTIVITY 3. Earth Locations

1.
   a. Polaris got closer and closer to the horizon.
   b. Anchorage, AK = 61°
      Portland, OR = 45°
      Honolulu, HI = 21°
      Quito, Ecuador = 00°
      North Pole = 89°

STAR NAVIGATION
ANSWERS SHEET

ACTIVITY 3 CONTINUED

2. The latitudes of each location and altitudes of Polaris are practically equal, only differing by, at most, 1°.

3. By measuring the altitude of Polaris, explorers could figure out what their latitude was on Earth.

4. Using Polaris only works in the northern hemisphere and only if it is clear out to see the right stars.

5. The Earth rotates 180° in 12 hours. It rotates 360° in 24 hours or one day.