What's Moving?

Summary of Activity

This lesson is designed to help students make connections between the movements of the Sun in the sky, the Sun on the horizon, and how these apparent motions are caused by the Earth revolving around the Sun.

This lesson will help students understand both the geocentric perspective as well as the heliocentric perspective. The geocentric or Earth-based perspective tracks the Sun's movement on the horizon as seasons change. The heliocentric or space-based perspective tracks the Earth's movement or revolution around the Sun as seasons change.

Each student will role play, pretending that their head is the "Earth." By mimicking the motion of the Earth around the Sun, the students will understand what they observe while on the Earth: the Sun moving along the horizon, back and forth on a yearly cycle, as the seasons change. They will also understand what is happening in space as the Earth revolves around the Sun.

Living Maya Time Website Connections

This activity provides an example of how the ancient Maya observed the movements of the Sun along the horizon using buildings and temples as markers. These observations allowed Maya astronomers to predict seasonal change and enabled them to plan their agricultural and ceremonial cycles. Today, Maya farmers still observe the movements of the Sun and use its apparent motion to plan the planting of corn and their ceremonial calendar.

Students should watch the following resources from the *Living Maya Time* website ahead of time:

- The entire *Maya Sun* section
- *Corn and Calendar Traditions* in the *Corn and Maya Time* section

Objectives

Students will learn that:

- Most objects in the Solar System, including the Earth, are in regular and predictable motion; these motions explain such phenomena as the day and the year.
- The position of the Sun in the sky changes throughout the day.
- The position of sunrise and sunset along the horizon in the sky changes throughout the year.
- The Sun has patterns of movement that can be observed and recorded; one way is by observing and recording shadows cast by the Sun.
- The Sun's apparent movement reflects the Earth's daily spin on its axis.

- The Earth's nearly circular yearly orbit around the Sun causes us to see the point of sunrise and sunset move back and forth along the horizon at different times of the year:
  - The point of sunrise on the horizon is furthest north on the June solstice[1], and the Sun appears to stand still, rising at the same spot on the horizon for a few days.
  - The point of sunrise on the horizon is furthest south on the December solstice, and the Sun appears to stand still, rising at the same spot on the horizon for a few days.
  - On the equinoxes, the point of sunrise on the horizon is half way between where the Sun rises on the summer and winter solstices, and the Sun is moving fast from day to day along the horizon at this time.

Students will be able to:

- Predict how the point of sunrise moves in the horizon as the year progresses.
- Predict and mimic how the Earth moves around the Sun as the year progresses.
- Develop an understanding of the Earth's rotational motion and identify the cause of the Sun's apparent motion in the sky.
- Develop an understanding of the Earth's motion around the Sun (revolution) and identify the cause of the Sun's apparent motion along the horizon.
- Make connections between the geocentric and heliocentric perspectives in the context of ancient observations of the Maya and other cultures.
- Identify connections between the movements of the Sun, cyclical time, and calendars.

Grade Level

Grades 6-8

National Science Education Standards Addressed

- Observing, measuring, and identifying properties
- Seeking evidence
- Recognizing patterns and cycles
- Identifying cause and effect and extending the senses

Physical Science

- Position and motion of objects

Earth and Space Science

- Objects in the sky
- Changes in Earth and sky

Duration of Activity

Two 1-hour periods

[1] Definitions for the words in red-colored font can be found in the Glossary page in the Resources section of the *Living Maya Time* website.

Student Prerequisites

Students should:

- Have the ability to notice patterns of change.
- Have a basic knowledge of Earth's rotation and revolution.
- Have a basic knowledge of the apparent motion of the Sun in the sky.
- Have a basic knowledge of the seasons.
- Explore the *Living Maya Time* website in advance of doing the activity.

Materials

- A 100-200 watt bulb on a stand in the middle of a darkened room to serve as your "Sun"
- One "Horizon Template" (at the end of this document) for each student copied onto card stock paper
- String and tape (several packs)
- Scissors (several pairs)
- 1 Earth globe
- 30 color markers (10 each in red, green, and blue)

Teacher Preparation

- Print one "Horizon Template" on card stock for each student
- Set up the room as described below
- Read Teacher's Notes section below
- Explore the Living Maya Time website in advance

Room Set Up

Find a room that can be darkened (a room without windows is best; or cover the windows with dark paper). Attach the "Sun" (your bulb or light fixture) to a chair in the middle of the room; or use a lamp without the shade, and stand it on a chair in the middle of the room. Tape any cords down so students can not trip over them. Your students will walk around this "Sun" in a circle, so be sure to make space for the students by clearing any furniture, etc. to the edges of the room. Place a sign labeled "North Star" up high on the wall that is on the north side (or closest to the north side) of your room.

Procedure

1. Begin the activity by finding out your students' existing knowledge of the movement of the Sun along the horizon throughout the year (geocentric perspective) and about what they might know is happening in space (heliocentric perspective). Here are a few example prompting questions you might ask:
    - How long does it take for the Earth to revolve, or orbit, around the Sun in one complete cycle?
    - What happens to the seasons as the Earth revolves around the Sun?
    - When it is winter in your town, where does the Sun rise or set? How is that different from summer or spring?
    - Have you ever watched the Sun rise or set on the horizon, by standing on the same spot each day, for a period of several days or weeks? What did you notice?
    - What do you think causes the Sun to move along the horizon back and forth as the seasons change?

Ask your students to pair up and consider these questions, discuss them, and then ask a few pairs from the group to share with everyone.

2. Make the "Headband" Horizon

   Distribute one cardstock "Horizon Template" to each participant; ask that they work in pairs, and make string, scissors, and tape available. Have one template ready made for demonstration purposes.

   Give these instructions verbally to the students, as you build your template:

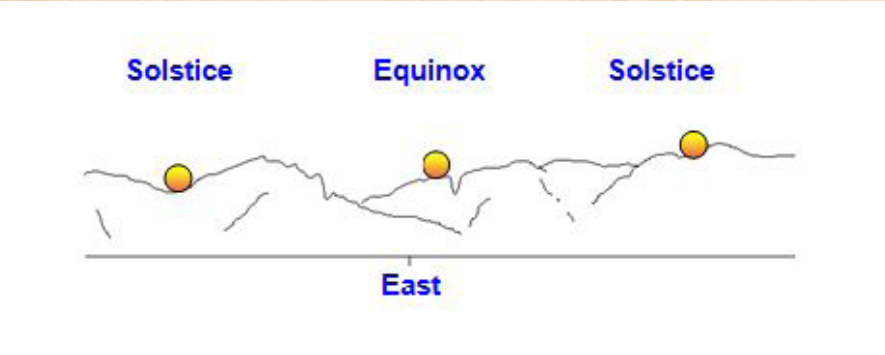
   Cut the template along solid lines. Punch a hole in the little circles. Take the ends of the two long strips and tape them in the middle to make one longer strip (leaving the little holes at either end). Pass a piece of string about 10 inches long through each hole and tie at each hole. Tie the headband vertically around the head of your partner with the string tied below the chin. Take the two flaps and bend the little strips back along the dotted line. Fit each flap in front of your partner's ears, by placing the little bent strips on top of the headband and taping them in place.

3. Set up the room as instructed above.
4. Ask students to stand in a circle around the "Sun" lamp, and turn lamp on. Leave the room lights on for now. Explain that each of them will pretend that their head is the Earth, and the white flaps are the horizon, east and west.
5. Using the Earth globe, demonstrate how the Earth rotates on its axis, with the North Pole pointing to the "North Star" clock or fixture in your room. This demonstrates one day or a 24 hour period. Turn room lights off.
6. Ask the students to point their "North Pole" (top of their head) to the North Star, and, holding on to their headbands with their hands behind the flaps, have them rotate in place to demonstrate earth's daily rotation, keeping their head pointed to the North Star (this can be challenging!). To rotate in the proper way, their heads should spin from right to left.
7. Ask students to spin so that it is noon (their nose will point to the Sun); and midnight (the back of their head will point to the Sun).
8. Using the Earth globe, demonstrate how the Earth revolves about the Sun, with the North Pole always pointing to the "North Star" – make one complete revolution, pointing out when it is summer in your latitude and when it is winter (the solstices), also pointing out the equinoxes for fall and spring. (Don't worry about daily rotation for this part of the demo, so you can hold the globe steady so that it won't spin).
9. Ask students to spin in place again, with the top of their head pointed to the North Star. Have them notice how the "Sun" rises and sets as they spin in place, as they look towards the light bulb along their

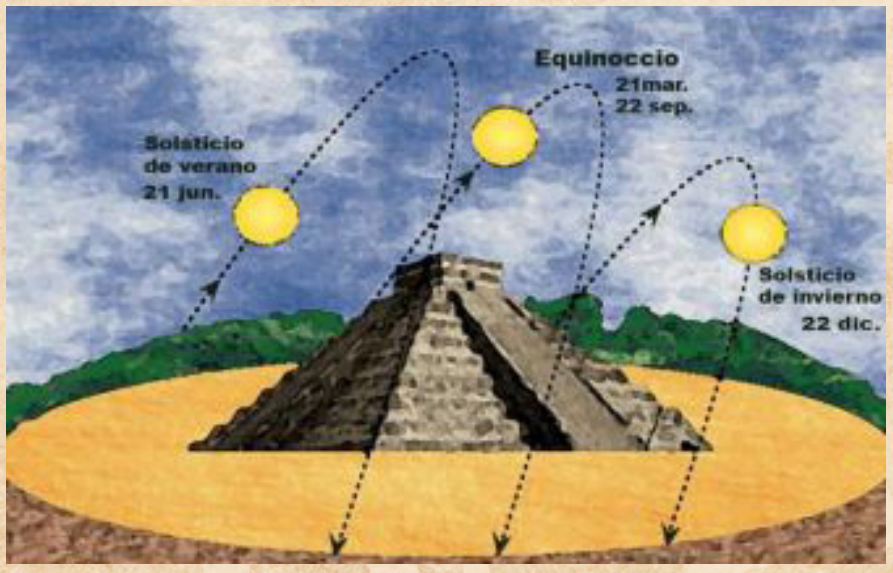
"horizon flap" and to take note where along their paper flap horizon they see the "Sun" rise or set. Depending on where they are standing in the circle, they will see the "Sun" rise and set either toward the top of the flap, the middle of the flap, or the bottom of the flap.

10. Ask students to walk one quarter circle around the room and stop. Repeat the spinning motion to mimic one day, or 24 hour period. (Remember to ask them to always point the top of their heads, the North Pole, towards the North Star, and to spin their heads from right to left). Ask them to notice how the "Sun" rises and sets as they spin in place, and to take note where along their paper flap horizon they see the "Sun" rise or set (was it top, middle, or bottom of the flap?).
11. Repeat Step 10 two more times to make one complete revolution (1 year) around the Sun (students should end where they began in the room). Students should be able to tell you at each quarter turn whether it is summer, fall, winter, or spring. Depending on the season, they will see the "Sun" rise or set as follows: (a) along their flap's bottom toward the south (winter in the northern hemisphere); (b) along their flap's middle (at both equinoxes; spring and fall); and (c) along their flap's top toward the north (summer in the northern hemisphere).

12. Repeat the whole sequence (steps 9-11) but this time, have students work in pairs. Each pair will spin at each quarter turn, but after they spin, taking turns, they will draw a line on each other's' horizon flaps showing where they see the Sun rising at that location on the orbit. (It helps to use red for summer solstice, blue for winter solstice, and green for the equinoxes). Complete one whole yearly revolution.
13. By drawing the three colored lines on the horizon, the students can see how the revolution of the Earth around the Sun (heliocentric perspective) results in the motion of the Sun back and forth along the horizon (geocentric perspective).
14. Take your own flap off your head, and place in the middle of the room where the "Sun" lamp is. Lay the headband flat so that the horizon flaps are horizontal, pointing east/west. Un-clamp the "Sun" lamp and move it as if it were the real Sun rising and setting, from east to west, as seen in the geocentric perspective. Move the lamp to make an arch in the sky above the horizon flaps, going from south to north as we move from winter to summer in the northern hemisphere (opposite for the southern hemisphere). Show some images of the way native astronomers used features in the horizon to track the solstices and equinoxes, and how others used buildings constructed for that purpose. (See illustrations on next page).



Above: This illustration shows how one can use features in the horizon to track the passage of the seasons.



Above: This illustration shows an example of how we can observe the Sun move along horizon or with respect to a pyramid as the seasons change. The left position corresponds to "Summer Solstice on 21 June," the middle position corresponds to "Equinoxes on 21 March and 22 September," and the right position corresponds to "Winter Solstice on 22 December."

Discussion

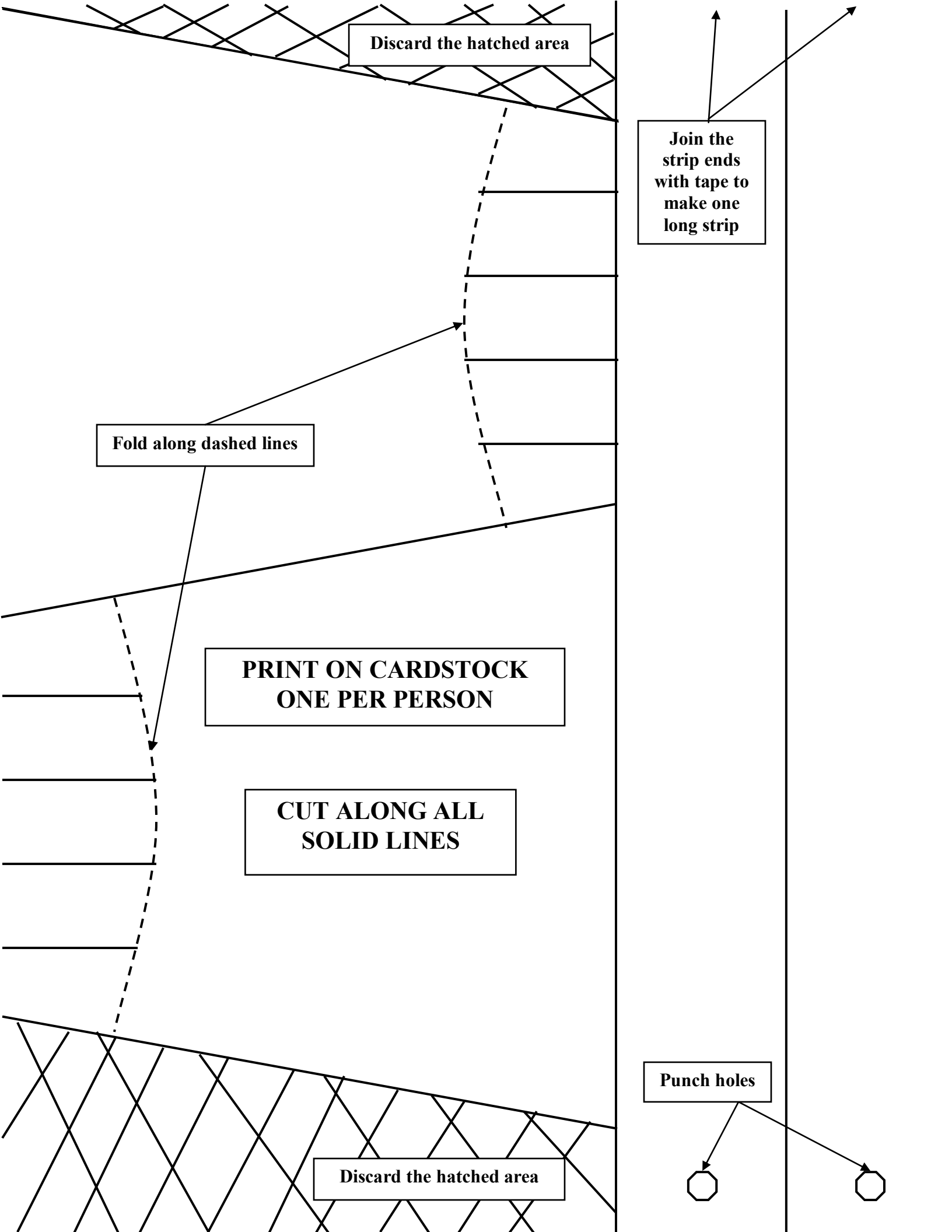
Ask the students the question: "What's Moving, the Sun or the Earth?" Well, the answer really depends on your perspective – in the geocentric perspective, the Sun moves, and in the heliocentric perspective, the Earth moves. This activity bridges both perspectives.

Assessment

Design an assessment with a set of questions that students will answer individually or in groups. Below are sample questions.

- How does the Sun move during the day, from sunrise to sunset, from the perspective of an observer on Earth?

- How does the Sun move during the day, from sunrise to sunset, from the perspective of an observer in space?
- How does the Earth move during the day, from sunrise to sunset, from the perspective of an observer on Earth?
- How does the Earth move during the day, from sunrise to sunset, from the perspective of an observer in space?
- What is the North Star? What is its relationship to the Earth's axis?
- What causes the apparent motion of the Sun along the horizon throughout the year? Draw a fictional horizon and the motion of the Sun, marking the solstices and equinoxes, and approximate dates when they happen.


Discard the hatched area
Join the strip ends with tape to make one long strip
Fold along dashed lines
PRINT ON CARDSTOCK ONE PER PERSON
CUT ALONG ALL SOLID LINES
Punch holes
Discard the hatched area