

Kinesthetic Astronomy for Utah 4th Grade SEEd Standards

This activity is adapted (with permission) from Kinesthetic Astronomy, Sky Time lesson developed by Cherilynn Morrow and Michael Zawaski. © Dr. Cherilynn A. Morrow and Michael Zawaski

For the original Kinesthetic Astronomy lesson plan and related resources, visit:

<https://www.space-science.org/eduresources/kinesthetic.php>

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UTAH SCIENCE WITH ENGINEERING EDUCATION (SEEd) STANDARDS GRADE 4

Strand 4.4: OBSERVABLE PATTERNS IN THE SKY

The Sun is a star that appears larger and brighter than other stars because it is closer to Earth. The rotation of Earth on its axis and orbit of Earth around the Sun cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the Sun and stars at different times of the day, month, and year.

Standard 4.4.1 Construct an explanation that differences in the apparent brightness of the Sun compared to other stars is due to the relative distance (scale) of stars from Earth. Emphasize relative distance from Earth. (ESS1.A)

Standard 4.4.2 Analyze and interpret data of observable patterns to show that Earth rotates on its axis and revolves around the Sun. Emphasize patterns that provide evidence of Earth's rotation and orbits around the Sun. Examples of patterns could include day and night, daily changes in length and direction of shadows, and seasonal appearance of some stars in the night sky. Earth's seasons and its connection to the tilt of Earth's axis will be taught in Grades 6 through 8. (ESS1.B)

Phenomena:

- **Apparent motion of the Sun. The Sun appears to rise in the east, move across the sky, and set in the west. This pattern repeats every day.**
- **Different stars and constellations are visible at different times of year. This pattern repeats every year.**

INSTRUCTIONS for ASSEMBLY and SET-UP of the ZODIAC SIGNS

MATERIALS:

- Ball or other object to represent the Sun
- 12 laminated cards labeled with the names of the Zodiac constellations
- 4 signs labeled with titles and dates of two equinoxes and two solstices on Earth
- For each student: a laminated map of North America and “E” and “W” signs

BACKGROUND AND INTRODUCTION: The planets orbit the Sun in almost exactly the same plane. The Zodiac is a band of constellations (e.g. Leo, Aries, etc.) made of distant stars that lie in the same plane as the Sun and planets. These stars are far outside the Solar System, but still within the Milky Way Galaxy. Because these constellations happen to be in the same plane as the Solar System, when we look out into space, we see these constellations as the “backdrop” for the apparent motions of the Sun, Moon, and planets. For Kinesthetic Astronomy lessons, we place these constellations outside the circle of students who are representing Earth’s position around the Sun at different times of year. All models are inaccurate in some way. This curriculum will address inaccuracies of size and distance.

LOCATION/SETTING:

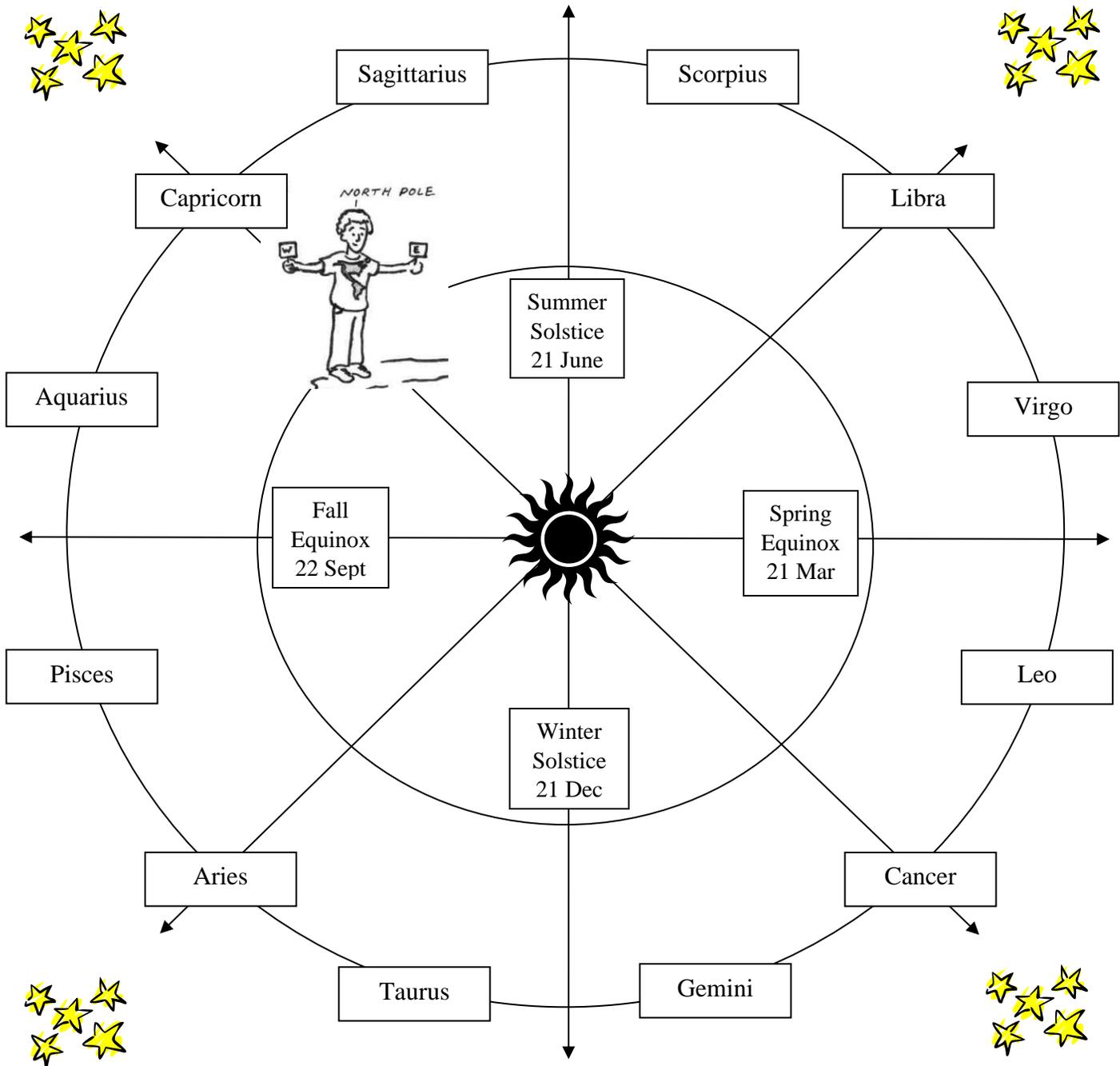
An indoor or outdoor space large enough for your students to form a circle with arms outstretched to their sides. (For a class of 25-30 students, this is about half a basketball court.) This lesson is best with at least eight students participating.

PROCEDURE FOR SETTING UP THE ZODIAC for KINESTHETIC ASTRONOMY

- 1) Determine where you will set up the Kinesthetic Circle with the “Sun” at the center.
- 2) Mark off the solstices and equinoxes:
 - a) Select Earth’s position on 21 June, the summer solstice. Place the “Summer Solstice” sign on the ground as in the Zodiac Diagram.
 - b) Circle the Sun in a *counterclockwise* direction for $\frac{1}{4}$ of an orbit. Place the “Fall Equinox” sign.
 - c) Place the “Winter Solstice” and “Spring Equinox” signs accordingly.
- 3) Mark off the constellations of the Zodiac:
 - a) Return to the Summer Solstice position. Face away from the Sun – midnight on the Summer Solstice. Place Sagittarius slightly to your left and Scorpius slightly to your right.
 - b) Place the remaining Zodiac signs as shown in THE ZODIAC DIAGRAM. Hanging the signs from chairs or taping them to the wall at the height of the ball representing makes them more readable to students in the Kinesthetic Circle.
- 4) Remove the Season solstice/equinox signs until they are called for in the lesson.

THE ZODIAC DIAGRAM

The diagram below depicts the modern order of the Zodiacal constellations relative to the Sun (*not to scale*). It also indicates Earth's approximate orbital locations at the two solstices and two equinoxes. The boy represents Earth on the Kinesthetic Circle (as defined in the "Sky Time" lesson).



Astronomical Meaning of a Day

Phenomenon: Apparent motion of the Sun. The Sun appears to rise in the east, move across the sky, and set in the west. This pattern repeats every day.

Why does the Sun appear to do this? We can **construct an explanation** by **using a model**. In our model this ball will represent the Sun and each of you will represent Earth.

The Proper Size-Distance Scale for the Sun, Earth, and Stars

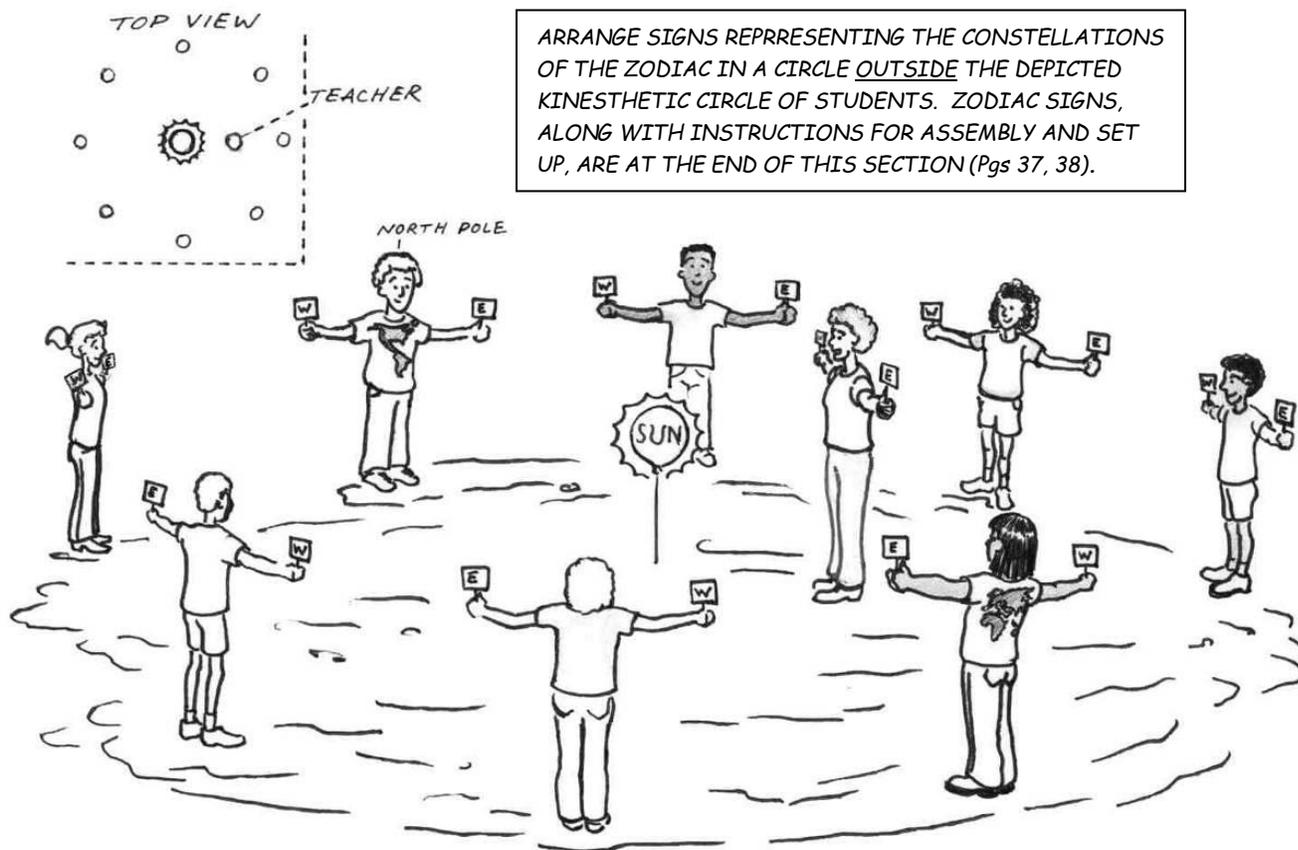
1. Gather students at one end of a space at least 45 feet long. Use a 5 inch diameter ball (included in the kit) to represent the size of the Sun (of course it is really 10 billion times bigger around).
2. Ask students to use their hands to predict how big Earth would be compared to the ball on this 1:10 billion scale. When students have shown you their predicted sizes of Earth, tell them that on this scale Earth would only be as big as the tip of a ballpoint pen. [The Sun has a diameter 100 times that of Earth.]
3. Ask students to walk as far away from the ball Sun as they predict the pen-tip Earth would be located in the scale model.
4. When students have arrived at their predicted locations, pace out the 45 feet to where Earth belongs. Gather the class around you and explain that in the scale model, Earth would be 45 feet away. [The actual Earth-Sun distance is 93 million miles.] Also tell them that the planet Pluto would be 0.5 mile away.
5. Ask: "What is the next closest star to our Sun?" [Alpha Centauri]. "How far is this star is from our Sun?" [4.3 light-years]. NOTE: a "light-year" is the distance light travels in one year = about 6 trillion miles.
6. Tell students to assume that the ball Sun is located in Salt Lake City, UT. Ask: "In the scale model, where would the next "ball" (Alpha Centauri) be?" [The nearest star would be represented by another ball about 2250 miles away. That's like having the Sun (5 inches) in Salt Lake City and the nearest star just past New York City!]

Object	Diameter (Scaled)	Distance from the Sun (Scaled)
Sun	5 in = ball or large grapefruit	0
Earth	.05 in = tip of ballpoint pen	45 feet
Alpha Centauri	5 in = ball or large grapefruit	2250 miles

7. Tell students that the Sun and Alpha Centauri are only two of about 250 billion stars in our galaxy called the Milky Way, and that the Milky Way is one of more than 100 billion galaxies in a very large Universe.

The Kinesthetic Astronomy Circle

8. Signs representing the constellations of the Zodiac should be assembled and placed before students arrive (see the setup procedure on pages 2-3). Place the 5 inch yellow ball at the height of an average students' chest to represent the symbolic Sun at the center of our Solar System.
9. Ask students to arrange themselves in a circle around the central object representing the Sun. This circle of students should be inside the surrounding Zodiac constellations (not depicted below). Students should have room to rotate with their arms outstretched to the sides.



All drawings of students by Andrew Sanchez

10. Tell students that each of their bodies represents planet Earth. Point out the symbolic Sun at the center and the signs representing the constellations of the Zodiac (the Zodiac signs are not depicted above).
11. Remind students of the true scale model with the ball "Sun" and pen-tip "Earth" located 45 ft away.

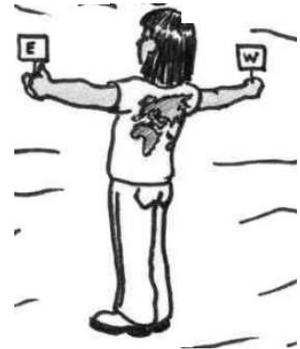
NOTE: The “E” and “W” signs are not needed until Step 21.



Body Geography: Our Bodies as Planet Earth [ST 7]

12. Students should be standing around the Kinesthetic Circle, facing the center. Remind students that each of their bodies represents the entire planet Earth.
13. Ask students to touch their “North Pole”. [Top of their head.]
14. Tell students their “South Pole” is located at the bottom of their spine – their tailbones.
15. Ask: “Where is the equator?” [About where the chest meets the belly; encircling the body.]
16. Ask: “What hemisphere is above the equator?” [Northern] “What hemisphere is below the equator?” [Southern]
17. Tell students to imagine that North America is located on their chest. Have students put one hand on their “North America”.

18. Ask students to touch their “South America”? [Lower left belly]
19. Gesture toward your upper back and ask: “What is on the other side of Earth from North America? [China, Asia.]
20. Ask: “Where is Australia?” [Lower right back – “Down Under”.]



21. **Give each student a “North America” map to wear on their chest. Give each student both an “E” and “W” sign.**
22. Remind students that North America is on their chest. Ask: “Which of your hands is eastward (towards New York on the US map) and which is westward (towards California on the US map)?” Give students a minute or so to think and discuss with neighbors.
23. Tell students to put their “E” sign in their “eastward” hand and the “W” sign in their “westward” hand. [Students should have their “E” in their left hand to indicate an eastward direction and their “W” in their right to indicate westward.]

TEACHER TIP: Be alert for students who are having trouble visualizing which way is eastward and reversing the “E” and “W” signs. Have them look at the “North America” map over their chest. Students can look down and see which arm is extending toward New York and which arm is extending toward California.

24. Give students the “**Body Geography**” **Student Worksheet [ST 7]** as homework or an in-class assessment activity.

Earth's Rotation & Times of Day [ST 8]

25. Ask: "How does the Sun appear to move in the sky?" [Rises in the east; Sets in the west.]

26. Have students face directly toward the symbolic Sun with their arms outstretched – "E" in the left hand and "W" in the right hand. Ask: "What time would it be along a line that runs down the middle of the front of you?" (Gesture with a karate-chop motion of your hand from the middle of your face down along the front of you) [Noon or Midday.]

27. Ask: "Why is it midday?" [The Sun is midway between east and west.]

28. Tell students: "The line that runs north-south, midway between your east and west is called your **meridian.**" Ask everyone to show you their meridian. [Hands moving up and down the middle of the front of their bodies.]

29. Tell students: "When the Sun is directly out in front of you at noon, it is 'on your meridian'".



30. Have students face directly away from the Sun with their arms outstretched to the sides. Ask them: "Is the Sun on your meridian?" [No] Ask: "What time is it at your meridian?" [Midnight] "What would you see?" [Stars]

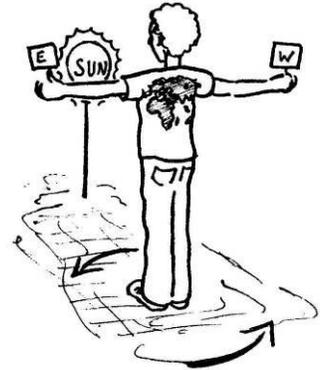
31. While students are still in their midnight positions, ask: "What time is it along a line that runs along the middle of your back?" [Noon] "What would people there see in the sky? [The Sun]

32. Call students' attention to how it can be different times at different places on Earth, and how there are 12 hours between their front and back.

33. Return students to face the Sun (i.e. "noon" or "midday at their meridian"). With arms outstretched, have students look down along their "E" arm. Tell them that the student to their left is "low in their east."

34. Next have students look down their "W" arm. Tell them that the student to their right is "low in their west."

This section begins by making the connection between Earth's rotation and the times of day. It demonstrates why the Sun appears to rise in the east and set in the west and how different parts of Earth can experience different times of day at the same moment. The section goes on to explore whether stars rise and set. For all subsections, students should be at noon around the Kinesthetic Circle with "E" and "W" signs in hand and the Zodiac ring in place.



35. Demonstrate to students that what is visible to them at any given time includes what can be seen down along their “E” arm, panning out in front of them through their meridian, and over to looking down along their “W” arm. What’s behind their arms is out of sight.

36. Have students make a 90-degree turn toward their east (toward their “E” arm). Ask: “What is low in your east?” [A constellation of the Zodiac.] “What is low in your west?” [The Sun]



37. Ask: “What time of day is this when the Sun is low in your west?” [Sunset]

38. Ask: “Why is this sunset?” [Because the Sun is disappearing in the west.] Remind students that they can turn their head to look down their arm and see the Sun low in their western sky.

39. Ask: “Why does the Sun seem to disappear in the west?” [Because I turn away from it.]

40. Ask: “Does the Sun set at the same time every day of the year?” [No, the Sun sets earlier in the winter and later in the summer.] Tell students to use a time in-between for sunset = 6pm.

41. Return to noon. Ask: “So which way does Earth turn so that the Sun appears to set in the west and rise in the east (i.e. re-appear in front of their outstretched “East” (left) hand as they continue to turn). Give students time to work out the answer, using trial and error if need be. Give them a minute or so to compare their thoughts with their neighbors.

42. Now guide everyone in rotating through a complete day. Start with the noon position, facing the Sun. Command students in sequence:

- “Go to sunset.” Ask: “About what time is this?” [~ 6 pm]
- “Go to midnight.” Ask: “What do you see in your sky?” [Stars]
- “Come to sunrise.” Ask: “What do you see in your sky?” [The Sun low in the east.] Remind students to look out along both arms as well as in between. “About what time is this?” [~ 6 am]



NOON



SUNSET



MIDNIGHT



SUNRISE

43. Return to noon. Ask: “What do we call this turning of Earth that causes the Sun to rise and set?” [Rotation.] Define and demonstrate the term “Rotation” as the spin of a body around an axis, just as students spin around the axis of their bodies with their heads as North Poles.
44. Ask: “How long does it take Earth to rotate around one time?” [24 hours = 1 day]
45. Define the term “Rotational Period” as the *time* it takes a body to spin on its axis.

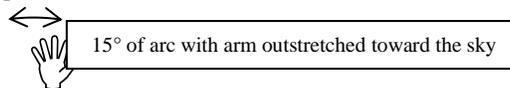
TEACHER TIP: As enrichment, you may alert students to the enjoyment of trying to “sense” Earth’s rotation during a sunrise or sunset. For example, when the Sun is low in the east, its apparent rising motion seems more rapid because you have the horizon as a reference to measure its progress. It is then fun to try to reverse the usual perception of the Sun moving, and instead try to perceive Earth turning toward the East thus making the Sun appear to rise.

46. Confirm that students are relating Earth’s rotation to different times of day. Have them start at noon with outstretched arms and then make a 45° turn toward the east. [This is midway between noon and sunset, and students often need a reminder not to turn 90° to sunset.]
47. Ask: “What time of day is this for you?” If needed, follow up with: “Is it before or after noon?” [After noon.] “Is it before or after sunset?” [Before] “So about what time is it?” [About 3pm.] “Is the Sun in the eastern or western sky?” [Western]
48. Tell students: “Go to 3am.” If needed, follow up with: “Is it before or after midnight?” [After.] “Is it before or after sunrise?” [Before] [Students turn to the east (left), until facing about 45° past midnight.]
49. Have students return to 3pm. Ask: “What is the time along a line down the middle of the back of you, say in China?” [3am – twelve hours later.]
50. Ask: “What is today’s date in the US at 3pm?” “What would be the date in central China where it is 3am?” [Tomorrow’s date.]
51. Have students complete the worksheet “**Kinesthetic Times of the Day**” [ST 8] as homework or in-class assessment.

Do Stars Appear to Rise and Set?

52. Ask: “What do we call the patterns of stars we see in the sky?” [Constellations] “What are some examples of constellations?” [Orion, Big Dipper, Zodiac names like Leo and Scorpius.]
53. Ask: “Between what times of day do we see stars other than the Sun?” [After sunset until before sunrise.] “Why?” [The sky is dark – the Sun is not visible.]
54. Ask: “Will these stars and constellations appear to rise and set?” [Show of hands: “yes” or “no”. Most students respond with “no”, and if queried will explain that the stars are “fixed”.]

55. Have students rotate *just past* the sunset position. [The Sun is out of view behind their right (west) hand.]
56. While at the sunset position, have students turn their head and choose a constellation sign (or other object in the learning environment) that is low in their eastern sky (down the “E” arm).
57. Have students *slowly* rotate to midnight and pause. Ask: “What happened to your chosen constellation?” “Is it still low in the east?” [No. It’s in front of me...on my meridian.]
58. Have students rotate slowly onward from midnight to sunrise while keeping an eye on their chosen constellation. Ask: “Where is your constellation now?” [Low in my west.]
59. Return to noon position. Ask again: “Do stars appear to rise and set?” [Show of hands: “yes” or “no”. Many more students should indicate “yes”. If not, then repeat Steps 56-60.]
60. Ask: “Why do the stars appear to rise and set?” [Because Earth rotates. The same reason as the Sun appears to rise and set.]
61. Invite students to observe the motion of the stars at night and report their observations. Just after dark they can use where the sun has set or Polaris to tell directions (N, S, E, and W). Tell them to notice where a constellation or bright star is relative to some earthly feature such as a building, tree top, or ridge. Then before they go to bed, they can look again to see how the constellation or star has “moved” in the sky. Camping trips are great for this making this observation! [The Sun and stars appear to move at the rate of Earth’s rotation = 15° per hour, which is the same thing as “ 360° per 24 hours”. This amount of movement can be estimated by an open hand with arm outstretched: Fifteen degrees of arc in the sky is about the distance between the tip of the index finger and the tip of the pinky finger with the hand spread open.]



TEACHER TIP: Four questions often arise during this part of the lesson:

- 1: Do the stars themselves move?
- 2: How do we explain the motion of stars that do not appear to rise or set but that can be seen all night and all year round (such as the Big Dipper)?
- 3: Do people at different latitudes [say, the North Pole, the equator, and the South Pole] see the same collection of stars when they look up at night?
- 4: If the Sun is a star, why is it so much brighter than the other stars? *Answers appear in the FAQ section of the Lesson Plan.*

Astronomical Meaning of a Year

Phenomenon – [Midnight Constellations PowerPoint] Use the power point to show that different constellations are visible at different times of year.

This pattern repeats every year. *Note: Each slide shows the view (facing south) from Salt Lake City, Utah at midnight on the date shown on the slide.*

Why do we see different stars at different times of year? We can construct an explanation by using this same model.

This part of the Sky Time lesson uses kinesthetic techniques to introduce Earth's orbit around the Sun and to construct the meaning of "orbital period." Students determine the dates and orbital positions of the solstices and equinoxes based on constellations visible at midnight.

Teachers then assess whether students are making the connections between orbital positions and the dates of the year by asking students to find their birthday positions. At their birthday positions, students discover that they cannot see the constellation representing their "sign" of the Zodiac in their nighttime sky. The lesson leads them to understand that their "sign" is a "Sun sign", meaning that if they look toward the Sun at noon on their birthday, the stars of their zodiacal constellation will be in the background (though not visible due to sky brightness). Students go on to explore why we see different stars at different times of year.

Finally, the students experience their kinesthetic birthdays (rotation in their birthday orbital position).

Earth's Orbit of the Sun [ST 9]

1. Have students stand in the Kinesthetic Circle around the "Sun". Ask: "Who has a birthday closest to today?" Identify this student and present him or her with a birthday hat (optional).
2. Ask the birthday person: "How many trips around the Sun have you made in your life?" [Pause to allow time for everyone to reflect on this question, making the connection between their age in years and the time it takes for Earth to make one trip around the Sun.]
3. Randomly ask a few other students how many trips around the Sun they have made; or if learners are of comparable age, poll them: "How many have made 9 trips?" "How many have made 10 trips?"
4. Tell students that Earth's "trip" around the Sun is called an "orbit". Ask: "What is the shape of Earth's orbit around the Sun?" [An almost perfect circle.] Point out that this means Earth is always about the same distance from the Sun. (NOTE: Actually, Earth is a tiny bit closer to the Sun in Northern Hemispheric winter, but this does not cause the seasonal changes.)

5. Define and demonstrate the difference between “orbit” and “rotation” carefully. Ask: “How many times does Earth *rotate* around its axis during one *orbit* around the Sun?” [365 times = 365 days.] (NOTE: Ask the question in this way to connect “time” and Earth’s motions.)

TEACHER TIP: As you move forward in the lesson, insist that students use the terms “orbit” and “rotation” correctly as they address questions and make their explanations.

6. Tell students they will complete one year for Earth. Ask: “Do you think it’s a good idea to rotate *all* 365 times as you orbit?” [No, just a few times.]
7. Ask: “Which way does Earth orbit around the Sun?” Give students a hint and give them time to explore: HINT: “On December 21, you would see Taurus and Gemini at midnight. Then on March 21 you would see Leo and Virgo at midnight. On June 21 you would see Scorpius and Sagittarius.”
8. Poll students: “How many say Earth orbits clockwise around the Sun?” “How many say counterclockwise?” [Confirm that Earth’s orbit is counterclockwise around the Sun.]

TEACHER TIP: Before having students perform the year, check to be sure that there are not obstacles they might trip over. If you are working with more than a dozen or so students, you can invite those who would like to rotate and orbit more quickly to take two steps toward the “Sun” to form an inner circle. Those who want to rotate and orbit more slowly can remain in the outer circle. For larger groups a half-year may be a better option.

9. Say: “Let’s make a year happen! Start with rotation toward your “E” arm, and then begin to move in orbit around the Sun as well.” [Ensure all students are rotating and orbiting in the proper sense. Enjoy their smiles. Contain students who are moving recklessly.]
10. Allow time for recovery and re-focus attention. Ask: “How long does it take Earth to orbit the Sun?” [1 year = 365 days] Define the term “Orbital Period” as the *time* it takes one body to orbit another body. Ask: “What is Earth’s orbital period?” [1 year or 365 days]
11. Find each pair of constellations that were shown in the “Midnight Constellations” power-point presentation.
12. Ask: “What time of year is it when Earth is in each of these positions in its orbit about the Sun?”
13. Place the “Winter Solstice/21 December” sign, “Spring Equinox/21 March”, “Summer Solstice/21 June” and “Fall Equinox/21 September” signs on the floor in front of students in the circle at the appropriate locations.

Finding Everyone’s Birthday

Form the Kinesthetic Circle with Solstice and Equinox signs already set. The Zodiac ring should be in place. “E” and “W” signs are again needed in this subsection.

14. Lead students to find other dates in circle. Have them try to figure out the locations on the orbit of January 21, February 21, April 21, etc. Hint: These dates should be evenly spaced (about a third of the way) between the solstice and equinox signs.
15. Tell all students: "Go to your birthday." [This helps confirm that students are making the connection between a date and the position of Earth in its orbit around the Sun. It also gives them an interpersonal opportunity to share their birth dates with others.]
16. Check results by asking each student to report out the date of their birthday. Make any needed adjustments by drawing attention to the dates of the solstices and equinoxes and the direction of Earth's orbit around the Sun.
17. Set a new inquiry: "Do people on the night side of Earth see different stars in the night sky at different times of year?" Follow up with: "Do we see the same stars in summer that we see in winter?" Have students near the Summer Solstice rotate to midnight and report the constellations they see. Have students near the Winter Solstice rotate to midnight and report the constellations they see.
18. Have all students turn to midnight. Have them note the names of two constellations they can see. Now have them stay at midnight and move $\frac{1}{4}$ of an orbit [3 months – the Equinox and Solstice students can be the guides for this amount of orbit.]. Have students again note the names of two constellations they can see. Ask: "Are you seeing different stars at this new time of year?" Shift again, if needed to make the point.
19. Ask a few students to explain why we see different stars at different times of year. [Because Earth orbits the Sun, at different times of year, the night side of Earth faces out in different directions in space and so we see different stars.]
20. Assign "**Your Birthday Stars**" **Student Worksheet (ST 10 – ST 11)** and/or "**Different Stars for Different Seasons**" **Fill-in-a-Poem (ST 12)** as homework or in-class assessments. "Birthday Stars" makes use of the Zodiac Diagram below.

Applying/Assessing New Knowledge about the Day and Year [ST 13 – ST 17]

The “China inquiry” [ST 13] below calls on students to apply what they have learned about Earth’s day, year, and seasons. It also deepens understanding about the relationship between the day and year. At minimum, we recommend use of the cumulative post-lesson assessment [ST 14 – ST 17].

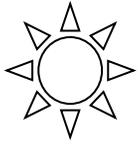
Will We See the Same Stars in the US Tonight that People in China Saw Last Night? [ST 13]

Students should be at noon around the Kinesthetic Circle with “E” and “W” signs. The Zodiac ring must be in place.

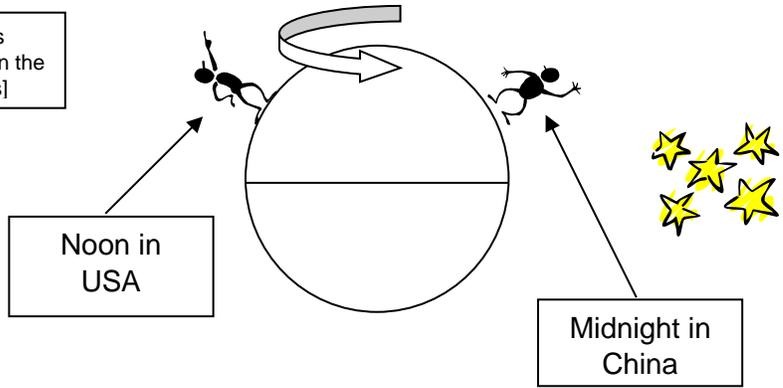
1. Set the inquiry: “Do you think we will see pretty much the same stars in the US tonight that people in China saw last night?” After a few seconds, poll students with a show of hands for a “yes” or “no” response. [Usually many students respond with “no” and if queried will explain that China is on the other side of Earth so we cannot see the same stars as they do.]

TEACHER TIP: This question is not confined to consideration of the US and China. The more general question is whether people on one side of Earth will see pretty much the same stars tonight that people on the other side of Earth (at the same latitude) saw last night.

2. Ask: “How much does Earth move in its orbit of the Sun during one rotation (in one day)?” Lead their reasoning with follow-up questions: “How many degrees in a circle?” [360°] “How many days in one full orbit?” [365 days] “So about how many degrees of orbit in one day?” [About one degree per day.]
3. Have students demonstrate about how much they would move in orbit during one rotation of Earth. [Inching just a tad in a counterclockwise direction around the “Sun”.]
4. Have students start at noon. Ask: “What time is it in China?” [Midnight.] “What are the people there seeing in their sky?” [The stars. Have students look over their shoulders and note at least one constellation.] “What are we seeing in the US?” [The Sun at noon.]
5. Have students rotate to midnight. Ask: “How long did it take for us to rotate to this position?” [Lead students to the answer of 12 hours = $\frac{1}{2}$ day] Ask: “How much does Earth move in its orbit during this time?” [about $\frac{1}{2}^\circ$]
6. Give each student a copy of the worksheet, “**The Night Sky in China**” [ST 13]. Have students work in pairs to conduct their own investigation into the inquiry: “Do you think we will see pretty much the same stars in the US tonight that people in China saw last night?” Tell students to assume that the people in China and the US are located at the same latitude. [This is important because the stars that can be seen in the sky are different for different latitudes. See FAQ 3.]



People in China see the stars now. How long until people in the US will see the stars? [12 hrs]



TEACHER TIP: The worksheet **[ST 13]** also calls on student pairs to prepare and present a kinesthetic demonstration to prove their answer to the “China question”. Students should have access to all the props and be free to create new ones. Students can be quite creative with their demonstrations. Some or all of their demos can be shown to the class as an assessment activity.

FREQUENTLY ASKED QUESTIONS (FAQ) FOR THE SKY TIME LESSON

FAQ 1: The patterns of the stars (constellations) appear to rise and set because of Earth's rotation, but do the stars themselves move?

Yes, all stars do move, but because they are so far away their motion is imperceptible to us with the naked eye, and thus the patterns of stars (the constellations) will appear unchanged for many lifetimes.

FAQ 2: Why is it that some constellations (such as the Big Dipper at northern and mid-latitudes) do not appear to rise or set, but can be seen all night and all year round?

Because Earth rotates around an axis pointed toward Polaris, the objects in the sky will all appear to move around this star. If you were at the North Pole, where Polaris appears directly overhead in the sky, no stars would rise or set, but the dome of the sky would appear to rotate around parallel to the horizon. At lower latitudes, those stars appearing closest to Polaris in the sky still would not rise or set, but instead would appear to move in circles around Polaris. Those stars appearing farther away from Polaris (e.g. farther south in the sky) will still be moving in circles around Polaris, but these circles intersect the horizons and thus the stars appear to rise and set. So, if you are at 40°N latitude, then Polaris appears 40° above the northern horizon, and stars that appear within 40° of Polaris (such as those in the Big Dipper) will appear to move around Polaris without rising or setting. These are called *circumpolar* stars. Your latitude dictates which stars will be circumpolar and which stars will appear to rise and set.

FAQ 3: Do people at different latitudes [say, the North Pole, the equator, and the South Pole] see the same collection of stars when they look up at night?

No. Earth is spherical, and thus when we are at different latitudes we are looking out in different directions in space when we look directly up overhead. Using a globe (or other spherical object) and a small doll or action figure, you can show how the direction of “directly overhead” changes as the doll is positioned at different latitudes from pole to pole.

FAQ 4: If the sun is a star, why is it so much brighter than the other stars?

Other stars are much farther away than our sun. The Sun is about 100 million (100,000,000) miles away, but even the nearest star is about 24 trillion (24,000,000,000,000) miles away. The light we receive from a particular star depends on how far away it is.

FAQ 5: Where do I find Polaris in the sky?

At the North Pole, Polaris appears directly overhead in the sky. At lower latitudes Polaris appears closer to the northern horizon. Polaris is located above the northern horizon by the same number of degrees as the north latitude at your location. For example, if you are at 40°N latitude, then Polaris appears 40° above the northern horizon. If you are at the equator, then Polaris is on the northern horizon (0° above the northern horizon). In the Southern Hemisphere, Polaris is not visible at all because it is below the northern horizon. Polaris is 500 light years away.