

NEW HORIZONS

To Pluto and Beyond

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Orbit and Spin

Overview: A whole-body activity that explores the relative sizes, distances, orbit, and spin of the Sun, Earth, and Moon.

Target Grade Level: 3-5

Estimated Duration: 2 40-minute sessions

Learning Goals: Students will be able to...

- compare the relative sizes of the Sun, Moon, and Earth.
- contrast the distance between the Moon and Earth to the distance between the Sun and Earth.
- differentiate between the motions of orbit and spin.
- demonstrate the spins of the Earth and the Moon, as well as the orbits of the Earth around the Sun, and the Moon around the Earth.

Standards Addressed:

Benchmarks (AAAS, 1993)

The Physical Setting, 4A: The Universe, 4B: The Earth

National Science Education Standards (NRC, 1996)

Physical Science, Standard B: Position and motion of objects

Earth and Space Science, Standard D: Objects in the sky, Changes in Earth and sky

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Background:



Sun

The Sun is the center of our Solar System, as all of the planets orbit around it. Its rays warm our planet and sustain life as we know it. The Sun is very hot compared to temperatures we usually encounter. Its mean surface temperature is about 9980° Fahrenheit (5800 kelvins) and its interior temperature is as high as about 28 million° F (15,500,000 kelvins). Some of that energy reaches Earth and keeps our surface temperatures relatively moderate; without the Sun our planet would be dark, icy and unable to sustain life as we know it.

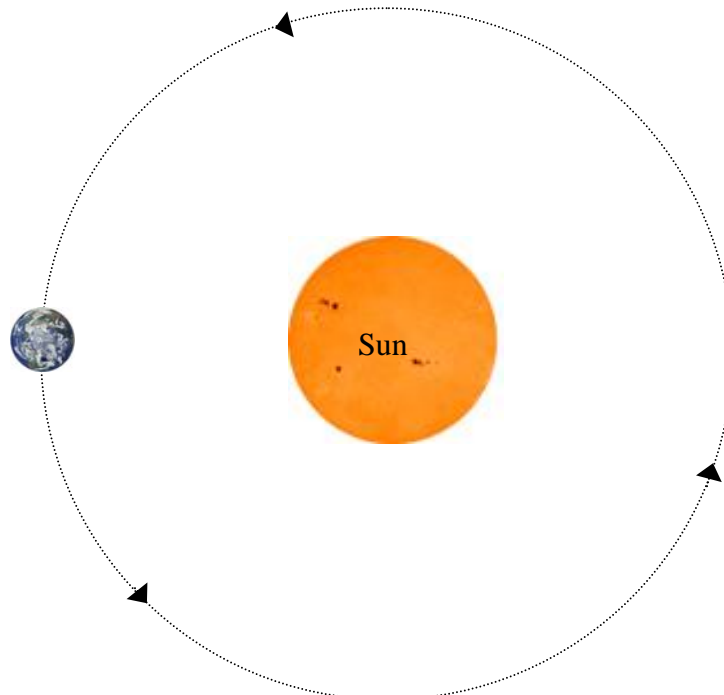
The Sun is by far the largest member of our Solar System and is a star. In fact, the Sun accounts for about 98% of the total mass of the Solar System. Even though the Sun is quite far away—a mean distance of 149,598,000 km—it is still a very prominent feature in our sky due to its large size.



Earth

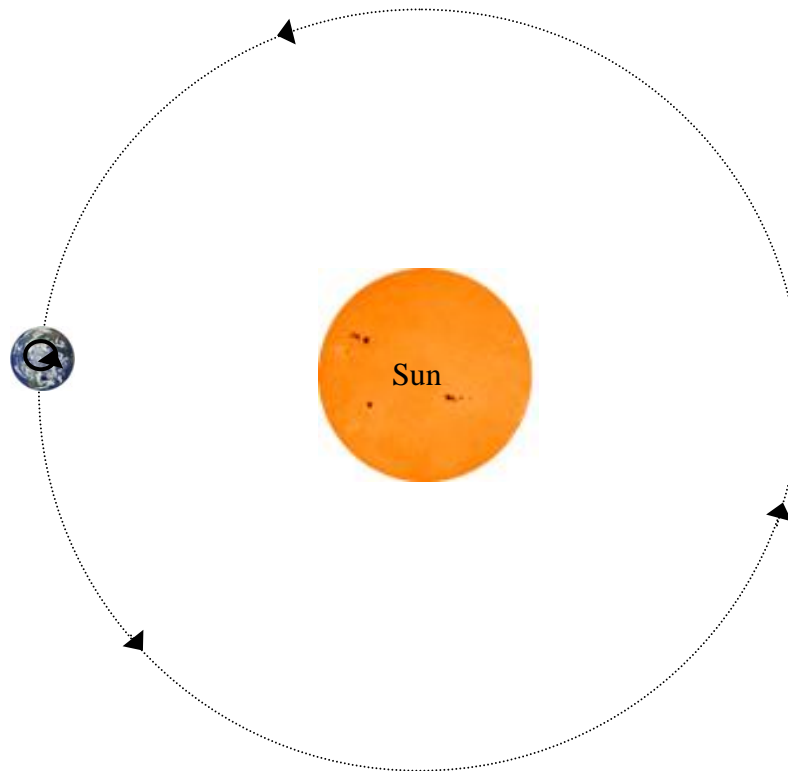
Home! We know quite a bit about Earth and its oceans, landforms, people, biota, atmosphere, etc. So let's look at Earth from a different perspective and consider the aspects of the planet that are not so tangible. Earth is the third planet from the Sun after Mercury and Venus.

These planets, as well as the other planets, orbit around the Sun. The *American Heritage Dictionary* defines orbit as “The path of a celestial body or an artificial satellite as it revolves around another body.” Our year corresponds to one journey or one orbit around the Sun for a travel time of 365.26 days. If viewed from above our North Pole, Earth's orbit around the Sun is in a counterclockwise direction (not to scale):



While Earth orbits the Sun it also spins about its own axis. One day—noon to noon, for example, or 24 hours—corresponds to approximately one complete spin of Earth on its axis. The apparent motion of the Sun in the sky is due mainly to the fact that Earth is spinning.

Earth spins in a counterclockwise direction if viewed from above the North Pole. Notice that orbiting requires movement along a path, whereas spinning is around an axis within the body and could therefore happen without changing location. Of course Earth is both spinning and orbiting at once, so it is never spinning in place. (The following drawing is not to scale).



We have emphasized that these drawings are not to scale. Since the distance between the Sun and Earth is so large (150 million kilometers or 93 million miles) compared to the diameter of Earth (12,750 km), fitting a proper scale model of the Sun-Earth system on a regular sheet of paper would make Earth about 4/1000 of a centimeter – too small to see! Put another way, if the image of Earth were 1 cm in diameter the image of the Sun would be 110 cm or 3.6 feet in diameter and the distance between them would be 110 meters or 360 feet!



Moon

The Moon, with a diameter of 3,476 kilometers (2,160 miles), is significantly smaller than Earth, let alone the Sun. Using the same scale model as in the 'Earth' section above, note how this diameter relates to the diameters of the Earth and Sun.

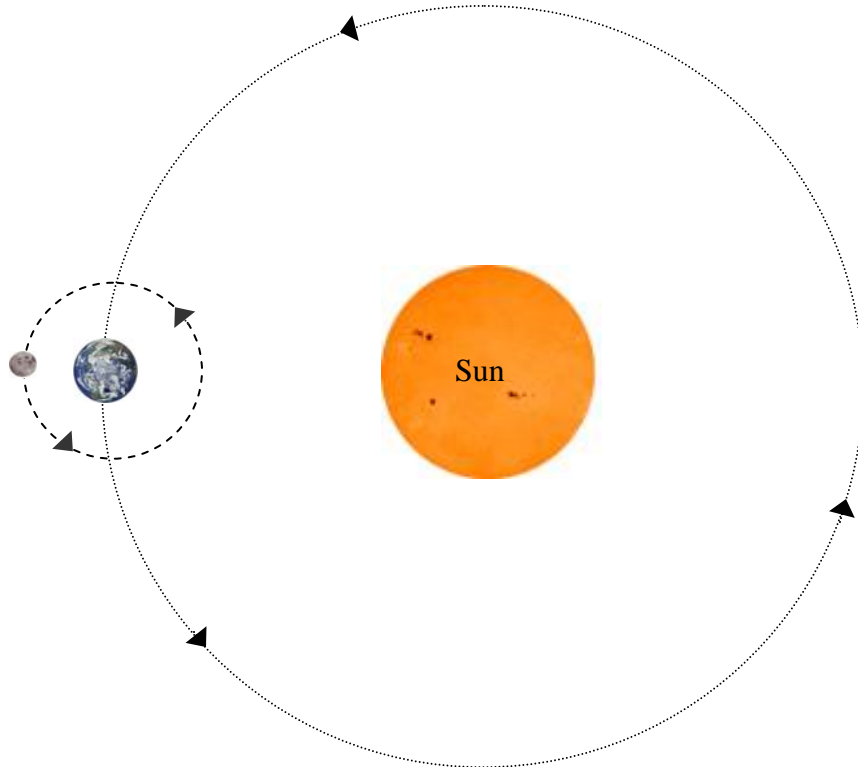
- If Earth is 1 cm and the Sun is 110 cm, the **Moon would be 3**

mm in diameter.

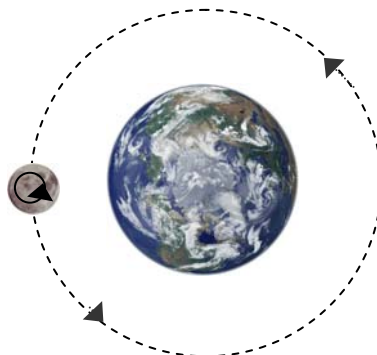
- Using the same scale, the distance between the Earth and Sun would be 110 meters and the **distance between the Moon and Earth would be 30 cm.**

In summary, the Moon is very small and very close to Earth compared to the Sun.

The Moon orbits Earth in a counterclockwise direction if viewed from above Earth's North Pole. It takes the Moon about 27 days to complete a full orbit. (Again, following diagram is not to scale!).

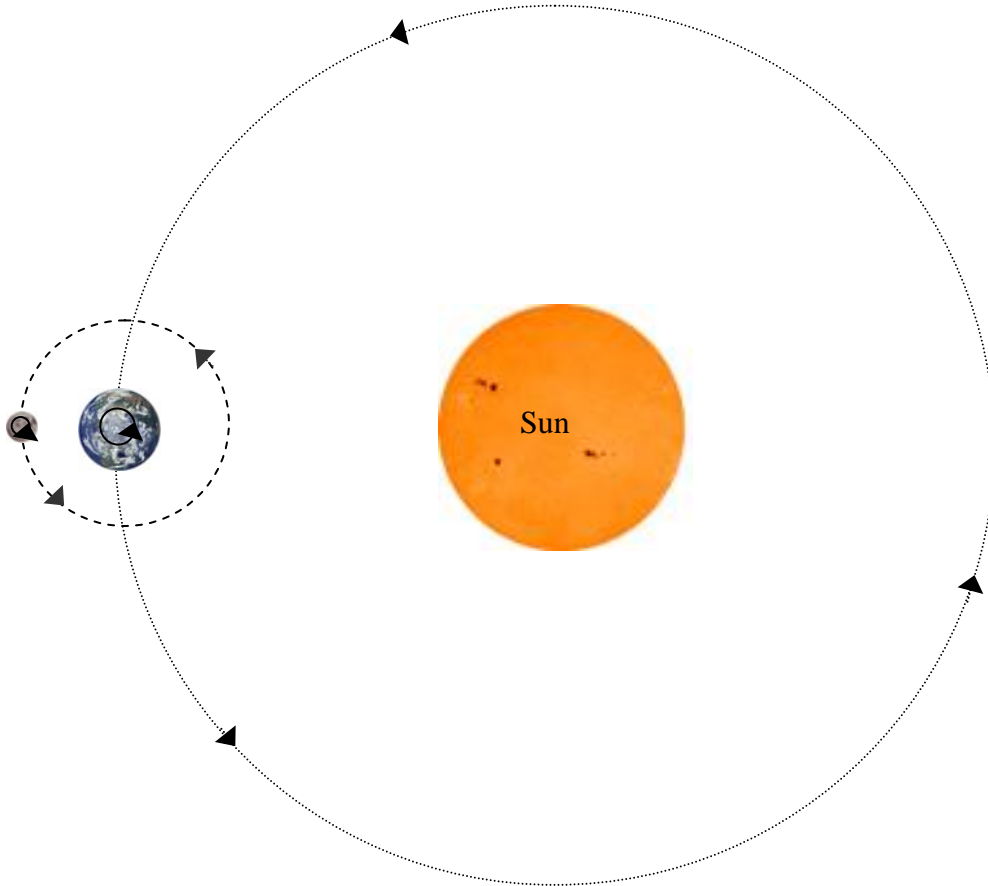


Interestingly, like Earth the Moon also spins on its axis, and the time to complete one spin is the same as the time to complete one orbit. That is, both the orbit of the Moon and the spin of the Moon take about 27 days. This means that the same side of the Moon is always facing Earth, and likewise the far side of the Moon never faces Earth. Like Earth, the Moon spins in a counterclockwise direction if viewed from above Earth's North Pole. For clarity the Sun has been removed from the following image, but you can image it off the right side of the page and very large.



Unlike the other planets and their moons, we have walked on the surface of our Moon. Neil Armstrong was the first person to step foot on the Moon on July 20, 1969. He and other astronauts confirmed the Moon's surface is heavily cratered from historical meteor impacts. These craters remain long after the meteor impacts due to the absence of an atmosphere or significant geologic activity.

Now to put the orbit of and spin of the Sun, Earth and Moon together in one diagram, which is really, really not to scale:



Note: The Sun also spins on its axis in the same direction as the Moon and Earth, but its spin is a bit more complicated. The Sun spins faster at the equator than at higher latitudes, a phenomenon called differential rotation. Differential rotation is beyond the scope of this activity, but may be appropriate for students in later grades.

Materials:

- *if possible*, additional people (teacher's aide, volunteer, older students, parents, etc.) to help answer questions/guide learning at three stations on day 1 and two stations on day 2
- copies of What I learned about... Science Journal page (5 per student)
- For the Earth, Sun and Moon stations, you may wish to ask students to bring in objects that *they* feel represent these bodies

Day 1

- markers, crayons, or colored pencils
- copies of Fact Sheets (2 or 3 per station)
 - Sun: <http://www.windows.ucar.edu/tour/link=/sun/statistics.html>
 - Moon: http://www.windows.ucar.edu/tour/link=/earth/moons_and_rings.html
 - Earth: <http://www.windows.ucar.edu/tour/link=/earth/statistics.html>
- a marble/1 cm diameter ball to represent Earth
- a piece of rice/3 mm item to represent the Moon
- poster board to make 110 cm (3.6 ft) representation of the Sun

Earth station items (suggestions; modify as necessary):

- cup of water (fresh and salt if desired)
- rocks
- plants/leaves
- balloon to represent 'air'
- ball to represent spherical shape
- pictures to represent people/figurines
- a toy house to represent this is our home

Moon station items (suggestions; modify as necessary):

- rocks
- bowl of sand and marble—students can make craters in the bowl by dropping the marble
- pictures of moon
- pictures of footprint on moon
(http://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/aldrin_lem.html;
http://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/apollo11_footprint.html)
- ball to represent shape (smaller than Earth ball if possible)

Sun station items (suggestions; modify as necessary):

- large ball to represent shape
- light bulb to represent daylight
- pictures of Sun
- star shapes to represent the Sun is a star

Day 2

- ball firmly affixed to 2-3 foot string or paddle ball game (remove paddle)
- print out of Earth spin station demonstration page
- print out of Moon orbit station demonstration page

- 2 blank pages to assemble the Earth spin and Moon orbit station demonstrations
- scissors to cut out Earth and Moon for the station demonstration pages
- 2 brads to affix Earth to Earth spin station demonstration and Moon to Moon orbit station demonstration page (paperclips may also be used by bending the smaller part of the paperclip at a right angle to the larger part. The larger part is parallel with the table while the small part goes through the holes in the pages, as indicated in the instructions for the station demonstrations).
- hole punch or a sharp pencil (brad is inserted through a hole—hole must be round so Moon can freely orbit or Earth can freely spin)
- copies of Earth spin and Moon orbit student pages (1 set per student, distribute to stations as indicated below)

Orbit station items (suggestions; modify as necessary)

- Moon orbit station demonstration (assembled)
- Picture of a satellite around Earth
- Part of the Earth spin and Moon orbit student pages, as follows:
 - Moon orbit student page (classroom set)
 - Blank page with black circle in the middle (if desired, half of classroom set)
 - Brads or paperclips (half of classroom set)
 - Scissors (half of classroom set)
 - Hole punch or sharp pencil to punch holes (2 or 3)

Spin station items (suggestions; modify as necessary)

- Pencils or pens that the students can spin
- Ballerina that spins on a music box
- Top
- Earth spin station demonstration (assembled)
- Sit-n'-spin toy or an office chair that students can sit on and spin
- Part of the Earth spin and Moon orbit student pages, as follows:
 - Earth spin student page (classroom set)
 - Blank page with black circle in the middle (if desired, half of classroom set)
 - Brads or paperclips (half of classroom set)
 - Scissors (half of classroom set)
 - Hole punch or sharp pencil to punch holes (2 or 3)

Procedure:

Generally speaking...

What the teacher will do: The teacher will gather materials for stations used throughout the activity, and rotate between stations to facilitate exploration. Stations include: Earth, Moon, Sun, Orbit, and Spin. The teacher will lead discussions about the Earth, Moon, Sun, orbit and spin, including demonstrations of orbit and spin. During the whole-body portion of the activity, the teacher will assign students to groups to represent the Sun, Earth, and Moon and facilitate

proper size of groups, distance between groups, and the orbit and spin of these groups. Teachers will assess student learning via collection and review of student Science Journal pages.

What the students will do: Students will discuss as a class what they know about the Earth, Moon, Sun, orbit, and spin. The teacher may wish to have students bring an item or items from home that they feel represents or should be included at the Earth, Moon, or Sun station. They will further explore these topics in small groups as they rotate between the stations. All students will participate in whole-body activities demonstrating qualitatively the relative sizes of the Sun, Earth, and Moon; the relative distances between the Sun, Earth, and Moon, and the orbit and spin of the Sun, Earth, and Moon. Students will assemble the Earth spin and Moon orbit student pages. Throughout the lesson, students will record thoughts and draw pictures in their Science Journal pages.

Advance Preparation

1. Gather Earth, Moon, Sun, orbit, and spin station items listed in the Materials section for the 5 stations and assign students to bring in items that represent these objects (perhaps divide class into three groups so each student only has to bring in one object). Since stations will be used on different days, you can spread this task out according to station.
2. Make copies of Science Journal pages (5 per student).
3. Make copies of Moon orbit and Earth spin student pages (1 per student)
4. Print out pictures of Earth, Moon, and Sun (affix them to the walls or bulletin board prior to beginning the activity if desired).
5. Make a flat representation of the Sun out of poster board that is 110 cm or 3.6 ft. in diameter.
6. Firmly affix a small ball to a 2 or 3 foot long piece of string or use the ball and elastic from a paddle ball game.
7. Assemble the Earth spin and Moon orbit demonstration pages to be used on day 2.
8. *Setting up the classroom*
 - a. **Earth, Moon, Sun (Day 1):** you will need to set up three stations (Earth, the Moon, and the Sun). You can place Science Journal pages at each station as well as the items listed for that station. You may want to reserve the gymnasium, use a hallway, or go outside for part of this activity.
 - b. **Orbit and Spin (Day 2):** you will need to set up two stations (Orbit and Spin). You can place Science Journal pages at each station as well as the items listed for that station. Place the Moon orbit demonstration page at the Orbit Station. Place the Earth spin demonstration page at the Spin station. Also place a classroom set of unassembled parts of the Moon orbit and Earth spin student pages at each station along with brads, scissors, and hole punches so students can assemble their own. You may want to reserve the gymnasium, use a hallway, or go outside for part of this activity.

In-class Procedure: Earth, Moon, Sun (Day 1)

1. Lead the class in a discussion of “What we know about the Sun, Earth, and Moon”.

Here are some ideas of what to discuss and how to explore this topic:

- Use the pictures to talk about the relative sizes of the three bodies; the Moon is the smallest, Earth is in the middle, and the Sun is very, very large.
- If students describe the bodies as “round” encourage them to take this description further—the bodies are all spherical or resemble a ball. Use a ball to further illustrate this point.
- Earth is home; we can’t see that it looks like a ball from where we are standing but we can from space, just like when you are sitting in your bedroom you can’t see what your house looks like from the outside.
- We see the Moon and Sun in the sky. It looks like they move across the sky, but really we are moving around the Sun and the Moon is moving around Earth. This is like when you are in a school bus/car and you pass a tree. The tree appears to move across the window and is then out of sight, but actually the bus/car is moving.
- The Sun is very bright (which is why we never look directly at it) and it provides us with daylight.
- Formal (replicated) studies of children from different countries and of various ages suggest that students cannot understand the motions of the Sun, Moon, and Earth and their relative positions until they understand a few fundamental concepts (Driver et al., 2000). These fundamental concepts are important to include in the initial discussion to prepare the students for the whole-body activity. The common misconception and the associated fundamental concept follow:

Common Misconception	Fundamental Concept to Teach	How to Address the Concept
Earth is flat	Earth is a sphere	Show a spherical globe; use bedroom/house analogy from above
Earth is not moving, but objects (e.g. the Sun) move around it	Earth is moving in space	Use car/tree analogy from above; use a model of the Earth and Sun to demonstrate
The sky is a horizontal surface above and parallel to the flat Earth	The sky completely surrounds the spherical Earth	Discuss flying in an airplane at a constant ‘cruising altitude’, and you can fly all the way around Earth at this same altitude—wouldn’t work if Earth and sky were flat!
Space is only above Earth	Space completely surrounds Earth and spreads out in all directions from Earth	Show a spherical globe and use a model of a person standing on it. Place model person at different points and ask if they

		see stars there? if they see stars, they see into Space!
Falling objects always fall in an absolute down direction no matter where one is on Earth	Objects fall toward the center of Earth, which looks like 'up' if looking at a picture of a globe and a person in the southern hemisphere	Drop an object, and note direction of fall. Move to back of room and repeat. Ask students if they have been to the next closest town; which direction would objects fall there. Ask about next state over in both directions, then further to Canada, Mexico, etc... Continue moving further away, with same concept, and always referring to the globe.

2. Divide the class into three groups. Assign each group to one of the following stations: **Earth**, **Moon**, or **Sun**. Think of this as a free association exercise, but with objects to manipulate and investigate. Students will spend about 5 minutes at each station, and then rotate to the next station as a group. At each station students will freely explore the materials gathered to represent that body (Earth, Moon, or Sun) and form their own ideas of why these specific items were chosen. Encourage them to talk to the other group members about why these objects are here and what they represent. They should also look at the fact sheet provided at each station to learn more about the body (Earth, Moon, or Sun). They should record their observations in their Science Journal page for each body, which will include drawing a picture of the respective body, writing a new fact learned about the respective body, and other things they learned at each station. Science journal pages can be collected and used for assessment if desired. **Note:** this is where it would be helpful to have a parent, assistant, older student, etc. available to help. However the goal of this activity is to allow students to interact with materials without lecture or strong guidance. Consider this a warm-up to the greater goal, which is to understand the concepts of orbit and spin.

3. What to do at the STATIONS:

- a. **Earth.** Allow students to freely interact with materials that represent Earth. Leader/Teacher should encourage students to ask questions and the leader can also ask guiding questions such as, “How are these things like Earth, why are these things at the Earth station and not the Sun station or the Moon station, how are these materials different from the materials at the other stations and how are they similar?” Topics to include: relative sizes, LIFE on Earth and not the Sun and Moon, rocks are also on moon, balloon full of air to represent an atmosphere/air at the surface of Earth, water on Earth, etc. Before students rotate to the next station allow them adequate time to draw a picture of Earth and answer questions in the “What I have learned about Earth” Science Journal page.

6. Now that you have established the three groups you need to discuss the relative distances between the objects. Using the same scale as in the previous discussion, with the Earth's diameter equal to 1 cm:
 - The Moon would be 30 cm (about 1 foot) away from the Earth
 - The Sun would be 110 meter (360 feet) away from the Earth (Note: that is greater than the length of a football field, which is 100 yards or 300 feet long!)

Since the Sun group probably will not be 110 meters away from the Earth, establish where you would like the groups to be and discuss how much further apart they would actually have to be for a true scale model. Provide each group with the representation of their object: the Earth group should have a marble, the Moon person should have a piece of rice, and the Sun group should have a cardboard Sun. For the next part of the activity you may want to move outdoors, into a hallway, or gymnasium. The groups should stand where you discussed and hold up their object (the marble Earth, the rice Moon, or the cardboard Sun).
7. Ask students to go back to class and lead a discussion on what they have learned about the Sun, Earth, and Moon. Be sure to probe students understanding of the spherical Earth which is completely surrounded by space. This concept will be fundamental to understanding the second day of the activity: Orbit and Spin.

In-class Procedure: Orbit and Spin (Day 2)

1. First ask students if they have ever heard of the terms 'orbit' and 'spin'. Allow students to talk about some of their preconceptions. Introduce the concepts of orbit and spin to the class using brief demonstrations.
 - **Orbit:** affix something (like a ball) securely to a string that is about 2 or 3 feet long and, grasping the end of the string opposite the ball, swing it around your head. The ball is orbiting your hand. Place an object, such as a large ball, in the front of the room and walk around it; you are orbiting the ball/object. Note to students that you are tracing out a path as you orbit the object. Also discuss the fact that although the ball you swung around your head was attached via a string, actual bodies in orbit are not attached by a string.
 - **Spin:** you should stand in one place and spin around. Ask students to verbalize what is different about the motion of orbit and the motion of spin. They should indicate that you do not make a path when you are spinning, you stay in one place.
 - Ask students to come up with examples of things that orbit (satellite, ball on the end of a string, runners on a track (around the center of the field), etc.). Then ask students to come up with examples of things that spin (top, ice skater in one spot, ballerina spinning on her toes on a music box, dials such as volume on a stereo, etc.).
 - Note: Students may also encounter the terms 'rotate' and 'revolve', however they can be used interchangeably according to the American Heritage Dictionary (2000), among others:

Revolve: 1. To orbit a central point. 2. To turn on an axis; rotate. See synonyms at turn.

To avoid this potential confusion, the terms ‘orbit’ and ‘spin’ are used in this activity.

2. Assign half of the class to the Orbit Station and half of the class to the Spin Station, where they will discover the concepts of orbit and spin through interactions with materials and other students. At each station there are three goals, which you may wish to write on the board as follows: 1. Interact with materials, 2. Make a model using the Earth spin and Moon orbit student pages, 3. Record thoughts in science journal pages. This is a warm-up to the whole body activity demonstrating orbit and spin that follows, and is intended to allow students to manipulate and explore materials rather than telling them about orbit and spin via a more traditional lecture.
3. STATIONS: At each station students should be divided into pairs of two. Students will spend approximately 10 minutes at the first station, and then the two halves of the class will switch stations for an additional 10 minutes. Be sure to allow students enough time to record their thoughts at each station in their “What I learned about Orbit/Spin” Science Journal pages. These journal pages can be collected for assessment if desired.
 - a. **Orbit.** Students explore the concept of *orbit* at this station. Allow them to interact with the materials provided. The three goals for this station are:
 - i. Students should create their own model of the Moon orbit demonstration by following the instructions provided in the Earth Spin and Moon Orbit student pages. If they visit the orbit station first, their moon will simply orbit the brad or paperclip used to attach it to the blank page and they will add the Earth when they transfer to the Spin station. If they visit the Orbit station second, they will have to remove the brad and place the arm of the Moon between the blank bottom page and the Earth, and re-insert the brad through the holes.
 - ii. Upon your announcement, each pair of students should model the Moon Orbit demonstration page provided at the station and physically demonstrate the concept of orbit, with one standing in place and the other walking in a circular path around the stationary student. Then students should change roles and repeat the demonstration.
 - iii. Students should individually record “What I learned about Orbit” in their Science Journal pages.
 - b. **Spin.** Students explore the concept of *spin* at this station. Again, they should freely interact with the materials provided. The three goals for this station are:
 - i. Students should create their own model of the Earth spin demonstration by following the instructions provided in the Earth Spin and Moon Orbit student pages. If they visit the spin station first, their Earth will spin, and they will not have a moon orbiting the Earth until they visit the orbit station. If they visit this station second, they will have to remove the brad and place the Earth on top of the moon arm, aligning the hole in the Earth

with the other holes. Then they will re-insert the brad through the holes to complete the project.

- ii. Upon your announcement, students should physically demonstrate the concept of spin in pairs following the Earth Spin demonstration page they created. However, they will soon see you do not need a partner to illustrate this concept! They should simply spin in place (slowly!), and they should not change their location. Every student should demonstrate spinning.
 - iii. Students should individually record “What I learned about Spin” in their Science Journal pages.
4. Ask students to return to their seats and lead a discussion about orbit and spin. Probe students’ understanding of the topics and be sure all agree on the same definitions of the concepts:
 - Orbit: The **path** of a celestial body or an artificial satellite as it revolves around another body (American Heritage Dictionary).
 - Spin: To rotate about an axis; whirl; turn (American Heritage Dictionary).Introduce students to the fact that the Moon we see is orbiting Earth, and that Earth is orbiting the Sun.
 5. Now you will model the concepts of orbit and spin in a whole-body activity involving the entire class. Begin with the simple example of Earth orbiting the Sun. Divide students into groups similar to those of the Earth, Moon, Sun activity from day 1, however there will be no student representing the Moon at this time (2 students in the Earth group; the rest of the class in the Sun group). Ask students to recall the relative sizes and relative distances from the previous day, even though the groups will be standing much closer for this activity than a true scale model would require. Once the groups are standing in place, ask the Earth group to begin **slowly** orbiting around the Sun. If the question of which direction they should be walking hasn’t come up yet, be sure to ask it now. If viewed from above the North Pole of the Earth, Earth orbits the Sun in a counterclockwise direction. After the Earth group has completed one full orbit, ask the class how much time would have passed if this were a real Earth orbit? (One year.) Relate this to their birthdays; from one birthday to the next, Earth completes one orbit.
 6. Now incorporate the orbit of the Moon around Earth; ask one student to leave the Sun group and represent the Moon. Again, the relative distances from the previous Earth, Moon, Sun activity should be discussed. The person representing the Moon should stand much closer to the Earth than the Earth is to the Sun. Before the Earth group begins moving the Moon should practice orbiting the Earth. After the Moon has completed one orbit, ask the class how much time would have passed if this were a real Moon and the real Earth. (about 27 days) Relate this to turning the calendar; from one month to the next the Moon will have complete about one orbit around Earth. Then the Earth can begin slowly orbiting the Sun while the Moon is orbiting the Earth.

7. To incorporate the spin of the Earth about its axis, ask the Moon to re-join the Sun group. Discuss as a class the direction of Earth's spin about its axis (counterclockwise as viewed from above the North Pole). Also discuss how much time on Earth corresponds to about one spin on its axis (one day). Therefore, how many times would the Earth have to spin on its axis as it makes one orbit around the Sun (about 365!). It would be too dangerous for the Earth group to spin fast while orbiting, so ask them to slow down and they will only move a fraction of the orbital path while spinning only a few times. Have the Earth students stand back to back and stop them as one is facing directly toward the Sun group and the other is facing directly away from the Sun group. Ask the class if the side of the Earth (represented by a student) facing the Sun can see the Sun. If so, is it day or night for that side of the Earth? Likewise, can the student facing away from the Sun (representing that side of the Earth) see the Sun? Therefore, would they conclude it is day or night for that side of the Earth?
8. For safety reasons, the final whole-body activity will ignore the spin of the Earth and the orbit of the Earth around the Sun. Instead, a person from the Sun group will again become the Moon. The Moon will spin about its axis and orbit the Earth group. To accomplish this, the Moon must always face the Earth as it orbits. In other words, the time it takes for the Moon to spin about its axis is equal to the time it takes for the Moon to orbit the Earth! Ask the class which spins faster, the Earth on its axis or the Moon on its axis? (Earth spins on its axis about every 24 hours, whereas the Moon spins on its axis once in about 27 days).
9. Ask the students to return to their seats and discuss what they have learned about orbit, spin, the Earth, the Moon, and the Sun. Perhaps you should write some of the salient points on the board for review. Ask questions like, "Does the Earth stop rotating? Does the Moon stop spinning?" (No!!). Relate the orbit of the Earth to a year or from one birthday to the next. Relate the orbit of the Moon to about one month or from about the beginning of one month to the beginning of the next.

Name: _____

What I learned about _____

List 2 items from this station, and why you think each item belongs at this station.

1.

2.

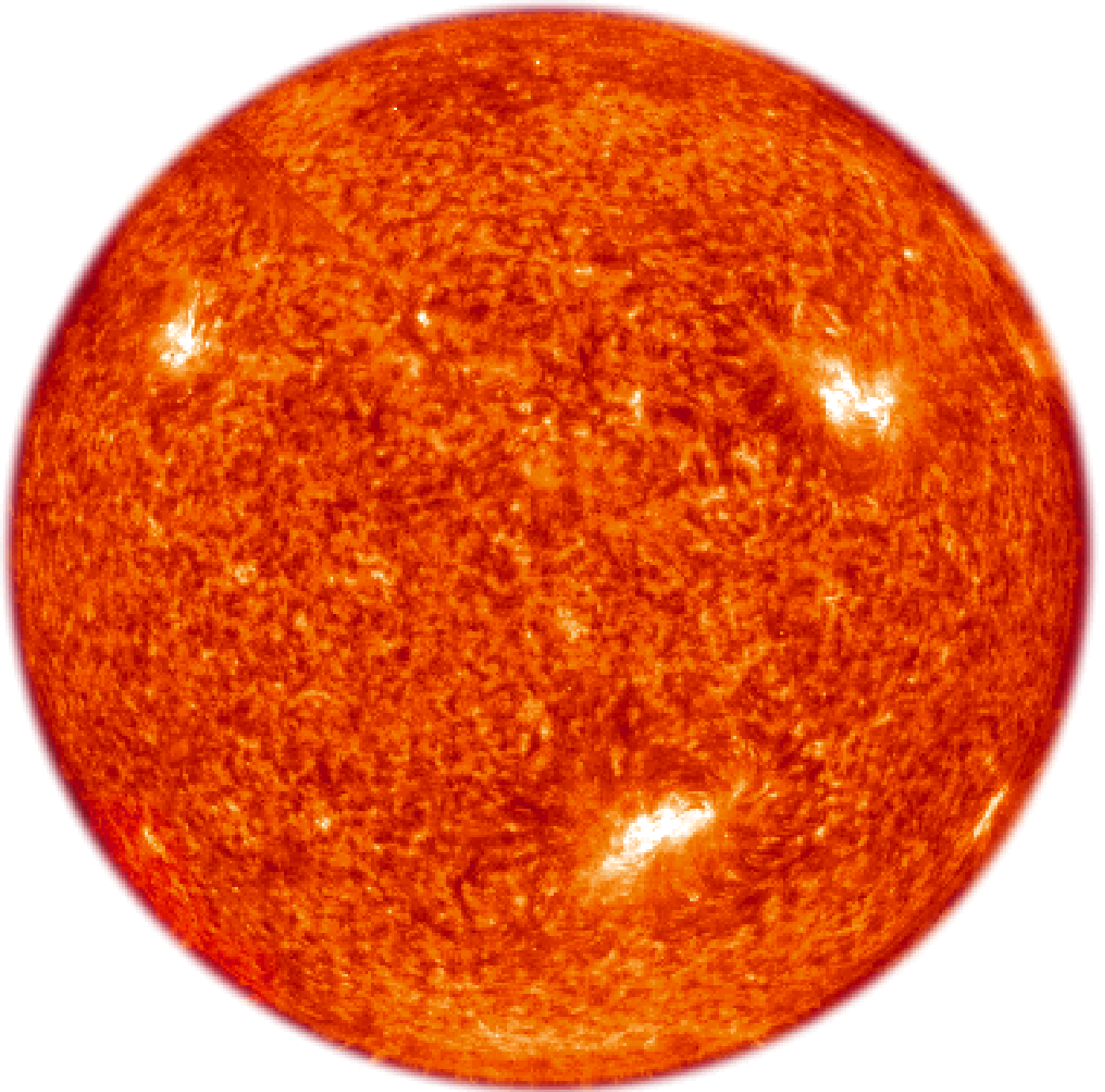
Record at least one interesting fact that you learned at this station:

Draw pictures and write other questions you have below here!

The Earth



The Sun



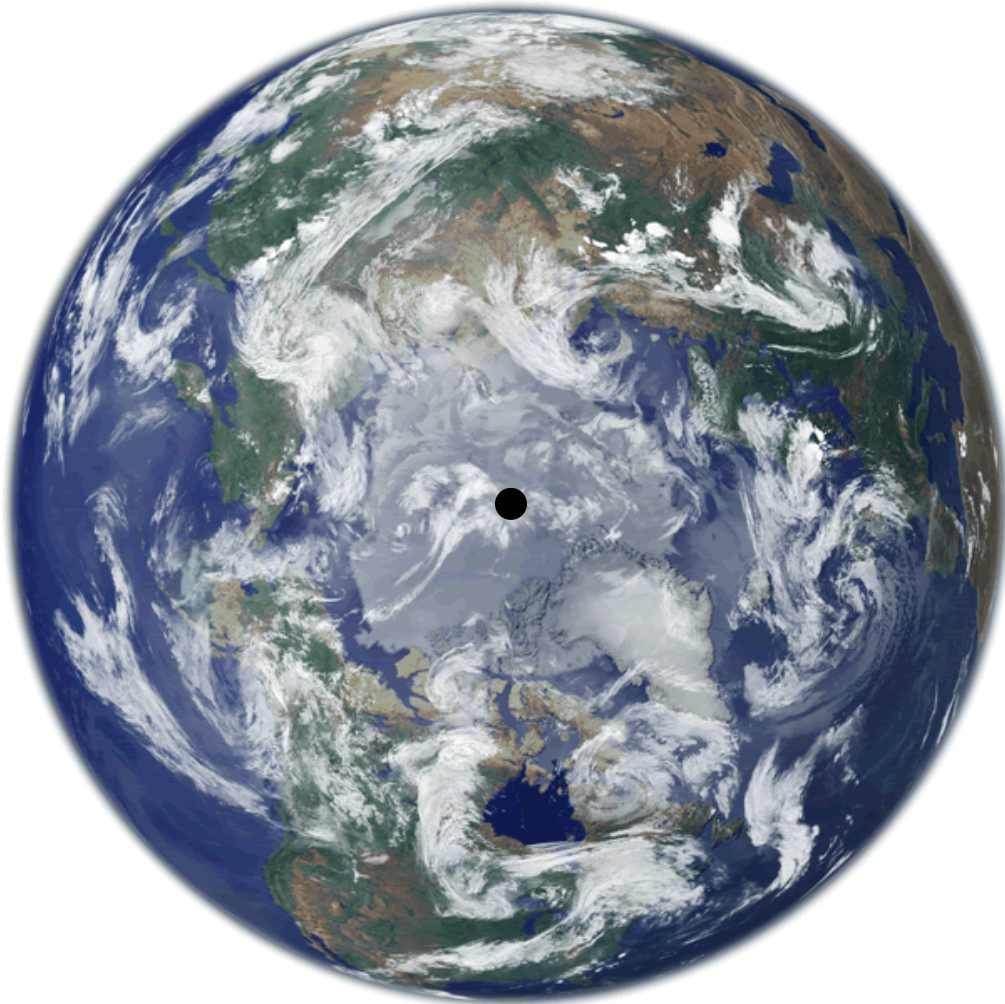
The Moon



Day 2: Earth Spin station demonstration (to be used at the Spin station)

Directions:

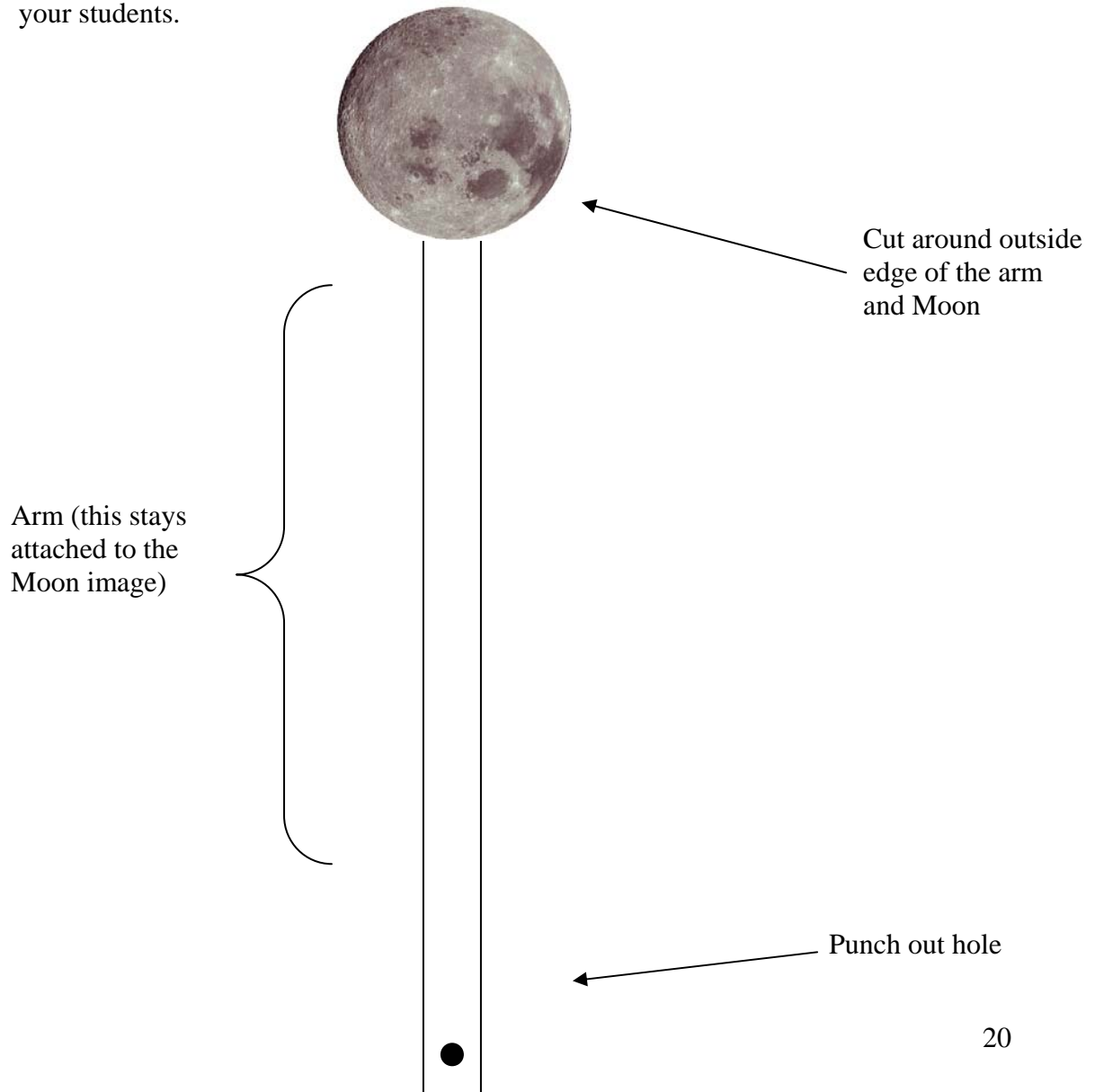
- Make 2 copies of this page. 1 to be used for the Earth spin demonstration and the other to be used with the Moon orbit demonstration (which follows).
- Cut around the edge of the Earth and punch a hole in the center of the Earth image.
- Punch a hole in the center of the blank page.
- Align the holes in the Earth cut-out and the center of the blank page and attach them together by inserting a brad through the holes.
- The Earth should then be able to spin while holding onto the blank page.



Day 2: Moon orbit station demonstration (to be used at the Orbit station)

Directions:

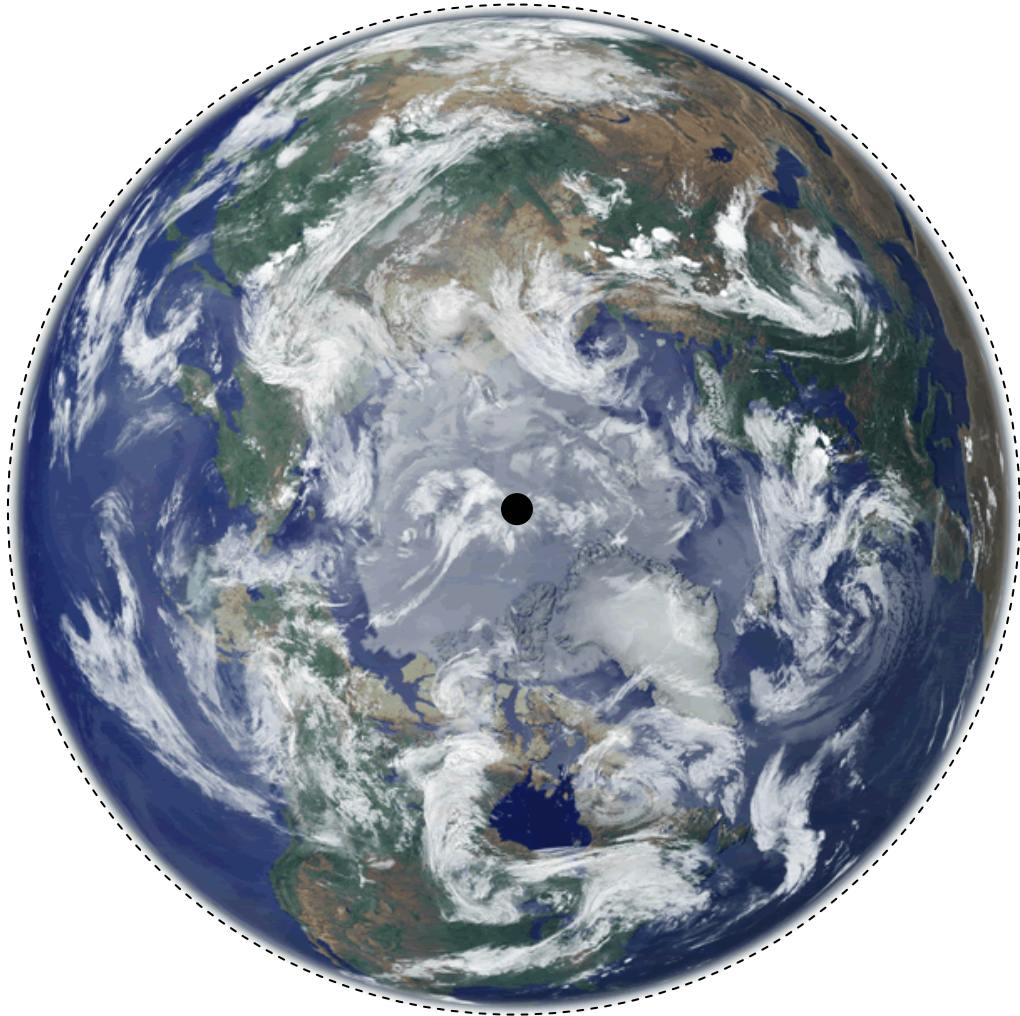
- Cut out around edge of Moon and the arm. Do not separate Moon from arm.
- Punch a hole near the end of the arm of the Moon cut-out (black circle indicated).
- Cut out the Earth from the Earth spin demonstration (previous page) and punch a hole in the center of the Earth image.
- Punch a hole in the center of a blank page.
- Align the holes in this order:
 1. Bottom is the blank page
 2. Next, align the hole in the center of the blank page with the hole in the arm of the Moon cut-out
 3. Finally align those two holes with the hole in the center of the Earth and attach them by inserting a brad through the holes. (Make sure the Moon and Earth are both face-up).
- The Moon should then be able to orbit the Earth.
- NOTE: The size of the Moon and the size of the Earth are to scale, but the distance that separates them is NOT to scale! You should definitely discuss this issue with your students.



Moon orbit and Earth spin: Earth student page

Instructions:

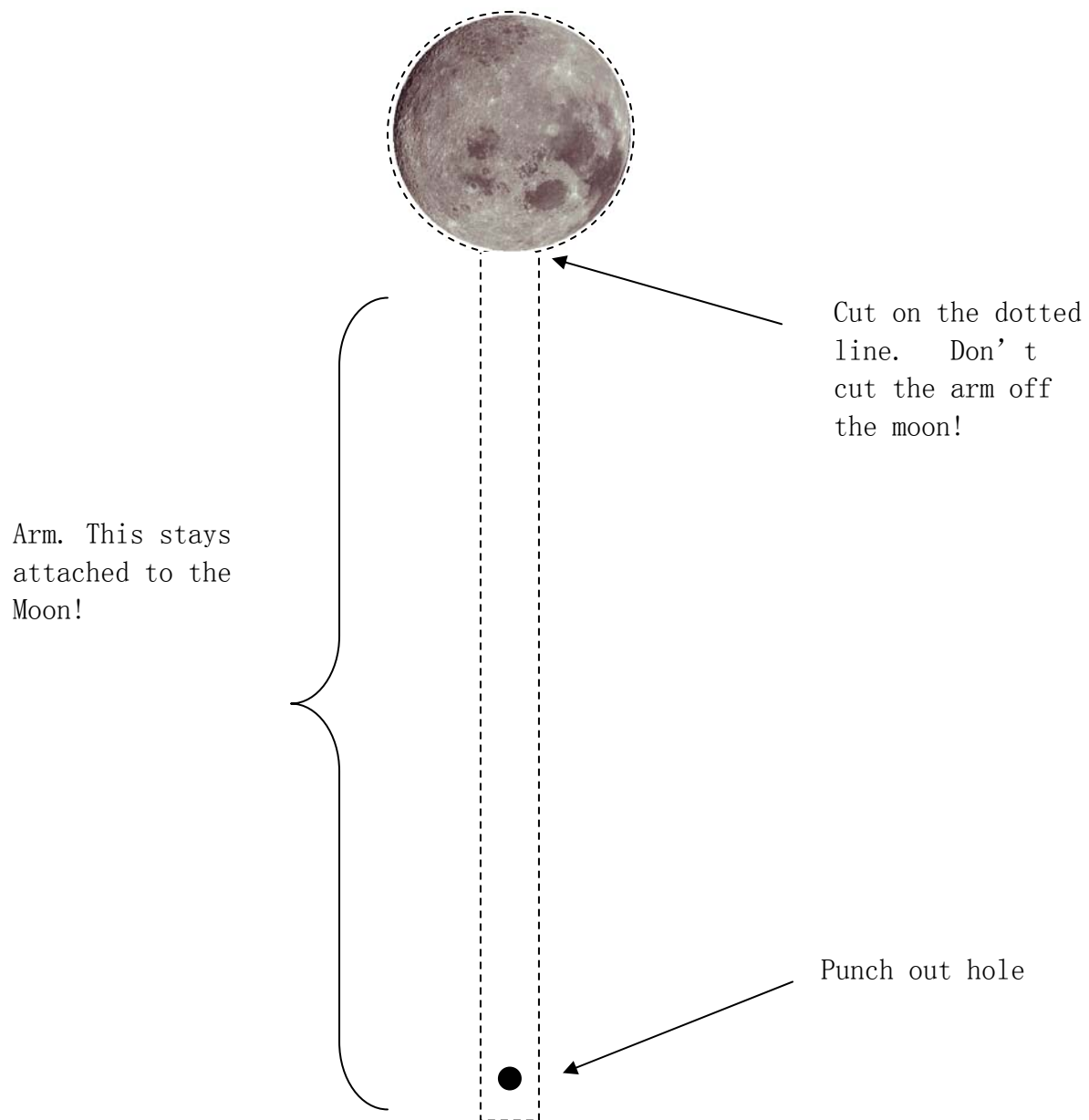
1. Cut out the Earth on the dotted line
2. Punch a hole in the center of the Earth (the black circle)
3. Punch a hole in the center of a blank piece of paper and attach the Earth to the blank page using a brad or a paper clip



Moon orbit and Earth spin: Moon student page

Instructions:

1. Cut out around the Moon and the Arm on the dotted line. Be sure you don't cut the arm off of the Moon!
2. Punch a hole in the end of the arm
3. Punch a hole in the center of a blank piece of paper
4. Attach the arm and Moon to the blank page by putting a brad or a paperclip through the hole.





Extensions and Adaptations:

- Model the geosynchronous orbit of Pluto and Charon, and compare this with the synchronous orbit of our Moon and Earth. For Pluto and Charon: have two students back-to-back representing Pluto and two students back-to-back representing Charon. The Pluto students remain in one place, spinning on an imaginary axis between their backs at the same rate as Charon orbits and spins. Therefore, the student facing Charon is always facing Charon and the student initially facing away from Charon is never facing Charon. Meanwhile the spin and orbital periods of Charon are the same, so the same student always faces Pluto as it they walk in orbit, and the student initially facing away from Pluto never faces Pluto. There is a great animation of this relationship here: <http://pluto.jhuapl.edu/Participate/learn/What-We-Know.php?link=Phases-and-Seasons> (scroll down the page and view the animation under the “Cycle of Phases” heading).
- Using a pin-hole camera “look” at the Sun
- Determine when the Moon will be visible during the day, and take students out to look at the Moon
- Here is an activity from the Space Science Institute in which students model the Earth’s tilt and the reason for the seasons using a similar kinesthetic activity. http://www.spacescience.org/education/extra/kinesthetic_astronomy/index.html
- To incorporate reading, try one of these books:
 - My Place in Space, by Robin and Sally Hirst
 - What Makes Day and Night, by Franklyn Branley
- Additional resources:
 - Driver, R., E. Guesne, & A. Tiberghien, Eds. 2000. *Children’s Ideas in Science*. Open University Press: Philadelphia, PA.
 - Driver, R., A. Squires, P. Rushworth, & V. Wood-Robinson. 2000. *Making Sense of Secondary Science: Research into Children’s Ideas*. RoutledgeFarmer: New York, NY.
 - Windows to the Universe: <http://www.windows.ucar.edu/>
 - Solar System Exploration: <http://sse.jpl.nasa.gov/index.cfm>
 - Views of the Solar System: <http://www.solarviews.com/eng/homepage.htm>
 - Scale of the Solar System and Universe: <http://www.uwgb.edu/dutchs/planets/sizeuniv.htm>
- Links from the **Materials** section have been copied here for your convenience:
Fact Sheets:
 - Sun: <http://www.windows.ucar.edu/tour/link=/sun/statistics.html>
 - Moon: http://www.windows.ucar.edu/tour/link=/earth/moons_and_rings.html
 - Earth: <http://www.windows.ucar.edu/tour/link=/earth/statistics.html>
 - pictures of footprint on moon
http://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/aldrin_lem.html;
http://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/apollo11_footprint.html

Standards Addressed:

Benchmarks (AAAS, 1993)

Chapter 4. The Physical Setting

4A: The Universe

Grades 3 through 5

- The Earth is one of several planets that orbit the Sun, and the Moon orbits around the Earth.

4B: The Earth

Grades 3 through 5

- Like all planets and stars, the Earth is approximately spherical in shape. The rotation of the Earth on its axis every 24 hours produces the night-and-day cycle. To people on Earth, this turning of the planet makes it seem as though the Sun, Moon, planets, and stars are orbiting the Earth once a day.

National Science Education Standards (NRC, 1996)

Content Standards: K-4

Physical Science, CONTENT STANDARD B:

- Position and motion of objects

Earth and Space Science, CONTENT STANDARD D:

- Objects in the sky
- Changes in earth and sky