PD Leader Master
Script for Outdoor Activity

Talking Points for Activity 3: Experience the Scale

- Take the group outside to experience the scale model of Earth and the Sun. Bring the marble and a cup of water with you and direct participants to bring their notebooks and a pen.
- Start with an object that represents the Sun (ideally a large landscaping boulder, a yoga ball with about a 1-meter diameter, or something of similar size that you can see on the ground from a distance). Hold the marble up next to the boulder so the group can experience the difference in size between Earth and the Sun. Remind participants that 1 meter is the length of large stride, and then start striding and counting off a 100-meter distance from your model Sun. Your strides don't need to be precisely 1 meter long, but they should come consistently as close as possible to 1 meter without becoming unnatural.
- At a distance of 100 meters, pause and reflect on the perspective this scale model gives you. Participants may never have thought of this perspective before, so give them a moment to take it in.

PD leader talk: "About how far should the Moon be from Earth in this model? Can you use the data from the table you copied into your notebooks earlier to figure it out?"

- Remind participants to look at the data table in their notebooks and emphasize that they should use powers of 10 to estimate the ratios involved. The Moon is about 10^5 km from Earth, and Earth is about 10^4 km in diameter. The ratio of the distance from Earth to the Moon to the diameter of Earth is then 10^5:10^4, which is equivalent to 10:1.

PD leader talk: "If you hold the marble about 10 centimeters from your eyes and then turn and look back toward the Sun, you'll experience a scale model of the perspective astronaut James Irwin had from the Moon in 1971."

- Pass the marble around to let each participant experience this scale. If you wish, read the following James Irwin quote:

> As we got farther and farther away, [Earth] diminished in size. Finally it shrank to the size of a marble, the most beautiful you can imagine. That beautiful, warm, living object looked so fragile, so delicate, that if you touched it with a finger it would crumble and fall apart.

PD leader talk: "How could we represent the oceans and mountains on Earth in this scale model?"

- Direct participants to use the powers of 10 from the table in their notebooks to estimate some useful proportions to answer this question. Elicit predictions from the group.

PD leader talk: "The ratio of the depth of the Mariana Trench to the diameter of Earth is about 10:10^4, which is equivalent to ($1/10^3$):1. So the depth of the Mariana Trench is about 1/1000th of the diameter of Earth. Thus, barely a scratch on the surface of the marble would represent the Mariana Trench. Similarly, the ratio of the elevation of Mount Everest to the diameter of Earth is about 10:10^4 which is equivalent to ($1/10^3$):1. So the elevation of Mount Everest is about 1/1000th of the diameter of Earth. Thus, just a bit of dust on the surface of the marble would represent the tallest mountain on Earth."

- To represent the mountains on Earth, dip the marble in the cup of water to coat the surface with a thin film of water to represent the oceans of the world and then rub the marble on the ground to pick up some dirt. Show this to the group.

PD leader talk: "The content background document states that Earth's orbit is 'very nearly circular,' not perfectly circular. This means that Earth isn't always the same distance away from the Sun. It's 5 million kilometers farther away at its greatest distance from the Sun than at its closest point. In our model, that represents a difference of 2.5 meters on either side of the average distance from the Sun."

- Take the group two and a half large steps away from the model Sun.

PD leader talk: "This represents the distance when Earth is farthest from the Sun."

- Then take the group five large steps toward the model Sun.

PD leader talk: "This represents the distance when Earth is closest to the Sun. As you can see, this is an inconsequential difference compared to the vast distances involved. So Earth's orbit is very nearly circular."

- Take the group two and a half large steps back to your original Earth position.

PD leader talk: "The diagrams of Earth's orbit used in textbooks, which show Earth's circular orbit from an angle so that it appears elliptical, often create the student misconception that Earth is significantly closer to the Sun at certain times of the year than at other times. Students tend to confuse higher temperatures on Earth with being closer to the Sun. This model should demonstrate that variations in the distance from Earth to the Sun are so small relative to the total distance from Earth to the Sun that this difference isn't relevant. Ironically, Earth is actually closest to the Sun in January and furthest from the Sun in July, which is completely opposite from the result students might predict about the Northern Hemisphere based on the misconception! This is further evidence that Earth's distance from the Sun is not what matters in explaining long-term temperatures patterns on Earth. What matters is how sunlight striking Earth's surface at different latitudes impacts locations on the planet throughout the course of the year."

- Following the activity, bring the group back inside.

Fun facts (time permitting): To simulate a circular orbit in this scale model, with the model Sun at the center, the model Earth (marble) would travel approximately 1.7 meters along the circle in one day and would complete one full rotation on its tilted axis.