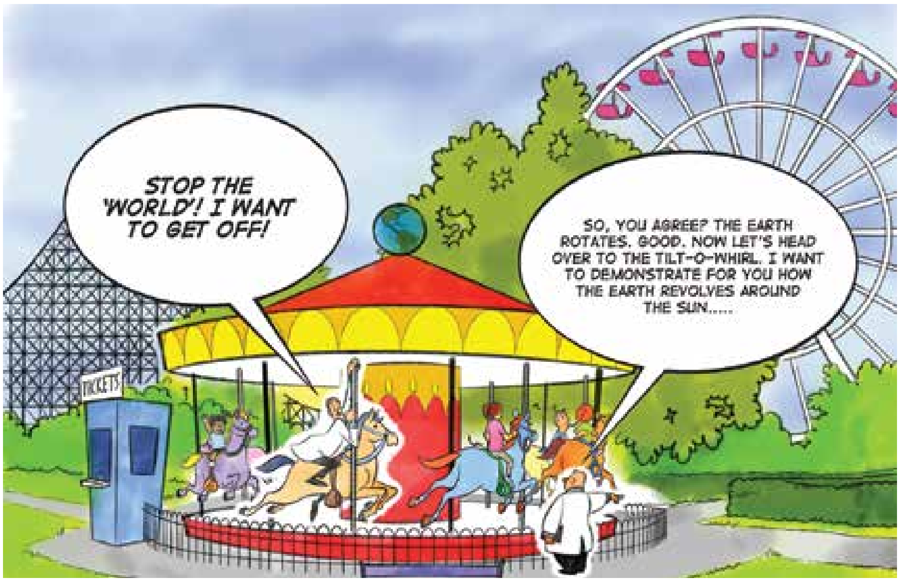
Q: What are some common misconceptions to be aware of when teaching about astronomy?

By Matt Bobrowsky

A: Most teachers are quite aware that students do not enter the classroom as blank slates. They arrive with prior knowledge and opinions—preconceptions—that might not be based on adequate evidence. Some of those preconceptions are correct. And those that are not correct we might call *misconceptions*. There's a lot of research about misconceptions and how difficult they are to change. For example, you might correctly teach that it's hotter in the summer than in the winter because the tilt of the Earth makes sunlight hit a specific part of the Earth more directly and for more hours each day. But then on a test, you'll still get some students saying that it's hotter in the summer because the Earth is closer to the Sun. Misconceptions are very persistent, and the research shows that simply teaching the correct information is not enough to get students (and many adults) to change their thinking. What *does* help is to directly address the misconception, e.g., "Many people think that…," and then allow students to see how, if that were true, we would see something different from what we actually observe.



BRIAN DISKIN

One of the first things people tried to figure out about celestial bodies thousands of years ago is: What revolves around what? Consider the two possibilities shown in Figure 1. Watching the Sun, Moon, and stars rise and set each day (or night), one might easily get the idea that everything is revolving around us. That would mean that the Earth is at the center of the solar system. But 2,300 years ago, a Greek astronomer and mathematician named Aristarchus proposed (correctly) that the Sun is at the center of the solar system and that the daily rising and setting of the Sun, Moon, and stars is due to the Earth's rotation (spinning). However, a few centuries later, another astronomer and mathematician, Ptolemy, popularized the idea that the Earth is at the center of the solar system. And his Earth-centered model of the solar system was accepted for the next 1,400 years! That tells you something about how hard it is to figure out that it's really the Sun that's at the center of the solar system.

Misconceptions related to all of this include…

1. …that we have day and night due to the Sun revolving around the Earth;
2. …that day and night are caused by the Earth revolving around the Sun;
3. …that the Earth is at the center of the solar system.

To dispel misconception #1, people needed to prove that it's the Earth, not the Sun, that is moving. That was pretty much impossible prior to the invention of the telescope. But once we had telescopes, different types of observations were possible that showed that the Earth is moving. One of them revealed how the positions of stars in the sky appear to change due to the motion of the Earth. Here's one way to demonstrate this idea if students are seated in normal rows and columns: Stand in front of one of the columns of students and, while pointing down the column (Figure 2a), show that, as seen from where you're standing, all the students in that column are aligned in the same direction. Now move some distance to the right or left, and show (by pointing) that those same students are now in different directions from your point of view (Figure 2b). In the same way, when the Earth moves to different places in its orbit, stars that appear aligned in almost the same direction, as seen from one location of the Earth in its orbit, appear more widely separated as seen from the Earth in another location in its orbit.

In Figure 3, p. 74, we see that when we view a nearby star from where the Earth is in April, that nearby star appears to be aligned in the same direction as Star A—in the same way that two of the students in that column you were standing in front of earlier appeared, at first, to be aligned in the same direction. But then, six months later, in October, the Earth has moved to the other side of its orbit, and now when we look at that nearby star, it appears to be in a different direction from that of Star A. Now it appears to be lined up with Star B! This apparent change in position wouldn't occur if the Earth were stationary at the center of the solar system. This is what astronomers observe, and this effect is called *parallax* (not an elementary-level term, but I thought you might want to know, especially since I'm about to use it again).

Here's how all of your students can experience parallax: Draw a dot on the board, which represents a distant star—like Star A in our previous example. I use a dot to remind students that real stars are not "star-shaped" but are round (i.e., spherical), like the Sun. You can also say that stars are actually other suns, just much farther away, which is why they appear much smaller and dimmer than the Sun. Now ask students to close one eye and hold up a finger or a pen so that it is blocking their view of the star on the board (see Figure 4, p. 74). Once everyone has the star blocked out, tell them to switch eyes. The instant they switch eyes, their finger or pen will no longer be blocking out the star. Their finger or pen will appear to jump to another position, so it's no longer in the same direction as the star. They can then relax as you explain that, by first observing with one eye and then the other, they were viewing the star from two different places, just like viewing real stars from two different places in the Earth's orbit. Recap: These apparent changes in position result from the Earth moving in its orbit and our viewing the stars from different places. Thus we know that it is the Earth that is moving, not the Sun, and that the Earth revolves around the Sun. So the Earth is not at the center of the solar system (misconception #3, Ptolemy's idea), and this means that the reason we have day and night is not due to the

WHAT'S THE GOOD WORD?

Many people confuse the words *rotate* and *revolve*. Rotate refers to spinning. The Earth rotates once (on its axis) in 24 hours. Revolve means to move around another object, or to orbit. The Earth revolves around the Sun once a year.

FIGURE 1

A Sun-centered solar system (left) vs. an Earth-centered solar system (right) (not to scale).

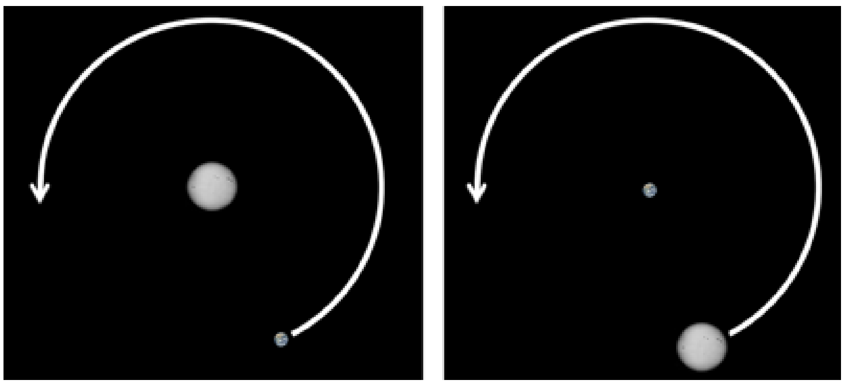
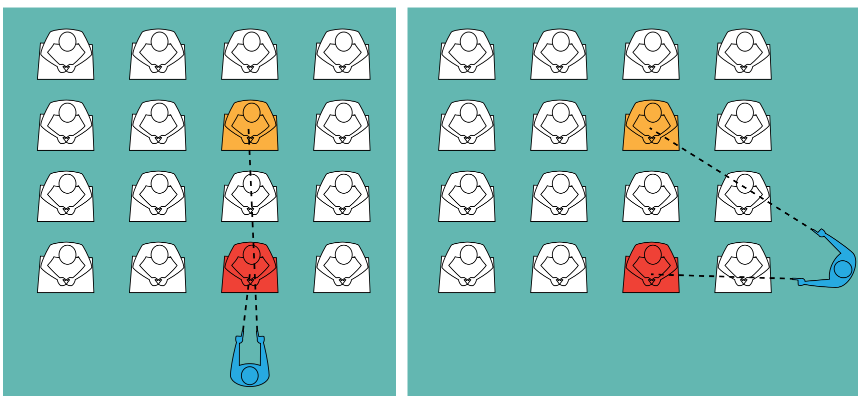


FIGURE 2



Teacher pointing out that a column of students are all in the same direction from the teacher's point of view.

Teacher pointing out that, from a different vantage point, students who were previously in the same direction no longer are.

FIGURE 3

A nearby star appears to change position relative to more distant stars as the Earth revolves around the Sun (not to scale).

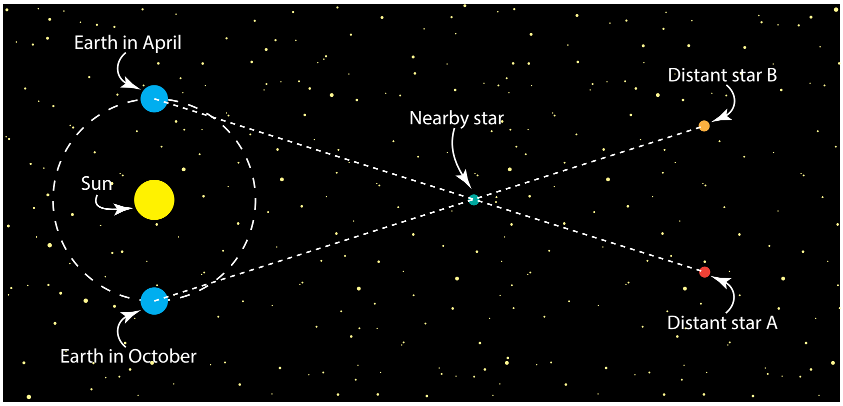
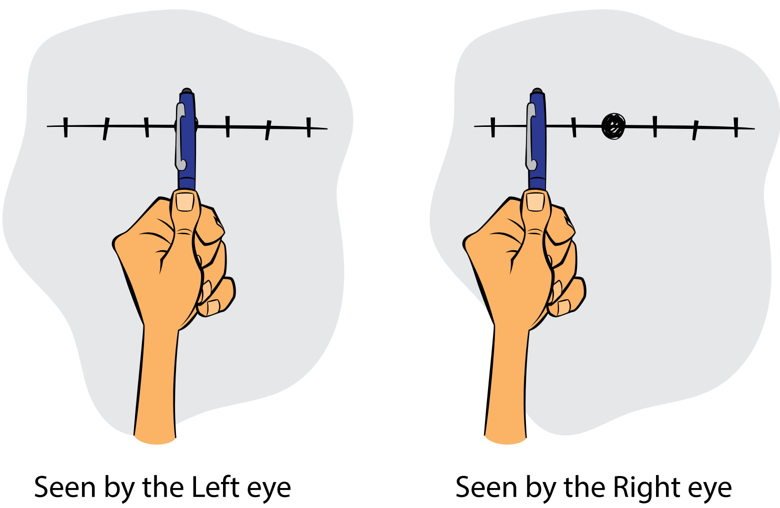


FIGURE 4

Seen by one eye, the pen is in the same direction as the "star" (left). Seen by the other eye, the pen is no longer in the same direction (right).



Sun revolving around the Earth (misconception #1)—even though it very much looks like it does, as we see the Sun rise, move across the sky, and set each day.

So something else must account for day and night and the rising and setting of the Sun, Moon, and stars. Imagine you're on a spinning merry-go-round. You see everything—people, trees, buildings—whizzing by in front of you, appearing to go around and around. One possible explanation (hypothesis) that you could consider would be that all these different things are revolving around you. But there's a much simpler explanation: It's not the things you're observing that are moving, only that you are spinning around. It's simpler because it only requires one object to be moving, rather than 100 different things all whirling around. That same simpler explanation applies to the Earth as well. Of course the simplest explanation is not always the correct one, but in this case it is. As we stand on the Earth, it's like we're on a spinning merry-go-round, and as the Earth turns, or rotates, once a day, we see everything appear to move around us. Not only do we now have telescopes, which help us to better understand what's going on in space, but we now also have spacecraft, so we have actual videos of the Earth's rotation. You can see links to two of them in the Internet Resources. Since Earth's rotation causes us to have day and night, we can reject Misconception #2 (day and night caused by the Earth's revolution around the Sun). We can reject this misconception also because it takes Earth a year to revolve once around the Sun, whereas the Sun rises and sets once a day.

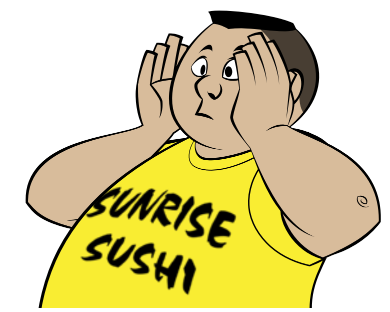
These types of evidence are important. If we just state a fact, students are likely to forget it—and revert to their misconceptions. But if we explicitly state the reason(s) why we know the fact is correct and why the misconception is incorrect, students are more likely to remember the correct information.

Here's a way to have students simulate the Sun rising, moving across the sky, and setting:

1. Turn on a lightbulb somewhere in the room, and turn the rest of the lights off, close blinds, and so on. The lightbulb represents the Sun.
2. Have students stand up and put their hands next to their eyes, like horse blinders, which will limit their field of view (see Figure 5).
3. Ask students to turn with their backs to the "Sun." Do they see the Sun? (No.) Since the Sun isn't in view, that means it's nighttime.
4. Ask students to sloooowly turn—just as the Earth rotates—to the left (counter-clockwise, which is the way the Earth rotates if you look down at the Earth from over the North Pole). Tell them to stop when the Sun just barely comes into view. This is sunrise!
5. Ask students to continue slowly turning to the left. Do they see the Sun appearing to move across their field of view? (They should.) That's just like the Sun appearing to move across the sky in the course of the day.
6. Have them stop when the Sun is directly in front of them. That's the middle of the day—around 12:00 noon (or 1:00 p.m. if you're on daylight saving time).
7. Ask students to continue turning to the left until the Sun is just disappearing from their view. That's sunset!
8. If they continue to turn, the Sun will no longer be in view, and it will be nighttime again. (Good night.)
9. So that illustrates how the rotation of the Earth causes the Sun to rise and set each day. The length of a day—24 hours—is how long it takes the Earth to turn from one Sunrise to the next, or from one Sunset to the next. You know, Earth's rotation really makes my day!

Never stop learning. ●

FIGURE 5



Students limit their field of view with their hands.

INTERNET RESOURCES

Daytime View of Earth's Rotation (The first 20 seconds shows smooth, time-lapse rotation.) *https://images.nasa.gov/details-GSFC_20151214_EPIC_m12097.html*

Nighttime View, Time-Lapse Earth Rotation Video (See city lights move as Earth rotates.) *https://svs.gsfc.nasa.gov/30082*

Matt Bobrowsky ***(DrMatt@msb-science.com)*** is the lead author of the NSTA Press book series, *Phenomenon-Based Learning: Using Physical Science Gadgets & Gizmos.* You can let him know if there's a science concept that you would like to hear more about.