Because our planet and our Moon are positioned where they are with regard to the Sun, we have a regular cycle of both lunar and solar eclipses each year. While both kinds of eclipses are visible, each eclipse is dependent on the position of the Sun, Moon, and Earth. In addition, a person’s location on Earth is a determinant for what the eclipse looks like. If there is a lunar eclipse and the Moon is visible, then you will be able to see part of or all of the eclipse (the viewing area across the Earth for a lunar eclipse is quite large). On the other hand, to see a solar eclipse, you have to be somewhere near the centerline of the path the eclipse follows across the Earth as the Earth rotates. Figure 1, adapted from a NASA publication (see Resources), shows the centerline of a solar eclipse path, the parts

**FIGURE 1** Area of visibility for November 3 eclipse
of the world where the Sun will be above the horizon, and the percentage of the Sun covered by the Moon. If, for example, you were on the centerline of a solar eclipse path, the Moon would be centered on the Sun, giving rise to either a total eclipse of the Sun and temporary nighttime or an annular solar eclipse, where the Moon does not completely cover the Sun.

The centerline of the eclipse path is the center of the Moon’s shadow. If the shadow reaches the Earth’s surface, the centerline is called the path of totality. Anyone along this path or within a few miles of it would see a total eclipse of the Sun. However, as distance from the path increased, the amount of the Sun covered by the Moon decreases. During an annular solar eclipse, when the Moon’s shadow does not reach the Earth, the centerline is known as the path of annularity. As with a total solar eclipse, as distance from the path of annularity increases, the amount of the Sun covered by the Moon decreases.

During 2013, there will be two solar eclipses, an annular in May and a hybrid in November. While the May eclipse will not be visible from the United States, the November eclipse will be visible (in progress) from a small part of the East Coast of the United States as the Sun rises. (This eclipse will be a topic of the upcoming October 2013 Scope on the Skies column.) Despite the unfavorable viewing conditions in our part of the world, both of these solar eclipses do create an opportunity for using available resources to follow the shadow path and learn something about the parts of the Earth that the eclipse path crosses—the countries, islands, climate, weather patterns, and so on.

**Annular solar eclipse**

An annular solar eclipse takes place on May 9 or 10, depending on which side of the international date line you are located. An annular eclipse of the Sun occurs at new Moon, as does a total solar eclipse. However, the primary difference between the two is the distance between the Earth and the Moon at new Moon phase, and to some extent the distance between the Earth and the Sun. Both the Sun and our much smaller Moon appear to be about the same size due to their respective distances from the Earth. However, the Moon has an elliptical-shaped orbit with respect to the Earth, so it will be at varying distances from the Earth at new Moon. (see Figure 2). Depending on the Earth-to-Moon distance, if the Moon is the same apparent size or larger than the Sun’s apparent size, the Moon will cover the Sun’s disk and give us a total solar eclipse, with the Moon’s shadow reaching the Earth’s surface. On the other hand, if the new Moon is closer and its apparent size is smaller than the Sun, we have an annular eclipse, where the Moon’s shadow does not reach the Earth’s surface. At mid-eclipse, instead of the sky darkening as with a total solar eclipse, there is a ring of Sun, the annulus, around the Moon.

**Do you know the way to Kiribati?**

An eclipse follower is someone who travels to different locations to view an eclipse. While most of us, especially our students, don’t have that opportunity, we can all be armchair eclipse followers and follow the eclipse path across the surface of the Earth using resources on the Internet and in the library. The May solar eclipse path begins in western Australia and then travels across the tip of northern Australia,

**Questions for students**

1. Look at Figure 1, in particular the Earth-to-Sun distance for each month. During which month is the Earth closest and farthest from the Sun? What does this suggest about the shape of the Earth’s orbit around the Sun? (The Earth-to-Sun distance varies each month, which means that the shape of the Earth’s orbit is not circular but slightly elliptical.)

2. How does the apparent size of either the Moon or Sun relate to distance from the Earth? (Apparent size increases as the distance between either the Moon or Sun and Earth decreases—the closer the Moon or Sun is, the larger it appears; conversely, as distance increases, apparent size decreases.)

3. What does the word mauri mean, and where is it spoken? (It is hello or welcome in the Kiribati language, which is spoken on the South Pacific island of the same name.)

4. Do you have a saros series on your birthday? If so, when will a solar eclipse be visible from your home location on your birthday? (Use the saros-series website to find a solar eclipse on your birthday. Click on the saros number to see a catalog of years when the solar eclipses belonging to this saros number occur. Use this catalog to follow eclipses on your birthday and from where they can be seen.)
slightly north of where last year’s total solar eclipse in May was visible. Crossing the southern tip of Papua New Guinea and the Solomon Islands, the centerline of the path curves north across the equator and then back toward an ending just south of the equator and around 4,828 km (3,000 mi.) west of the west coast of South America. For this eclipse, teachers could have students use a Google Earth interface (see the NASA Eclipse website in Resources) to zoom in on a map of the Earth to find the few islands that the centerline of the eclipse path crosses or passes near and perhaps turn this into an investigation of the geography and culture of the islands along the eclipse path. See Resources for information about Kiribati (islands northeast of Australia) and the eclipse path.

This particular eclipse will not cross many populated areas and will not be visible from the United States. Despite this, there is an interesting aspect of this annular solar eclipse for me personally. It is occurring on May 10, the same date as a total solar eclipse last year, which is also my birthday. Additionally, and memorable to me, May 10, 1994, was the date for an annular solar eclipse with its path of annularity passing right over the Kansas City area, where I live.

One might start thinking there is some sort of pattern going on here, and there is. There is a regular pattern to the occurrence of solar eclipses, known as the saros series. A saros is the time between solar

<table>
<thead>
<tr>
<th>New Moon date</th>
<th>Earth-to-Moon distance (km [mi.])</th>
<th>Moon apparent size (arc minutes)</th>
<th>Sun apparent size (arc minutes)</th>
<th>Earth-to-Sun distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 11</td>
<td>358,206 (222,578)</td>
<td>33</td>
<td>33</td>
<td>147,129,506 (91,421,539,299)</td>
</tr>
<tr>
<td>February 10</td>
<td>367,884 (228,593)</td>
<td>32</td>
<td>32</td>
<td>147,638,138 (91,737,816,604)</td>
</tr>
<tr>
<td>March 11</td>
<td>376,008 (233,640)</td>
<td>32</td>
<td>32</td>
<td>148,640,444 (92,360,429,293)</td>
</tr>
<tr>
<td>April 10</td>
<td>387,950 (241,061)</td>
<td>31</td>
<td>32</td>
<td>149,897,066 (93,141,491,319)</td>
</tr>
<tr>
<td>May 10 (solar eclipse)</td>
<td>397,061 (246,722)</td>
<td>30</td>
<td>32</td>
<td>150,944,251 (93,792,065,657)</td>
</tr>
<tr>
<td>June 8</td>
<td>400,185 (248,663)</td>
<td>30</td>
<td>32</td>
<td>151,841,839 (94,349,434,501)</td>
</tr>
<tr>
<td>July 7</td>
<td>400,417 (248,807)</td>
<td>30</td>
<td>31</td>
<td>151,991,437 (94,442,639,994)</td>
</tr>
<tr>
<td>August 6</td>
<td>395,975 (246,047)</td>
<td>30</td>
<td>32</td>
<td>151,692,241 (94,256,850,379)</td>
</tr>
<tr>
<td>September 5</td>
<td>386,650 (240,253)</td>
<td>31</td>
<td>32</td>
<td>150,794,654 (93,698,860,164)</td>
</tr>
<tr>
<td>October 5</td>
<td>374,957 (232,987)</td>
<td>32</td>
<td>32</td>
<td>(92,936,439,236) 149,567,951</td>
</tr>
<tr>
<td>November 3 (solar eclipse)</td>
<td>366,357 (227,644)</td>
<td>33</td>
<td>32</td>
<td>148,371,168 (92,193,280,777)</td>
</tr>
<tr>
<td>December 3</td>
<td>357,647 (222,231)</td>
<td>33</td>
<td>32</td>
<td>147,443,661 (91,616,649,463)</td>
</tr>
</tbody>
</table>
eclipses, approximately 18 years, and as a repetitive or cyclical event, the saros series can be used to predict solar eclipses. After one saros, a solar eclipse will occur with nearly the same circumstances as the one it follows; however, the eclipse will be approximately 120° to the west. So, every three saros, a solar eclipse returns (more or less) to the same spot. The saros series is also numbered, and each eclipse belongs to its own unique saros number, linking it to others occurring on the same date in different years. Using the one on my birthday in 1994 that was visible from where I live, the next one in my saros series was the eclipse of May 2012, which will be followed by one in 2030, and then back to Kansas City in 2048. My saros series is 128. What’s yours?

**Hybrid solar eclipse**

The solar eclipse on November 3 will be like the one on May 10 in that the path the Moon’s shadow follows across the Earth will take it across mostly ocean, but this time the Atlantic Ocean. The eclipse will begin over the Atlantic Ocean about 1,609 km (1,000 mi.) south-east of the southeastern coast of the United States, and then it will travel southeastward toward equatorial western Africa before curving northeast and ending on the eastern side of the African continent.

The November 3 solar eclipse will also be similar to the one in May in that it, too, will be an annular eclipse—at least at the beginning. About 5% of solar eclipses are hybrid—it begins as an annular solar eclipse and will end as a total solar eclipse. This has to do, in part, with the curvature and seasonal tilt of the Earth, and the position of the Moon as it casts its shadow. Typically, a hybrid solar eclipse starts as an annular, switches to total, and then ends as an annular eclipse. Because of the arrangement of the Earth, Moon, and Sun during the May eclipse, the Moon’s shadow will not quite reach the Earth’s surface during the first few seconds, resulting in an annular eclipse. However, the Moon’s shadow will very quickly reach the Earth’s surface, setting up the total eclipse. As the shadow traverses the Earth’s surface, the width of the path of the totality will vary, resulting in varying durations for the period totality. This eclipse path will spend much of the time over the Atlantic Ocean, but after “landfall” on the African continent, the eclipse path will travel northeastward across several African countries, including Gabon, the Congo, Uganda, Kenya, and Ethiopia. At the NASA Eclipse website, there is an interactive, Google-based map showing the path for this eclipse. (See “NASA Eclipse with Google Map of November Solar Eclipse” in Resources.) As with the May eclipse, students can explore the countries involved with this eclipse.

**Clear skies**

To get students started on exploring some of these faraway lands, take a look at the Eclipser website for weather predictions and incredibly detailed descriptions of the parts of Africa the eclipse centerline will track across. To extend the idea of having cloud- and pollution-free clear skies, especially for how the clarity of the sky (atmosphere) relates to day or night astronomical observations, students can go to the Clear Sky website to use a tool (a display the website produces for your location) that many astronomers from the United States and Canada regularly employ (see Resources). It may be interesting to compare the sky information from other locations to see how the geographical location has any influence on clear skies.

**Partial lunar eclipse**

Eclipses usually occur as pairs—a solar eclipse at new Moon and a lunar eclipse at full Moon. The May 10 solar eclipse’s “partner” lunar eclipse on May 25 will be more of a penumbral lunar eclipse, as the path of the Moon will mostly only go through the faint, outer penumbral shadow. At mid-eclipse, the Moon slightly nicks the darker umbral shadow; technically, this qualifies the eclipse as a partial eclipse. Overall, the brightness of the Moon will dim somewhat and therefore may be visible, but only if you live somewhere in Europe and Africa—it will not be visible from the United States. By contrast, the November partner lunar eclipse will be a very dim and barely, if at all, noticeable partial penumbral eclipse. At mid-eclipse, only about 80% of the Moon will be within the outer faint penumbral shadow. This eclipse, however, will occur when the Moon is above the horizon for North America and will be visible from the United States.

**Visible planets**

**Mercury** will be visible as a morning planet during April and will then move into the evening skies for the last half of May, where it will join Jupiter and Venus at the end of May.

**Venus** will be not visible for most of April and then will return to the evening skies during May.
Mars will be at superior conjunction during April and will not be visible until this summer in the morning skies.

Jupiter will be visible over the western horizon at sunset until the end of May, when it becomes too close to the Sun.

Saturn will be at opposition at the end of April and will be visible all night during April and May.

April

2  Last quarter Moon
3  Moon occults Pluto
5  *Cassini* Titan flyby
10  New Moon
12  Yuri’s Night World Space Party
13  Pluto begins retrograde motion
14  Waxing crescent Moon near the Pleiades
15  Moon near Jupiter and Aldebaran
15  Moon at apogee (404,900 km; 251,593 mi.)
17  Astronomy Week (April 15–21)
17  Mars in solar conjunction
18  First quarter Moon
19  Waxing gibbous Moon near Beehive cluster
20  Mercury near Uranus
20  Astronomy Day
22  Lyrid meteor shower peak night
24  Earth Day
25  Full Moon
19  Partial lunar eclipse
20  Moon near Saturn
27  Moon at perigee: (362,300 km; 225,123 mi.)
28  Saturn at opposition

May

2  Last quarter Moon
3  Space Day
10  New Moon
10  Annular solar eclipse
11  Mercury at superior conjunction
12  Moon near Jupiter
13  Moon at apogee (405,800 km; 252,152 mi.)
15  Waxing crescent Moon near the Gemini Twins
17  First quarter Moon
22  Waxing gibbous Moon near Spica
23  Waxing gibbous Moon near Saturn
24  *Cassini* Titan flyby
25  Mercury near Venus
25  Full Moon
25  Penumbral lunar eclipse
25  Moon at perigee (358,400 km; 222,700 mi.)
27  Mercury near Jupiter and Venus
28  Mercury near Jupiter and Venus
31  Last quarter Moon

Resources

Astronomy Day—www.astroleague.org/al/astroday/astroday.html


Clear Sky chart—http://cleardarksky.com/csk

Earth Day—www.earthday.org


Kiribati—www.mapsofworld.com/kiribati/kiribati-political-map.html


November eclipse path—http://eclipse.gsfc.nasa.gov/CH/CHfigures/CH2013-Fig05.pdf


Space Day—www.spaceday.org

Yuri’s Night—www.yurisnight.net