



GET READY FOR THE GREAT AMERICAN ECLIPSE!

A once-in-a-lifetime event provides an opportunity to increase science literacy.

By Charles Fulco



It's not often in a teaching career that an event in the natural world presents the opportunity for increasing science literacy on a national scale—on the same day for everyone. But on August 21, 2017, just such an event will occur, literally from coast-to-coast. On that Monday morning and afternoon, the 2017 Total Solar Eclipse (TSE2017) will bisect the United States in a narrow path stretching across 12 states, from Oregon to South Carolina (Figure 1, p. 62). As *all* teachers and students in the United States—weather-permitting—will see partial eclipse stages on Eclipse Day (“E-Day”), future articles in this series will present investigations and activities for both the partial and total event.


This year marks 38 years since any part of the continental United States was darkened by the Moon's umbral shadow. During this “eclipse drought,” no U.S. residents except those on Hawaii's Big Island in 1991 have had the opportunity to observe totality without traveling abroad. TSE2017 is also special in that the umbra (the Moon's shadow) travels the United States coast-to-coast, some-

thing that hasn't happened since 1918, and the Moon's umbral shadow does not fall on any other nation except the United States for the first time since we became a country—making this a truly Great American Eclipse.

For those teachers and students fortunate enough to be within this path, daytime will turn briefly to deep twilight, the Sun's elusive *corona* (the plasma that surrounds the Sun and is visible during an eclipse) will come into view, and all the other phenomena that accompany this amazing spectacle will present a rare and unique teaching opportunity that, if properly prepared for and taught to full advantage, can promote scientific literacy in classrooms on a magnitude unmatched in the history of U.S. education.

Are You in the Path?

While a solar eclipse is a surprisingly common event—at least two *must* occur each year—most people (teachers included) I surveyed have never witnessed a partial eclipse, let alone a total eclipse. The question then is: how does an



instructor prepare cross-content, NGSS-aligned lessons with STEAM activities and hands-on investigations when the *teacher* may not even be quite sure what he or she will be observing, or even how to observe it safely?

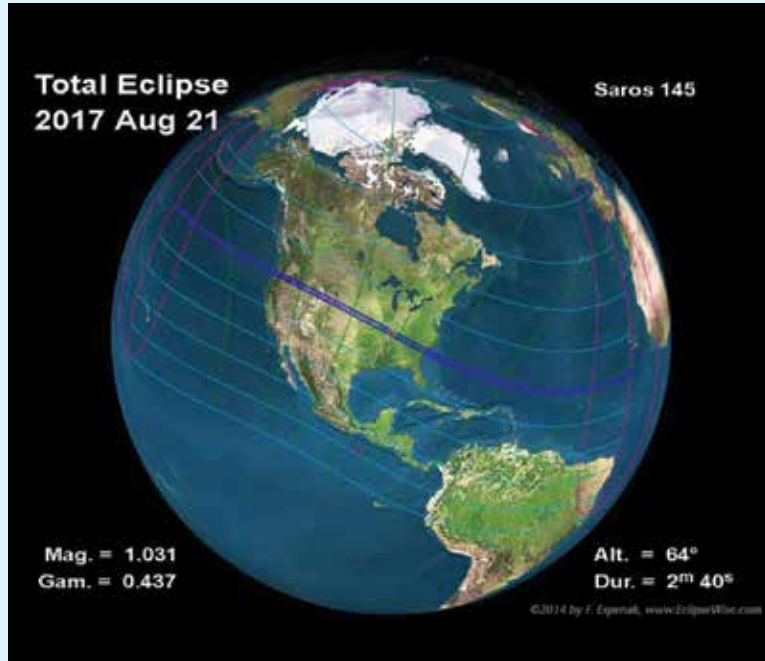
Another important question needs to be answered: *Am I in the path of totality on August 21, 2017?* As any eclipse veteran will tell you, the difference between the Sun being partially covered by the Moon and being fully hidden is literally night and day. The contrast between the two events is so striking because even a 99% partial solar eclipse is still about 10,000 times brighter than a total one; thus, most of the most memorable and scientifically important phenomena are lost in the Sun's glare during even a deep partial event. Therefore, if getting you and your students (and their families) to the path of totality is an option, it must be seriously considered.

For centuries, astronomers have known that to see the phenomena of totality, an observer needs to be within the path of the Moon's shadow, or *umbra* (see Figure 2, p. 62). Totality includes the ability to observe the solar corona, the chromosphere (an incandescent layer of primarily hydrogen, several thousand miles in depth, lying above the photosphere), and prominences (large eruptions of luminous hydrogen gas that rise thousands of kilometers above the chromosphere, sometimes forming loops). To determine if you live or teach in this area, consult a map of TSE2017 (see Internet Resources for the Great American Eclipse website and Jay Anderson's webpage of detailed maps, weather prospects, and other important information for every state in the path of totality).

If your location is not situated in the relatively narrow path—about 70 mi. wide for this eclipse—you have two options as a teacher: arrange a field trip to the path of totality for your group (perhaps selling eclipse glasses as a fund-raiser), or remain where you are and observe the partial eclipse.

FIGURE 1.

The path of the eclipse.



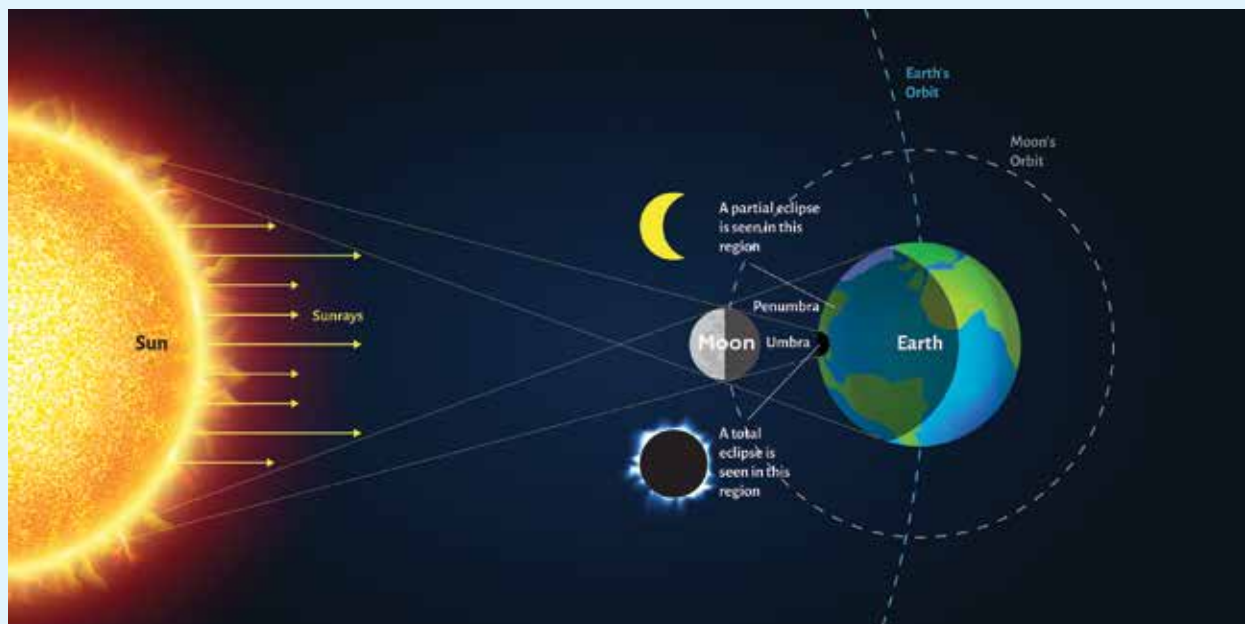
Science Literacy and TSE2017

Science literacy is the ability to ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a student has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read for understanding and form conclusions based on evidence. It also implies the capacity to argue from evidence and to apply conclusions from such arguments appropriately.

Integrating NGSS three-dimensional learning into your eclipse preparation will promote an environment of science literacy in your classroom, especially when combined with the 5E approach of Engaging, Exploring, Explaining, Elaborating, and Evaluating—all important learning skills that contribute to understanding a particular subject or scientific event, such as TSE2017.

FIGURE 2.

Diagram of a solar eclipse.



Unfortunately, based on my interactions with a large and diverse sampling of teachers in many districts across the United States, awareness of eclipses (and other celestial phenomena) appears to be low among our students, demonstrating the need to promote science literacy in schools beginning at an early age. One potential solution is to integrate technology that is familiar to students. This being the first total solar eclipse in the United States in the age of social media, there is both a level of excitement and uncertainty regarding the scientific literacy potential in current “handheld” technology. Several major social media-based experiments now being planned (see *Eclipse Megamovie Project* sidebar) involve nationwide internet participation and collaboration from teachers and students, merging observations with those of peer classrooms along the path of totality from Oregon to South Carolina to obtain a continuum of visual data from coast to coast. These experiments and how to arrange for you and your students to participate will be discussed in a later article in this series.

Eclipses 101

A little background is required in order to understand why this year’s celestial event is so special. The Moon orbits the Earth at a five degree angle, twice a month crossing a “node,” the imaginary point in space where the Moon’s orbit intersects the plane of the Earth’s orbit as it loops north and south of this plane. Due to celestial geometry, these nodes continually move eastward along the Moon’s orbit, eventually lining up with the Sun and Earth about every six months, thus causing either a solar or lunar eclipse, depending on whether the Moon is new or full. Your students will replicate this in a simple and fun activity described later in this series of articles.

Because the Sun is a disc and not a point of light (like a star), the Moon’s shadow is made up of two distinct sections: the *penumbra*—the lighter, outer part, and the aforementioned *umbra*—the darker, inner part. It is the latter that causes an eclipse to be total—that is why if you and your students are to see totality, you *must* be within the narrow path of the umbra—even 0.5 km outside the path is too far, so it is best to arrange your observing site well within the umbra’s path.



Safe viewing includes eclipse-viewing glasses.

The Eclipse Megamovie Project

The Eclipse Megamovie Project brings people together to share their images and experiences of total solar eclipses and other astronomical events. The goal for TSE2017 is to create high-resolution time-lapse movies from images taken by non-scientists (such as teachers and students), from Oregon to South Carolina. In this way, you and your students, using familiar technology, can collaborate with peers from across the country to help create a seamless 90-minute view of the solar corona and other phenomena of the eclipse on August 21, 2017.

You and your students may be able to help the solar scientists on the Megamovie team understand more about the Sun by providing quality, high-resolution images of the eclipse. (If you have taken photographs of any astronomical objects recently that you would be willing to share, please visit their Image Upload Page to do this. This will help refine their technical movie-making programs.)

You can visit their Facebook Page to see movies that their team creates using images submitted by many different contributors, including the educational community. If you have questions about this project, please contact the Megamovie team at outreach@ssl.berkeley.edu.



Since the penumbra casts its shadow over an extensive area, many more people can observe a partial eclipse than a total. The closer an observer is to the path of totality, the greater the amount of the Sun that is covered; this is called the “magnitude” of the eclipse. As the magnitude approaches 80–85%, a definite diminishing in ambient light occurs; as the magnitude nears 90% or greater, even a person unaware of the eclipse will sense something is not quite right. Once the magnitude reaches 100%, phenomena only visible during a total eclipse, such as prominences and the solar corona, can now be seen. It is at this point—and *this point only*—that protective filters are removed from optical instruments and human eyes, in order to observe totality to its fullest extent. Then, once the Sun reappears, all filters must be applied again and used until the end of observation. Eye safety will be more closely examined later in this series.

A total solar eclipse consists of four distinct “contacts,” which define its stages (see Figure 3):

- **First Contact** is the point at which the previously invisible lunar disc makes its first notch on the solar disc; at this moment, the eclipse has begun.
- **Second Contact** is the point at which the Moon completely covers the solar disc; this is the beginning of totality, at which point filters are to be removed to view all associated phenomena. Second Contact is marked by the “diamond ring effect.”
- **Third Contact** is the point at which the Sun appears again, signaling the end of totality, and again with a second “diamond ring.”
- **Fourth Contact** is the point at which the Moon disappears from the solar disc, marking the end of the eclipse.

Early on the morning of the eclipse, the Moon’s shadow first touches Earth over the Pacific Ocean, then encounters the Oregon coast by mid-morning and very rapidly traverses a dozen states, leaving the east coast at Charleston, South Carolina, by mid-afternoon, finally lifting off the Atlantic Ocean at eclipse’s end. During its time speeding across the United States, the umbra will pass over a great variety of landforms, weather conditions, and population centers, including five state capitals, three national parks, and vast numbers of towns and school districts.

Get Ready

While a solar eclipse lasts only several hours—with any period of totality lasting only minutes—an extensive educational component can start well in advance of E-Day. Utilizing the *Understanding by Design* method of instruction (Wiggins et al. 1998), teachers can “work backward” to plot lessons and budget an appropriate amount of classroom “science time” devoted toward TSE2017. The nature of a total eclipse also lends itself nicely to other content areas, and there are many STEAM components that can be applied to TSE2017 instruction.

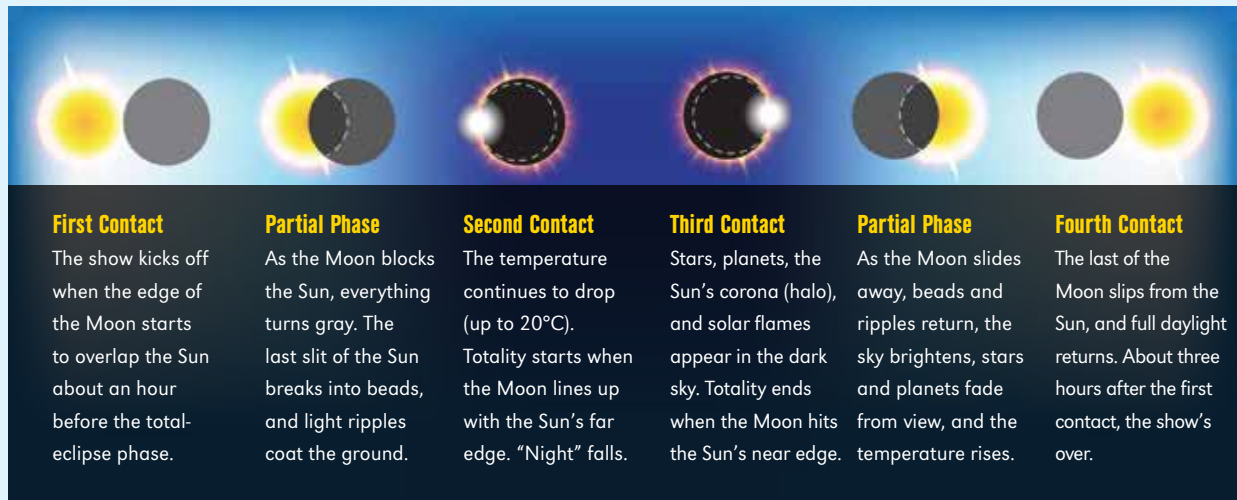
Given that there is no formal classroom time for most American students during much of the June-July-August period leading up to the eclipse, it is imperative that eclipse instruction in your classroom begin before your students depart for summer vacation. Parental engagement, while always encouraged, is especially de-

Engaging and meaningful out-of-classroom discovery should always be part of your elementary students’ summer learning experience, and this year’s special celestial event will add a wonderful component to this enrichment.



FIGURE 3.

The four distinct “contacts” of a total solar eclipse.



sirable during the summer, not only to keep students' motivation and enthusiasm high for the eclipse but also to reinforce that TSE2017 is a learning experience to be shared by the entire family. Engaging and meaningful out-of-classroom discovery should always be part of your elementary students' summer learning experience, and this year's special celestial event will add a wonderful component to this enrichment.

As educational ambassadors to the natural world, science teachers have the added responsibility in 2017 to promote and encourage viewing of TSE2017 in their communities. That may well mean you (or your science department chair) sitting down with the superintendent or board of education in order to obtain permission to do so on school property. You may also want to give your argument extra robustness by explaining how you will add TSE2017 into your science curriculum, aligning TSE2017 with NGSS 3-D and 5E learning. Fortunately, there are many valid and trusted classroom resources to offer support, including this series of articles in *Science & Children*. See the February through Summer issues of *S&C* for additional TSE2017 articles, including a special insert in the March issue. ■

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References

Wiggins, G.P., J. McTighe, L.J. Kiernan, F. Frost, and Association for Supervision and Curriculum Development. 1998. *Understanding by design*. Alexandria, VA: Association for Supervision and Curriculum Development.

Internet Resources

CitizenCATE
www.citizensciencecenter.com/link-chain-citizen-cate-experiment

Eclipse2017
www.eclipse2017.org/eclipse2017_main.htm

Eclipse Megamovie
<http://eclipsemegamovie.org>

Eclipseophile (eclipse weather statistics calculated by Jay Anderson)
<http://eclipseophile.com>

Google Earth
http://xjubier.free.fr/en/site_pages/SolarEclipsesGoogleMaps.html

Great American Eclipse
www.greatamericaneclipse.com

NASA

Mr. Eclipse (Fred Espenak)
<https://eclipse.gsfc.nasa.gov/solar.html>

2017 Eclipse
<http://eclipse2017.nasa.gov>

"Moon's Eye" View animation
<http://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4321>

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