SCIENTISTS IN THE FIELD

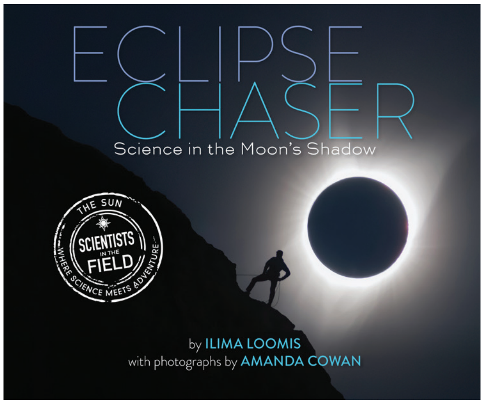
Where Science Meets Adventure

DISCUSSION AND ACTIVITY GUIDE

Eclipse Chaser by Ilima Loomis, Photographs by Amanda Cowan

About the Series

Eclipse Chaser is part of the award-winning Scientists in the Field series, which began in 1999. This distinguished and innovative series examines the work of real-life scientists doing actual research. Young readers discover what it is like to be a working scientist, investigate an intriguing research project in action, and gain a wealth of knowledge about fascinating scientific topics. Outstanding writing and stellar photography are features of every book in the series. Reading levels vary, but the books will interest a wide range of readers.



Eclipse Chaser
by Ilima Loomis
Photographs by Amanda Cowan
9781328770967

About the Book

From the provocative title, through the surreal photography, out to the sun and back again, *Eclipse Chaser* will have readers biting fingernails while rooting for cooperative weather and equipment. Most of the world has experienced an eclipse of one sort or another. Now we have a book that gracefully orchestrates the recording of them while detailing exactly what scientists hope to learn from these shadowy events.

About the Author

Ilima Loomis is an award-winning journalist who writes about space, astronomy, volcanoes, earthquakes, oceans, and other science topics. She is a big *Star Trek: The Next Generation* fan and has written about space travel to Mars. This is her first book for the Scientists in the Field series. Find her at ilimaloomis.com.

About the Photographer

Amanda Cowan is an award-winning, Vancouver, Washington-based photographer and photo editor. She received a Pulitzer Center grant to for a story on current immigration policies. She and Ilima Loomis have been friends for many years. Find her at amandacowanphotography.com

Pre-reading Activities

Have students define an eclipse and then explain how they happen. Have students list all the objects in the night sky that may experience or contribute to an eclipse. Ask students to list possible benefits of studying eclipses.

The definition of an eclipse, in addition to dealing with one celestial body shading another, also includes the idea of something falling into obscurity. Brainstorm with students situations in which trying to hide actually brings one more fame.

Make a list of artifacts, national or local landmarks, artwork, movies, television programs, clothing, food, etc., that is noted for being black, white, or both. Since eclipses also emphasize other colors, such as red, spend some time speaking with students and brainstorming ideas about the importance of contrast.

Since this book will take us around the world, review with students the differences in the movement of the sun in both the Northern and Southern Hemispheres. There are videos showing how the sun and moon appear in both hemispheres, but it may be more effective to have students figure this out with a globe, a flashlight, and a mirror.

Review the night sky, distinguishing among those celestial bodies in our solar system and those in other galaxies. Do any of these bodies experience eclipses?

Discuss with students instances in which we so want to see a particular result and are anticipating possible failures. Discuss with students the job of scientific observation and how what we want to happen often clouds our ability to see and interpret what does happen. Have students create a checklist for ensuring that their desires do not eclipse their ability to interpret what does happen.

Students may have fun looking at the word "occult" and researching how it factors into the science of astronomy as opposed to the way it is used in occult sciences.

Discussion Questions

The next total solar eclipse will not happen in the United States until 2024. What are the pros and cons of dedicating resources to this study? If you were in charge of granting funding, what kind of priority should this study receive? Since the next eclipse in this area is not until 2024, could funding wait until 2022 or 2023? Should this be an ongoing research project?

Astronomers in ancient Babylon and China learned how to predict eclipses. Thinking back to the fact that these scientists of yore did not have computers or telescopes, how did they do this?

The last question in this book that Shadia Habbal answers is: "You're at the mercy of the weather—is it really worth all this effort and expense?" (p. 69). Discuss answers before reading, during the reading, and upon finishing the book. Regardless of the answers, have students think of factors that could change their minds and document what in the book or not in the book has influenced their response. Have students document why Shadia says, "Yes." And, again, regardless of their personal answer, have them write down why one might say "No." Does our government have a responsibility to research risky topics like eclipses, hurricanes, earthquakes, etc.?

If you were the mayor of a city on the eclipse path, what would you do to ensure that the 2024 eclipse is a benefit to both your residents, the scientists observing it, and the tourists who will flock to your town? When would you begin the promotion? Are there scenarios that would have you attempting to dissuade folks from visiting?

The scientists researching these eclipses work hard to avoid crowds. Is this decision in the best interest of the science or is there a way to deal with crowds? Why do scientists not want crowds? Wouldn't crowds make it easier for them to attract sponsors or entice politicians into funding their research?

This book shows scientists working in extremely isolated places. Scientists are working with very delicate and very expensive equipment. Work conditions can include being isolated for long stretches while observing and then being in a lab for more hours working on interpreting the data. Discuss your observation skills, your stamina skills, and your ability to be persistent. What would have to happen for you to see yourself in a science career? On page 8, we read that Shadia spent twenty-two hours in planes, five hours in cars, and an hour plus in speedboats. Later we read about the hordes of tourists and the lack of toilets. We must not forget the rattlesnakes either! Do you have the stamina and fortitude it takes to do this sort of work? Are these aspects of Shadia's work something common to the work of scientists in general?

Many people complain that we underestimate their abilities. What one person sees as a risk, someone else sees as being safe. What is something you do that other people may not understand? If one of the scientists in this book asked you for help, what ability would that scientist want to use? What new skills or traits do you need to develop to move your skill up to the next level?

Applying and Extending Our Knowledge

"The Solar Cycle" on pages 64–65 state that each solar eclipse has a different look, and includes terms such as "solar maximum" (and minimum). The opportunities for both factual and creative explanation abound. The excellent nonfiction writer and photographer (such as Loomis and Cowan), however, seek to do both.

- If you were doing a newscast or were being interviewed on a national talk show, how would you explain to a large general audience just what we mean when we say "solar cycle?" How many phases would you describe? What information would you share or exclude? Record a video in two minutes that gives an explanation of a solar cycle. Share these with the class and come to a consensus on a video using the best parts of the various efforts by individuals.
- Create a visual explanation of the various phases of a solar cycle. Provide annotation explaining to the viewer what should be noticed in each picture to understand the solar cycle. Create a comic using the looks of an eclipse to create your characters. Use the details of a study of eclipses to endow your characters with quirks or special powers. Annotate these, explaining why you believe they match the science.
- Research various creation myths about the sun, including any that seem to suggest the eleven-year cycle or seem to imply magnetic activity. Invent a creation myth with eleven parts that traces the life of a solar cycle creature that both attracts and repels. Add music and create a musical. Turn this myth into a play and perform it for others.
- Create your own eleven-line poem (roundel) explaining the solar cycle. Require each line to use eleven poetic syllables. Or create a poem based on the life of astronomers researching the sun. Invent your own literary form, musical form, or dramatic form to explain the solar cycle or eclipses.

Common Core Connections

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Invite a local eye specialist in to show your students what retinal burn is and how it works. If you also have an astrophysicist in your neighborhood, invite this person as well to explain the timing of viewing a solar eclipse—When is it okay to look? When should you look away?

- Have students explain the difference between looking at the sun and staring at a total solar eclipse. Write this information in a way that will make sense for younger students, along with an explanation for why a total solar eclipse creates a unique set of dangerous circumstances.
- During the last eclipse, many schools, cities, and organizations distributed glasses that allowed for safe viewing of eclipses. Warnings were given to not use your sunglasses, which is also reinforced in the text. Some of these warnings even included a notice stating that even if one were to put together multiple sunglass lenses, they would not protect our eyes. Research and report back to the class on the differences between sunglasses and eclipse glasses. Include diagrams and graphics that compare and contrast.
- Using an empty box, white paper, and tin foil, students can make an eclipse pinhole viewer without any glass. Have students make one and explain why it works. There are also plenty of online resources for building eclipse viewers.
- Have students create a video or an illustration showing how the eye dilates and constricts. Juxtapose this video with a time-lapse presentation showing the changing light during eclipses.
- Many young students do not understand how the sun enables us to view the moon. Have your students design a skit for young students that reviews the phases of the moon in relation to the position of the Earth and the sun. When this is done, add a segment that shows when and how the moon gets in the way of this process to create a solar eclipse.
- Have students compare what they find in researching how eyes respond to total eclipses with the other types of eclipses, both solar and lunar.

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Ever stand in the sunshine and use someone's shade to screen yourself from the sun? If we look at the diagram on page 15, we see that only a small part of Earth will have the ability to see a total eclipse. The moon must be close enough and in just the right position to block the sun completely.

- Have students demonstrate how this works using balls and flashlights or using cut paper and lights. Have students explain why the distance and the angle indicate whether or not we will have an eclipse. How is an eclipse similar to using the shade of another?
- Using lights and shadows, try to create a video showing the differences in the eclipse light among the various locations within the range of the upper and lower yellow boundaries of the eclipse (again, using the diagram on page 15). The very center of that darker blue oval is the darkest color. What does the eclipse look like here? The upper and lower triangular shapes are still a deep blue, but a little lighter than the small center. What does this part of the eclipse look like? When you move just above or just below this is the eclipse not visible at all? Are the upper and lower yellow lines the absolute boundary of where you no longer see any type of eclipse?
- Total solar eclipses last less than eight minutes. The Earth revolves around the sun, and the moon revolves around Earth. In just a few minutes (some total eclipses are much shorter than others), all this moving will bring an end to the eclipse. Have students demonstrate this by creating a skit to share with others. Or create a video or a time-lapse set of images showing how this motion creates and then ends the eclipse.
- Compare this movement to more familiar movements, such as how far a walker, runner, bike rider, race car, high speed train, rocket, etc., could move in the same time. Use this to explore, say, how fast the Earth moves at the equator compared to the rotation speeds closer to the poles. Who knows, one of your students may be the next Pavel Štarha, writing math programs that do not yet exist to do the experiments required by science!

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As mentioned above, Pavel Štarha, a Czech mathematician, wrote computer programs that did not exist up to then to allow Shadia Habbal, a Syrian immigrant, to do her research. Shadia brought her mother, Riad, and her sister Rafif to see the eclipse and they helped cook for the team. During one eclipse, Judd Johnson, the engineer, needed to find a mechanic on an island in Norway to repair a necessary piece of equipment. Shadia calls her team the "Solar Wind Sherpas" in honor of the Sherpa people of Nepal that guide folks up and down Mount Everest and other mountains. On page 19 we read, "Teamwork is essential when working on an eclipse." It should be clear that expertise comes from all over and sometimes we do not even know expertise we will need until we do!

- Have students write autobiographies that highlight why they would be a productive member of Shadia's scientific team, one of her Sherpas.
- Many of the problems Shadia and Judd encounter are unexpected. Many of them involve equipment malfunction, but are not limited to that. Brainstorm the types of problems possible, using the text to guide the discussion, but anticipating other problems.
- Have a discussion with students on how best to deal with these setbacks.
- Have students create categories of unexpected problems and a procedure for moving forward on, say, documenting the next total eclipse. For example, students should create a category related to unexpected equipment malfunction or breakdown—what steps should be taken when a piece of equipment stops working? This activity

should involve students prioritizing the equipment value, which should involve researching what each piece of equipment does.

- If students were creating their own scientific team to study eclipses or other topics, who would they want on this team? What attributes does a person possess that makes others seek them out when creating a group of researchers? Shadia chose Nathalia Alzate (Naty), Martina Arndt, and others to lead teams on different point's of the eclipse's path. Why?
- Have students do a three-minute overview of the Sherpa guides of Nepal.

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The sidebar on page 34 is labeled "Stormy (Solar) Weather." It speaks of solar eruptions. The sidebars on page 43 address solar wind and the heat of the corona. All three of these topics have plenty of unanswered questions that are the focus of Shadia and her team's work.

- Assign groups to research these sidebars and then create a play, story, musical, folktale, etc. that explains why the sun is hotter both at the center and in the atmosphere (or corona) than it is on the surface.
- Create a playlist that feels appropriate for describing stormy solar weather. Add music that matches solar wind and the corona. Include annotations that explain what you hear in the music that matches the physical properties of each of these phenomena. Don't forget that on page 8, we read that Shadia found cool material floating in part of the corona that is very hot!
- The text states that a solar flare or storm can get so strong that it causes explosions of magnetism and electrically charged particles. Create a video that demonstrates what this means. Is a solar flare the same thing as a geyser? Volcano? How is a solar storm different from, say, a blizzard? Explain.
- On page 50, we learn that various forms of iron, nickel, and argon are part of the solar atmosphere. Create a visual with an annotation that shows the composition of the solar atmosphere. Write an encyclopedia entry that explains to readers what "solar atmosphere" is and how scientists figured out that elements like iron, nickel, and argon were part of it.
- The sidebar for the corona has a comment about holding your hand very close to a hot burner on a stove. It mentions something obvious: move your hand away from the surface and it will get cooler. However, the text goes on to infer that coronas do not work like this. It would be as if the stovetop was the coolest place to touch, and as you raise your hand higher, it would actually get much hotter. Write a paragraph that explains why this could be true.
- Create a graphic comparison of solar wind and wind. Explain how solar wind moves compared to the way other winds move in your neighborhood.

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Imagers, cameras, white-light cameras, telescopes, white-light telescopes, tripods, spectrometers, "observing instruments" (p. 16), computers, flat field, and phones are all pieces of equipment mentioned in this book. Loomis writes on page 39 that "eclipse expeditions were expensive." Only the spectrometer and telescope are included in the glossary, but without mentioning how they are used by the scientific team.

- Create an illustrated *Eclipse Chaser* glossary for these tools that includes more information about how they work and what the team uses them for in this study. Make sure to distinguish between cameras and white-light cameras; telescopes and white-light telescopes.
- There are several photographs in this book that include tools. Some of Cowan's photos include labels telling readers the name of the tool depicted. Some photos do not label the tool at all. For example, what is depicted on the title page? Look at page 8 (top left), page 13 (bottom right), page 16, and page 29. Label the tools in the photos.
- On page 39 Loomis tells us, "[Shadia] could afford only a couple of imagers." Research the cost range of the tools that you are able to. Using the photographs and text, have students predict how many of each tool this expedition must have to function, both minimally and ideally.
- Have students anticipate budget cuts and increases—where would students recommend cutting and what piece of equipment they add first. Have students write out a directive in the event of various percentages of budget cuts and surplus.

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Much in this book depends of technology. Shadia needed to write her own computer program and did just that. Computers and sophisticated imagers allow scientists to learn much more than they could ten years ago. On page 27 the text says, "In some ways, it's easier now that computers run the observations." Students reading this may forget how much we have learned without a single computer.

- Eratosthenes, a librarian, using shadows from the sun and trained pacers, was able to figure out the circumference of the Earth almost perfectly. This was in circa 200 BCE! Can students do this today?
- Have students research Aristarchus and try to determine what clues or what information led to his heliocentric theory of the universe. While Aristarchus was the first to propose a model of our current solar system, Copernicus independently came to the same conclusion. Why? What observations led to a conclusion that was decidedly not popular? Share this information with the class.
- How did Johann Galle discover Neptune?
- Shadia relies on computers, but that means "one more thing that needs to be set up, checked, and rechecked before the eclipse" (p. 27). Does technology sometimes limit our ability to learn, as well as make it possible for us to do so much more? Have students write down thoughts to keep in mind for making sure that we continue to know how to figure things out through careful observation and how to take advantage of technology to learn even more.

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Libya, Syria, Norway, Sweden, Kenya, and the United States are all mentioned as places that influenced this eclipse research. Future total solar eclipses will take place all over the world. Scientific cooperation will be required in order to research future eclipses.

- Have a discussion with students about how confident they are in our ability to work with other countries on scientific issues. Make a list of issues that make scientific cooperation easier and more difficult. Collect ideas for improving our ability to work with other countries. Have students look at all the ideas and prioritize them. Write a summary that includes an indication of the range of ideas suggested.
- Shadia is from Syria. The text also discusses the time her team spent in Libya. Have students research the

Syria that Shadia knew as a student and the Syria of today. How should the United States cooperate with countries like Syria and Libya in terms of scientific research? The video of Shadia listed in the resources is well worth watching to attach a human face to a person from Syria.

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Further Reading

Litmann, Mark and Fred Espenak: *Totality: The Great American Eclipses of 2017 and 2024.* Oxford University Press, 2017.

Brewer, Bryan: *Eclipse: History. Science. Awe.* 3rd ed. Earth View Incorporated, 2017.

Espenak, Fred. *Road Atlas for the Total Solar Eclipse of 2024.* Astropixels Publishing, 2017. (Espenak has other books related to eclipses that are worth checking out.)

Miller, Derek L. *Earth, Sun, and Moon: Cyclic Patters of Lunar Phases, Eclipses, and the Seasons.* Space Systems. Cavendish Square Publishing, 2017.

Other Websites to Explore

There is a wealth of online resources for the sun, moon, Earth, and eclipses. Here are a few:

NASA is an excellent starting point. I have selected the link dealing with eclipse definitions, but check out the complete NASA site: www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-an-eclipse-58

EarthSky covers lots of topics, including several interesting articles on eclipses: earthsky.org/astronomy-essentials/stages-of-a-total-eclipse-what-to-look-for

Shaddia Habbal does an interview with a colleague on YouTube: www.youtube.com/watch?v=rkn5f9GUBso
The Institute for Astronomy, where Dr. Habbal works, has its own website: www.ifa.hawaii.edu

The National Weather Service (NOAA) has information on solar cycles: www.weather.gov/news/190504-sun-activity-in-solar-cycle

Guide created by Ed Spicer, curriculum consultant, retired educator, and blogger at spicyreads.org. Follow him @spicyreads on Twitter or email him at edspicer@mac.com.