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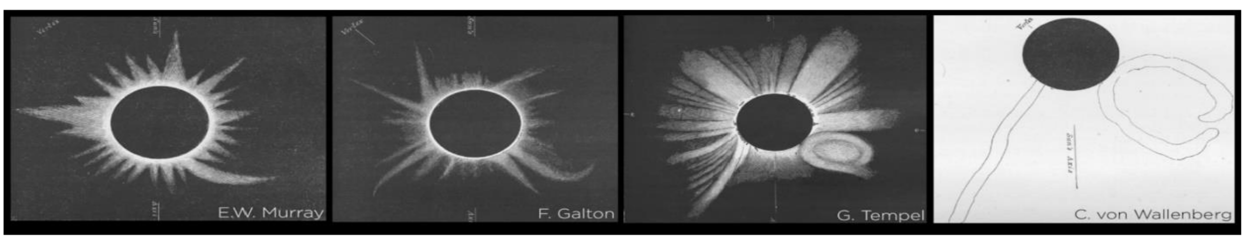
Title: What do Scientists Learn about the Universe from Observing Solar Eclipses?

Student Sheet

1. Total Eclipse Background
   1. A Total Solar Eclipse Revealed Solar Storms Years Before Satellites video questions.
      a. What scientific discoveries were made by viewing total solar eclipses, even before the modern satellite age, in the 1970s?

      b. What is a coronal mass ejection (CME)?

   2. Early Eclipse Images -
      These drawings made by early scientists, seen in the video, were made by using small-aperture telescopes between 6 and 10-inches in diameter with carefully designed filters so that the faint atmosphere of the Sun, the corona, could still be viewed.



Early eclipse images from 1860. Sketches of the corona from different scientists who observed the eclipse. All the images show a version of a curved extension of the corona., Credit: NASA Scientific Visualization Studio, https://mynasadata.larc.nasa.gov/sites/default/files/inline-images/Early%20Eclipse%20Images%20cropped.png

      a. What did these early observations reveal during the 1860 eclipse?

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c. Comparing images: Examine the two images of the Sun below, figures 1 and 2.

Figure 1: A photograph of a total solar eclipse. Credit: NASA/Nat Gopalswamy

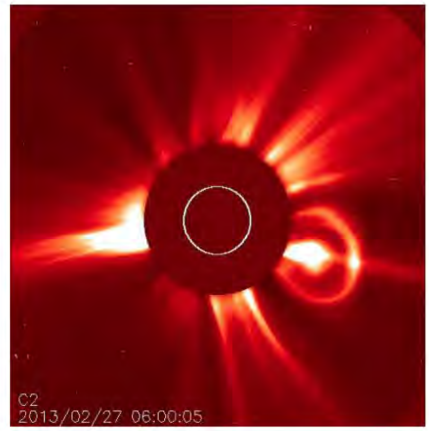

Figure 2: A coronagraph showing the Sun's corona. This image shows solar eruptions including solar flares and a coronal loop. Credit: NASA/ESA SOHO

The image in Figure 1 is what you would expect to see during a typical total solar eclipse, during the moment of totality when it is safe to remove your solar eclipse glasses. When the Moon blocks the bright light of the Sun's surface, you are able to see the Sun's atmosphere, the corona, shown as white light shining out from behind the Moon.

The image in Figure 2 is a coronagraph image, taken by NASA's SOHO spacecraft. A coronagraph simulates a total solar eclipse, blocking the Sun with an occulting disk to reveal its outer atmosphere, the corona. The Sun, behind the occulting disk, is outlined by the white circle in the center.

1. How are these two methods of viewing the Sun similar?

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2. Explore: Solar Eclipse Discovery Cards
   Using the information on the Solar Eclipse Discovery Cards, work together as a group to construct a timeline of how total solar eclipses have helped humans form a new understanding of the universe.

3. Explore Solar Wind
   Have students use the WSA-Enlil model to analyze space weather predictions. WSA-Enlil is a large-scale, physics-based prediction model of the heliosphere, used by the Space Weather Forecast Office to provide 1-4 day advance warning of solar wind structures and Earth-directed coronal mass ejections (CMEs) that cause geomagnetic storms. NOAA Space Weather Prediction Center WSA-ENLIL Solar Wind Prediction link

   Have students answer the questions about the solar wind.

   1. Record the dates of the collected data: __________________
   2. Record the dates of the predicted data: __________________
   3. Pinwheel Plot Observations:
      a. Is there an increase in the plasma density and velocity of the solar wind during the time period of collected data?
      b. How does the collected data inform the predicted data?
   4. Line Graph Observations:
      a. Is there an increase in the plasma density and velocity of the solar wind during the time period of collected data?
      b. How does the collected data inform the predicted data?
   5. Compare the pinwheel plot and line graph.
      a. How do the graphs change as the solar wind hits the two STEREO observatories and Earth on the pinwheel plot?
   6. Analysis: If a solar eruption, like a coronal mass ejection (CME) can take several days to reach Earth, how does the collected data help scientists predict the effects of space weather on Earth? Provide reasoning and evidence to support your claim.

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4. Explore Solar Features
    1. Two videos of the August 2012 solar event
        a. What did you see? Describe it in as much detail as you can.
        b. Where on the Sun did you see it?
        c. Record at least three observations of changes you observe in the features of the Sun in the data Data Table 1: 304 Angstrom Filter on the Student Sheets.
        d. Repeat the process with the second video and complete Data Table 2: 171 Angstrom Filter.

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Data Table 1: 304 Angstrom Filter		
UTC Timestamp	**Observation**	**Location**
Initial Observations Aug. 31 11:00 - 14:30		

Name: ______________________________ Date: _____________ Class: ______

Data Table 2: 171 Angstrom Filter		
UTC Timestamp	**Observation**	**Location**
Initial Observations Aug. 31 11:00 - 14:30		

Name: _________________________________ Date: ______________ Class: ______

b. Compare the data from each video and record similarities and differences in Table 3 in the student sheets.
Remember that these two videos were taken in different wavelengths of UV light, which we cannot see. Orange was assigned to one wavelength (304 A) and yellow was assigned to another wavelength of light (171 A). Different wavelengths of light are better for viewing some features of the Sun than others. Some features show up in one wavelength that don't show up in another.
   1. Compare the general features of the Sun that you observe in each video. What are the similarities and differences? Record your observations in Data Table 3.

Data Table 3

304 vs. 171 Angstroms (Å)	**Similarities**	**Differences**
General Features of the Sun		

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2. Then do an in-depth analysis of the observations you made with each filter and determine if the events coincide. Record your observations in Data Table 4.
   i. If you observed something on one video that you didn't observe on the other video, go back and take a second look. Add your observations to your analysis below.

Data Table 4				
Timestamp	304 Angstrom Filter Observation + Location	171 Angstrom Filter Observation + Location	Is this the same feature?	Justify your analysis

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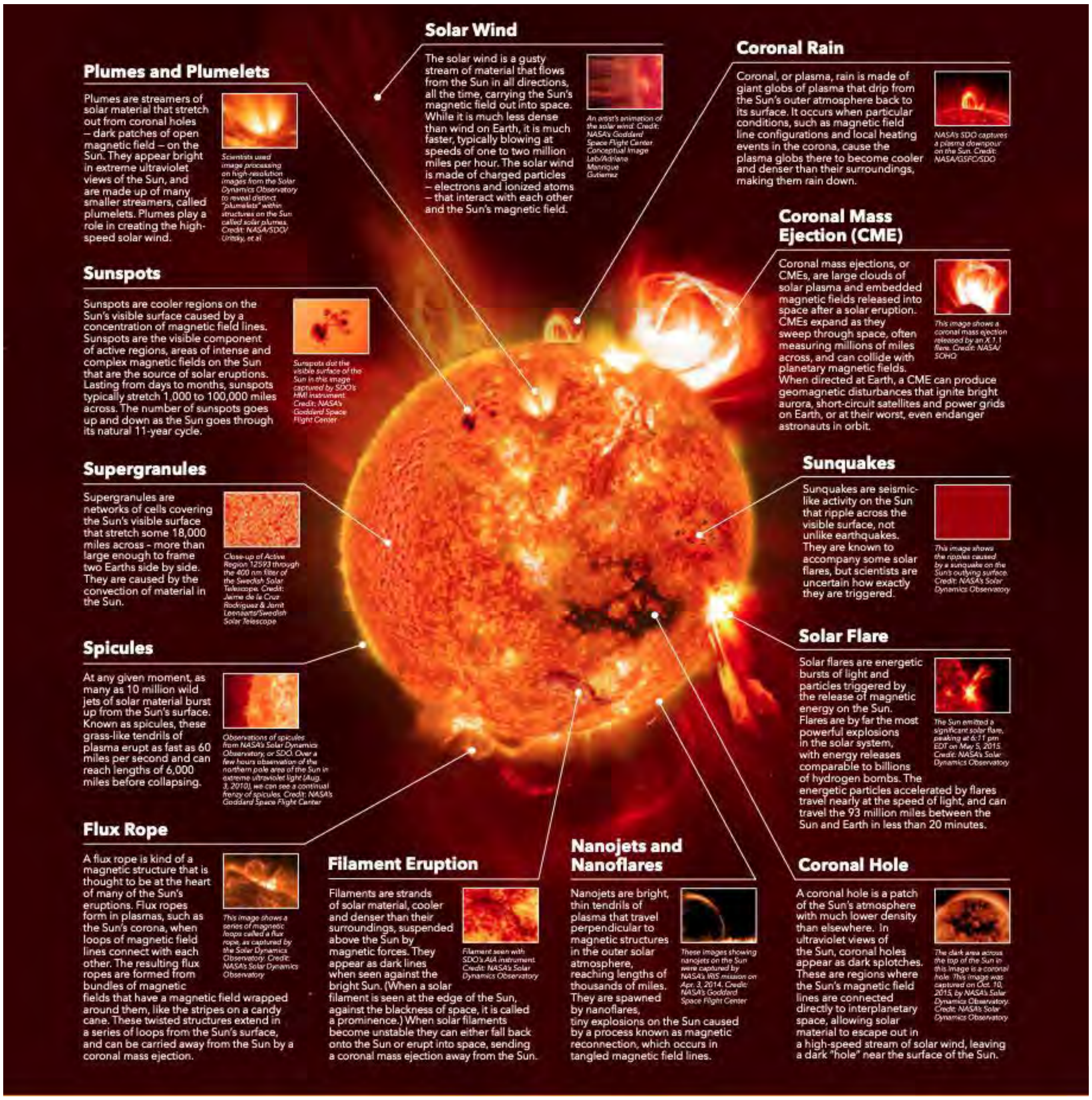

At the heart of our solar system is the Sun. Constantly churning material and magnetic fields there create an ever changing landscape of features that last from milliseconds to days. Here are a few of the most common features that can be seen on the Sun.
Credits: NASA/Mary Pat Hrybyk-Keith

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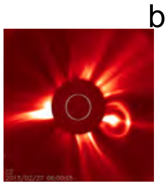
a. Identify Features
   1. Graphic showing different features of the Sun.
      i. Which features do you think you observed in the videos?

5. Complete your final analysis of the methods for observing the Sun.
   a. What features of the Sun are best seen with different SDO's AIA filters?

   b. What features of the Sun are best seen with a coronagraph?



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c. What features of the Sun are best seen during a total solar eclipse?

d. Why do NASA scientists use multiple methods for viewing the Sun?