Five Stars Pathway
Afterschool Science Curriculum


# Features of the Sun:
# Our 3D Sun

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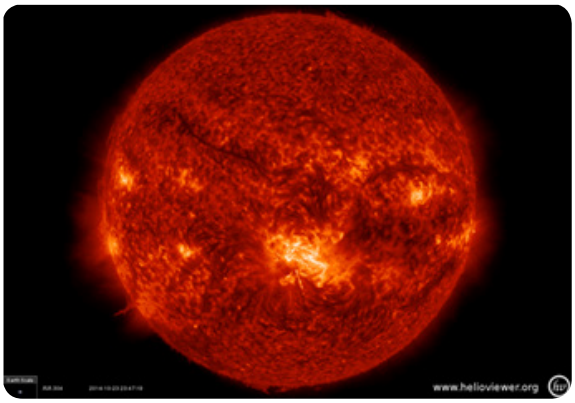
girls inc.®

# Features of the Sun: Our 3D Sun

**Age Range**
Ages 10+

**Duration**
20-30 minutes, plus 10 minute discussion

**Participants**
~ 15




## Overview

By making a 3D paper representation of the Sun, participants will learn about its dynamic structure in a simple, fun, and non-intimidating way. The different paper elements of the 3D Sun illustrate the Sun's outer layers (photosphere, chromosphere, and corona) and some solar features (coronal loops, sunspots and coronal mass ejections or CMEs). We recommend using this as a culminating activity after learning about the electromagnetic spectrum and the Sun through previous lesson plans.

## Activity Goals

Participants will:

- Review the structure of the Sun and explore its outer layers.
- Learn that scientists use light as a tool to better understand what they are seeing.
- Understand that sunspots, coronal loops and coronal mass ejections (CMEs) are all connected.

## Notes for Preparation

- Prepare the room by having images of the Sun in different wavelengths and solar features on display. A set of images of the Sun in different wavelengths is available from http://bit.ly/1ypdHt3 (PDF) or http://bit.ly/1EgN8rA (PowerPoint).
- Place all materials in a communal area.

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## Materials

- Paper plates (one per participant; larger is better but small will work fine)
- Pipe cleaners
- Markers or other coloring tools
- Tape
- Colored paper (at least one sheet per participant)
- Pens or a hole puncher
- Glue
- UV beads (optional)
- Glitter and/or bright shiny materials (optional)
- Streamers and/or tinsel (optional)
- Multiwavelength Sun images: http://bit.ly/1ypdHt3 (PDF) ~or~ http://bit.ly/1EgN8rA (PPT)
- NOTE: UV beads can be purchased from science education vendors such as www.teachersource.com

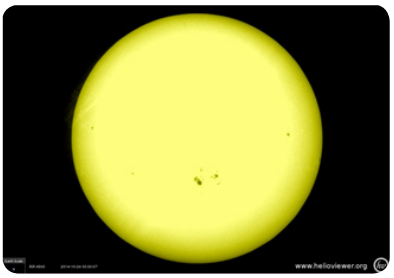
## Lesson Plan

**1. Photosphere**

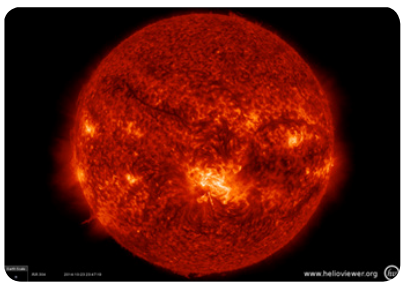
- Begin by identifying the image of the Sun's photosphere and have the participants describe what they see.
- Using an upside down paper plate, participants should draw their interpretation of the photosphere, including at least one pair of sunspots (which should be approximately 1" apart). [See photo on p. 3 for illustration.]
- Punch a small hole (approximately pen-sized) in each of the sunspots, large enough for a pipe cleaner to fit through.
- Label the Sun's layer (photosphere) and the kind of light we use to see it (visible).

**2. Chromosphere**

- Cut a circle approximately the same size as the base of the plate using colored paper.
- Place the colored paper circle over the photosphere and identify where the sunspot holes are.
- Punch holes in the chromosphere to match the holes in the photosphere.
- Decorate the region around the holes with glitter or other bright/shiny materials. This is an active region.
- Label the Sun's layer (chromosphere) and the kind of light we use to see it (ultraviolet).



*The region of the Sun that we can see in visible light with our eyes is called the photosphere. (Caution: Always wear safe solar viewing glasses when looking at the Sun.) This is the part of the Sun that appears most often as a plain yellow ball. Occasionally we will see black spots called sunspots in the photosphere. A sunspot is where the magnetic field of the Sun protrudes through the surface, pushing the hot gas out of the way. Contrary to belief, sunspots are not that much colder than the rest of the Sun, they just contain less material (since the magnetic field is getting in the way) which makes them appear darker since there is less material present to give off light.*



*The chromosphere is the layer just above the photosphere. It is where we begin to see the bright gases of active regions. An active region is where we see hot gas that is trapped in the magnetic fields protruding through the sunspots. These are called coronal loops and we see them in the corona also. This is a very dynamic region of the Sun where we start to see signs of solar activity.*

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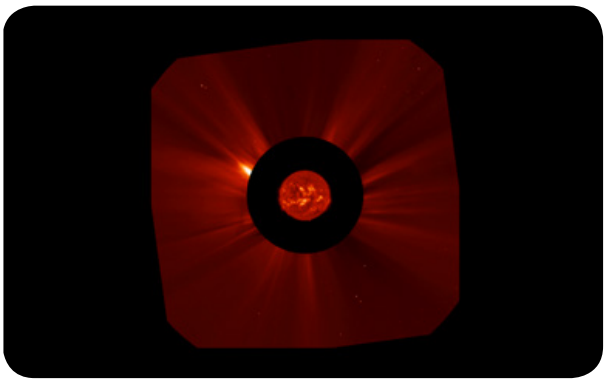
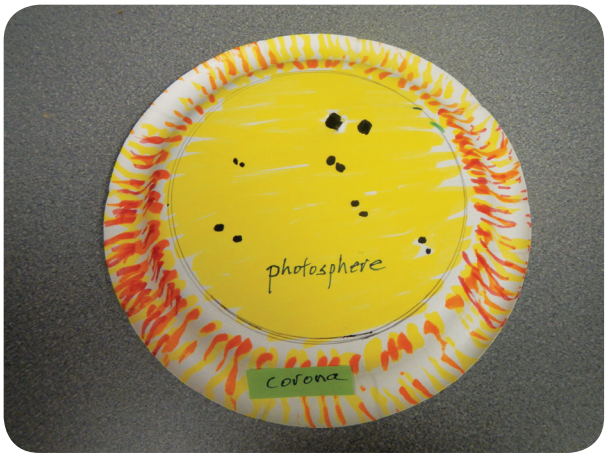
## Lesson Plan continued

**3. Corona**

- Identify the solar corona in the images.
- Decorate the brim of the plate as the corona. Using streamers or tinsel can make this even more elaborate.
- Label the Sun's layer (corona) and the kind of light we use to see it (extreme ultraviolet, visible).



*The outermost layer of the Sun's atmosphere is called the corona. This stretches from close to the Sun's surface, out towards the planets. We see long streaky features, called streamers, emanating from the Sun. The corona changes shape drastically, depending on solar activity. We can use extreme ultraviolet and visible light to view the corona.*



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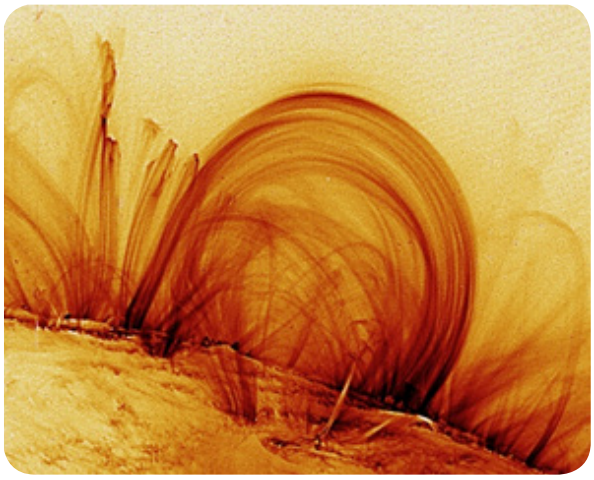
**Lesson Plan continued**

4. Coronal Loops

- Bend a pipe cleaner into a semi-circle and put the ends through the holes in both the chromosphere and photosphere. This is a coronal loop.
- You can add multiple pipe cleaners in a similar manner, all into the same two holes to create a three-dimensional loop. This is called an arcade.
- Decorate the pipe cleaners with brightly colored materials and UV beads, since these loops emit a lot of light.
- Label the Sun's feature (coronal loop) and the kind of light we use to see it (extreme ultraviolet, x-ray and/or gamma ray).

**Lesson Plan continued on next page**




*Coronal loops appear really bright in ultraviolet light. They are made of up very hot gas that is attracted to magnetic field loops, much like iron filings get trapped near a bar magnet: http://sunearthday.gsfc.nasa.gov/2010/images/ttt71-fig2.jpg. These are where solar flares and coronal mass ejections originate.*

*When we get a solar eruption, we use x-rays and gamma rays to see what is happening.*

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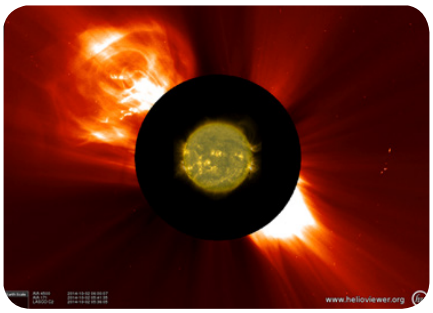
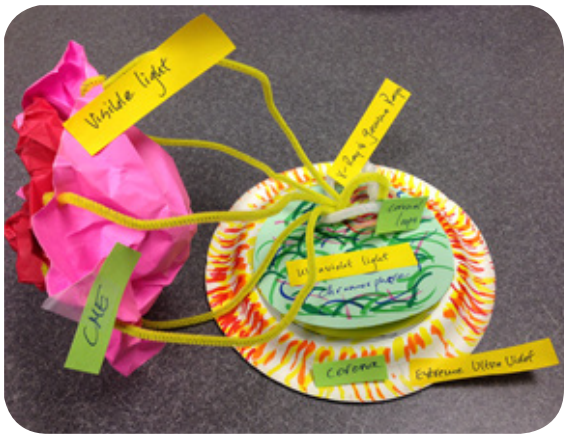
**Lesson Plan continued from previous page**

**5. Coronal Mass Ejection**

- Identify the coronal mass ejection (CME) in the images.
- Loosely scrunch a sheet of colored paper into a ball approx. 3" in diameter.
- Attach four or five pipe cleaners to the paper CME by punching small holes in the paper around the edge of the ball of paper.
- Bring the pipe cleaners together at the end and twist together.
- Gently bend the pipe cleaners out to form a pear shape, with the ball of paper at the wide end. This doesn't have to be exact.
- Decorate the twisted end of the pipe cleaners with UV beads and glitter. This is where the solar eruption begins and a lot of energy and light is released.
- Carefully put the twisted end of the pipe cleaners into one of the sunspot holes, alongside the coronal loops.
- Label the Sun's feature (CME) and the kind of light we use to see it (visible).




*Coronal mass ejections are eruptions of huge amounts of gas and magnetic field from the Sun. They generally originate in active regions and happen because a coronal loop becomes unstable for some reason. They travel through space and can encounter planets on their way. When a CME hits Earth, it causes fluctuations in the Earth's magnetic field, and in the upper atmosphere. Sometimes these effects—known as "space weather"—can results in interruptions to communications and GPS systems. If there is a large CME headed towards Earth, airplanes are not permitted to fly over the north and south poles, they must go the long way around. Space weather events also causes the beautiful effects of the aurora borealis (northern lights) and aurora australis (southern lights). However, CMEs don't generally affect people directly. The atmosphere absorbs any harmful material and protects us. CMEs happen all the time!*

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## Discussion

Invite participants to share what they now understand about CMEs and where they come from. Participants should be able to tell the difference between sunspots, active regions, and CMEs. Sunspots and active regions are closely related phenomena, with sunspots being the dark roots of the active region loops. CMEs frequently originate in active regions, but they are an eruption of matter and magnetic field that flies through interplanetary space. The important conclusion to take away from the discussion is that sunspots, coronal loops and CMEs are all connected and all very dynamic!

**Sample probing questions:**

1. What do you think is the connection between sunspots and active regions?
2. What do you now understand about the layers of the Sun that you didn't know after the solar cookie activity?
3. Can you describe how you think a CME happens?
4. Why do you think it's useful to use lots of different types of light (visible, UV, x-ray, gamma ray) to study the Sun?
5. Where on the EM spectrum do these types of light fall (all in the high-energy range). Why do you think that is?

## Further Resources

- **Interactive Solar Imager**—
  http://www.helioviewer.org/
  A tutorial on how to use Helioviewer—
  http://multiverse.ssl.berkeley.edu/FiveStars#helioviewer
- **From Core to Corona: Introduction and Definitions to the Sun's Layers and Features**—
  https://fusedweb.llnl.gov/CPEP/Chart_Pages/5.Plasmas/SunLayers.html
- **Sun-Earth Viewer: Live Solar Images from Multiple Observatories**
  (Click "Download Full-Size Image" on the bottom right for printable versions.) http://ds9.ssl.berkeley.edu/viewer/flash/


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