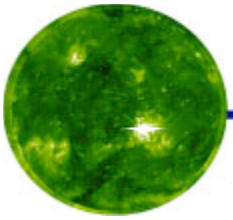


Features of the Sun

Middle School Grades

Lesson Summary
Students draw and label the parts of the Sun that they are familiar with. Next, using additional images and information, they update their original drawings to form a more complete understanding of the Sun's features.

Prior Knowledge & Skills
Completed the lesson:
- The Dynamic Nature of the Sun

Understanding of:
- The Sun as a dynamic object
- The basic structure and function of the Sun

Ability to:
- Make and record observations
- Express technical information by drawing

AAAS Science Benchmarks
The Nature of Science
The Scientific World View
Scientific Inquiry
The Nature of Technology
Technology and Science
The Physical Setting
The Universe
Energy Transformations
Motion

NSES Science Standards
Science as Inquiry
Abilities to do Scientific Inquiry
Understandings of Scientific Inquiry
Physical Science
Transfer of Energy
Earth and Space Science
Earth in the Solar System
History and Nature of Science
Nature of Science

Teaching Time: One 45-minute period

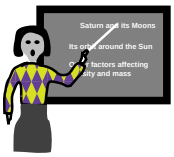
Materials
- Student page, *Features of the Sun*
- Schematic diagram of the Sun
- Images of the Sun at different wavelengths
- Copy of labels
- Colored pencils
- Scissors

Advanced Planning
Preparation Time: 20 minutes
1. Review the lesson plan
2. Copy student page, *Features of the Sun*
3. Gather materials
4. Form student groups
5. Large sheets of paper

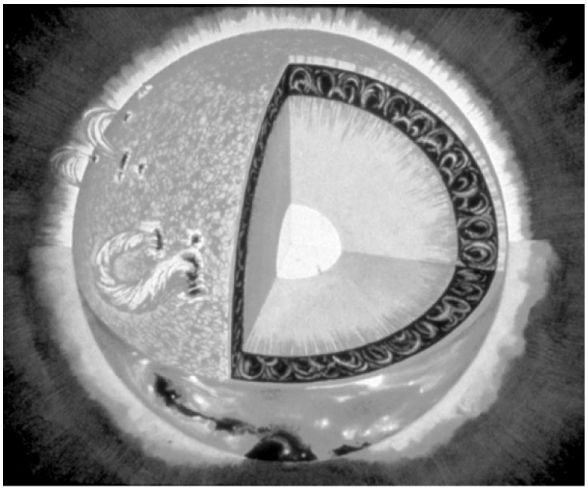
Solarscapes Sunspots and Solar Rotation, pp. 1-7, Space Science Institute (1999)
http://www.spacescience.org/Education/CurriculumDevelopment/Solarscapes/1.html

LASP
LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS

ACTIVITY 1:
FEATURES OF THE SUN

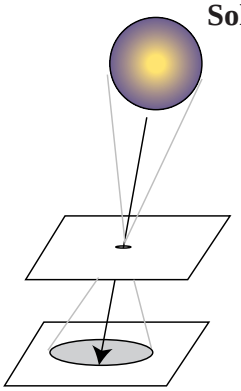


Guide to Teachers



Goal: Students will learn that the Sun contains many complex features and compare this to their own prior knowledge about the Sun.

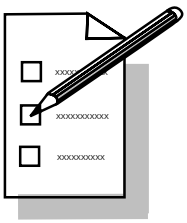
This activity introduces Solarscapes and allows students to learn about various features on the Sun, including sunspots. It functions as a DISCUSS phase for the Solarscapes unit overall.



Caution: Never look directly at the Sun. To view the Sun, project an image through a card or sheet of notebook paper, pierced with pin sized hole, onto a sheet of white paper. The Sun's inverted image will appear on the paper below.

MATERIALS NEEDED

- One copy of the student activity, "Features of the Sun" (included)
- A schematic diagram of the Sun (Figure 1) and two sets of images that illustrate the Sun as seen in different wavelengths (Figures 2 and 3, included)
- A photocopy of the student activity, preferably one copy per student. Provide the worksheet first, then the rest of the text once students have drawn their initial picture of the Sun
- One photocopy of labels per group of students (original included)
- Colored pencils
- Scissors
- Large sections of paper (newsprint, etc.)



Procedure:

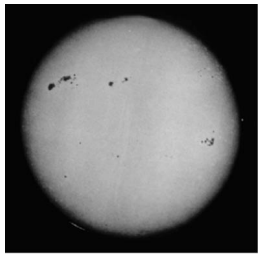
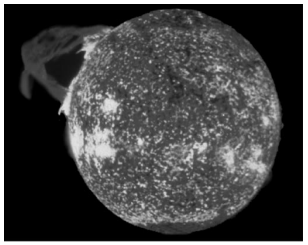
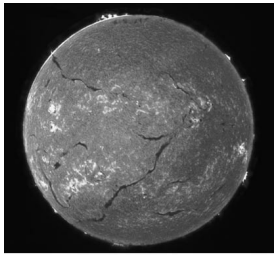
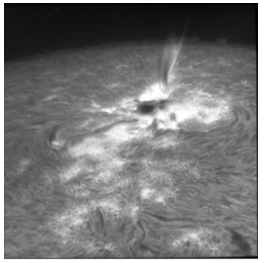
DISCUSS: Ask the class to discuss what they know about the Sun and what they would like to know. Brainstorm a list of ideas and ask the students to record this list in their notebooks. Working in groups of three or four, have students draw the Sun with as many features as they know about, and make a list of those features. Students are to write down these ideas and copy the group diagram in the space provided in their STUDENT WORKSHEET.

EXPLORE: After that, ask the students to read the **"Features of the Sun"** (in the Student Guide section). Have them compare what they read to their picture. As they read, they are to locate the boldface words from the reading that are on the accompanying schematic diagram titled "The Sun" (Figure 1).

APPLY: Students are to place labels of the Sun's features provided on the photographs in Figures 2 and 3 so that the arrow on the label points to the name of the feature where it is located. They are to identify as many different features in the time allowed (including locating the same feature on as many different photographs as possible).

REFLECT: On a large sheet of paper, each group of students is to draw and color a sketch for the exterior features of the Sun that were identified on the photos. The drawings are to be as realistic as possible. They then compare their new drawing to their initial drawing. How many features did they know about and how many were new? Students are to write down their comparison. The drawings are to be posted and students are to take a "wisdom walk" (without talking, go around the room and view the other group drawings). Students then are to use Think-Pair-Share with a member of another group to briefly discuss what they observed during the wisdom walk. Observations on what they learned are to be recorded in their portfolio notebooks, along with questions they have. Students are also to write a short essay to be turned into the teacher that answers the "Problem" question(s) at the beginning of this activity.

Students should identify the following features:

Visible Sun	Eclipse	Extreme UV	H-Alpha	Solar Flare
				
Photosphere Sunspots	Corona Coronal Hole Prominences Helmet Streamers	Granulations Plage Prominences Sunspots	Chromosphere Filaments Plage Prominences Sunspots	Solar Flare Sunspots
Visible or White-light images of the Sun show the photosphere and sunspots. Sunspots are regions of intense magnetic fields. They appear dark because they are somewhat cooler than the surrounding gas.	A solar eclipse shows the ethereal corona -- the crown of light that surrounds the Sun. Prominences can also be seen as small white blotches in the photograph.	This extreme ultraviolet image of the Sun shows the chromosphere, which is a thin region of the Sun just above the photosphere. A giant prominence can also be seen.	Light from hydrogen gas just above the photosphere shows the bright plages that surround the active sunspot regions. Dark string-like filaments are also seen that are in fact prominences seen head-on. The bright structures on the limb are pominences.	A solar flare is a highly concentrated explosive release of energy within the solar atmosphere that occurs near sunspots. Flares emit enormous amounts of energy.

Scoring Rubric for Activity 1: Features of the Sun

Student Name: _____

Individual Assessment (goal met if student achieves a "2")

Task(s)	0	1	2	3	4
Essay on the Sun's features	Student did not participate or write essay.	Student's essay incorrectly describes solar features or writes incomprehensible essay.	Student is able to identify most features correctly in a reasonable essay.	Student provides very clear essay that correctly describes all features of the Sun presented in the lesson.	Student does all of #3, but also compares and contrasts.

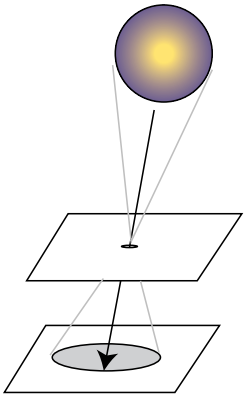
Group Assessment (goal met if group achieves a "2")

Task(s)	0	1	2	3	4
Diagram of Sun's features	Group does not produce diagram.	Group produces a diagram of Sun with major features incorrectly indicated.	Group produces a diagram of Sun with major features correctly indicated.	Group produces a diagram with the major features correctly indicated, drawn, and colored realistically and neatly.	

SUGGESTED USE: Make one copy per student; there is also room for you to add your own task and scoring criteria.

Student Guide to Activity 1: Features of the Sun

Problem: What do the following features look like on photographs of the Sun: sunspots, plages, solar flares, prominences, filaments, the corona, helmet streamers, and coronal holes? How do these features compare and contrast?

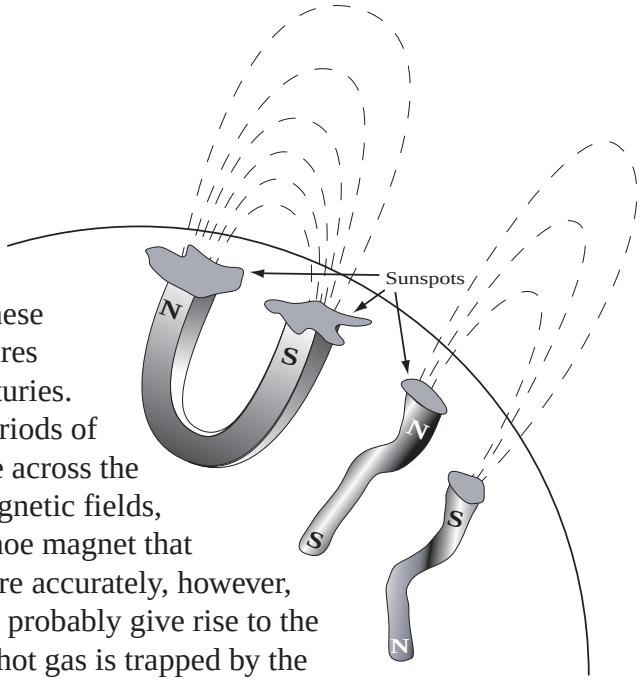


Caution: Never look directly at the Sun. To view the Sun, project an image through a card or sheet of notebook paper, pierced with pin sized hole, onto a sheet of white paper. The Sun's inverted image will appear on the paper below.

Introduction

Our Sun is a middle-aged, medium sized star, big enough to hold a million Earths. The ancient Greeks thought that the Sun was a perfect sphere of fire. Today we know that the Sun is a variable (changeable) star that produces life giving light and heat as well as harmful radiation. It causes space weather that can harm astronauts working in space and can interfere with satellites orbiting our planet.

Features of the Sun's Surface and Atmosphere:

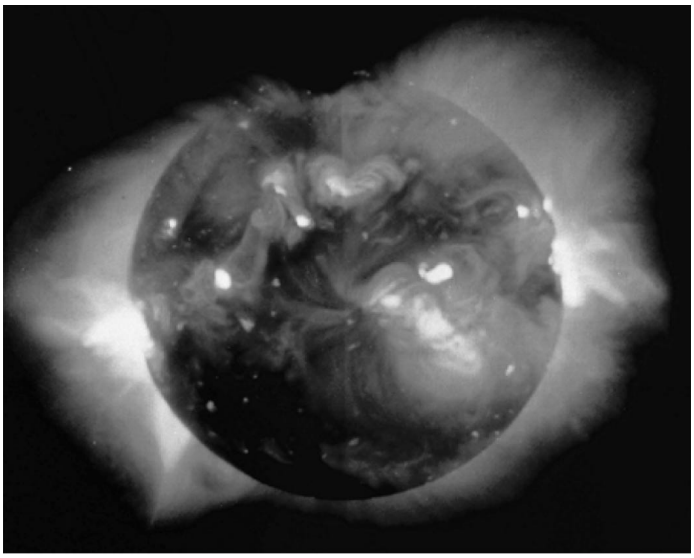


Although the average distance from Earth to the Sun is a whopping 149,600,000 kilometers (93,000,000 miles), careful observation from Earth reveals a surprisingly large number of different visible features. The most obvious and best known feature is the **sunspot.** Typically moving in groups, these dark (in visible light), planet-sized features have been known to humankind for centuries. As sunspots form and disappear over periods of days or weeks, they also appear to move across the Sun's surface. Composed of strong magnetic fields, sunspots are shaped much like a horseshoe magnet that rises from below the Sun's surface. More accurately, however, flexible magnetic tubes, or "flux tubes," probably give rise to the magnetic fields that we see. The rising hot gas is trapped by the sunspots' intense magnetic field which cools the sunspots from 6000 ½C to about 4200 ½C. The cool area appears dark compared to the area around it.

Thus, from Earth, we see spots on the Sun. In some photographs, we can also see light colored areas around groups of sunspots that resemble tufts of cotton candy. We call these fluffy looking fringes **plages**.

Sunspots are the source of massive releases of energy called **solar flares**, the most violent events in the solar system. In a matter of minutes to several hours, a solar flare releases about 10,000 times the annual energy consumption of the U.S. Solar flares give off radiation that includes X-rays, ultraviolet rays, and charged particles called protons and electrons. This sudden surge in radiation can damage spacecraft and even give a dose or radiation to travelers flying in airplanes over the polar regions.

Also visible for only minutes, are **granulations** in the Sun's **photosphere**. Granulations are rising and falling columns of hot gases that look like fluffy marshmallows arranged in a honeycomb pattern. The tops of these granules form the Sun's "surface." Although we refer to the Sun's "surface" as the photosphere, you probably know that the Sun has no solid surface, unlike Earth. It is an uneven sphere of glowing, hot gas!



Courtesy of the Lockheed Palo Alto Research Laboratory and the National Astronomical Observatory in Japan.

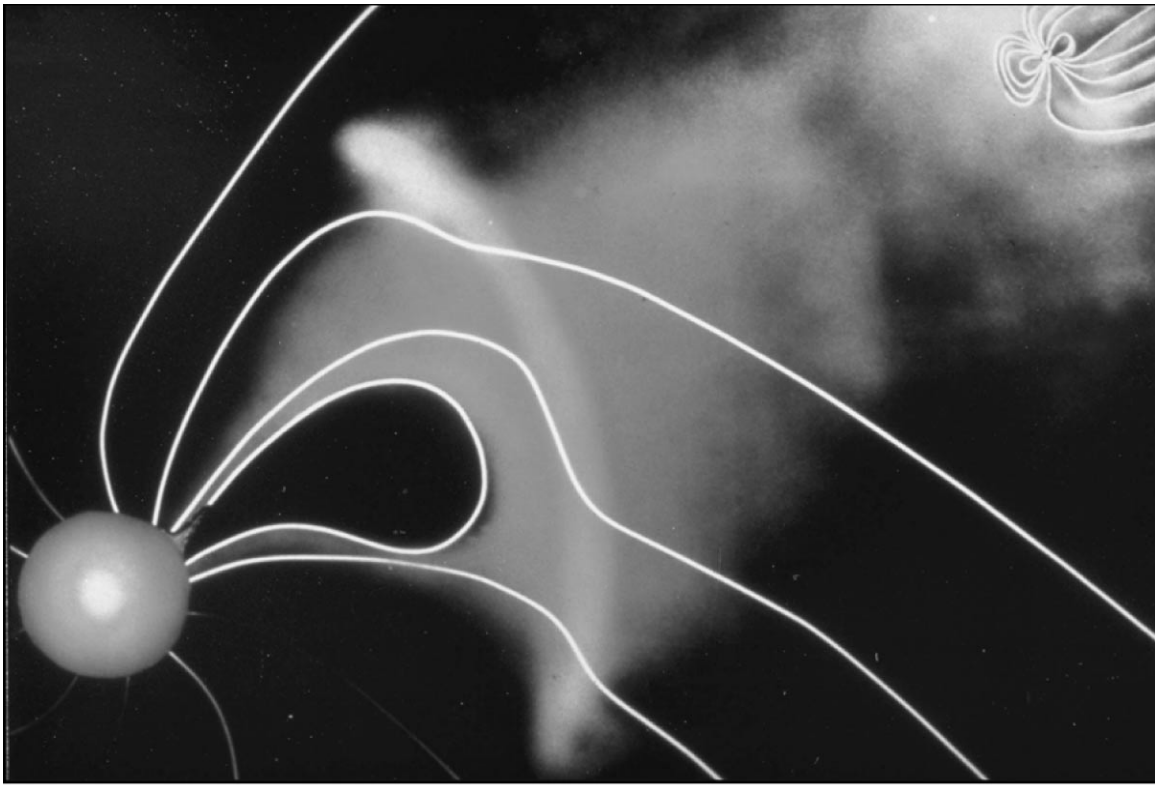
The bright areas in the X-ray image from the Japanese Yohkoh satellite are called "active regions," which contain hot, dense gas. They are also the source of the most intense X-ray eminations. The dark areas are coronal holes.

Just as the Sun disappears behind the Moon during a total **solar eclipse**, a flash of bright red light appears. This colorful layer of the Sun, called the **chromosphere,** becomes visible for a brief instant. Although we know little about the chromosphere, there are curious, permanent features of the chromosphere, called spicules, that we can study in more detail. There are so many of these fine, bright, hairlike features, that they are always visible near the Sun's edge, even though an individual spicule lasts only minutes. Like sunspots, spicules rise and fall vertically above the Sun's surface.

One of the most spectacular features of the Sun are solar **prominences**. They appear to stream, loop and arch away from the Sun. The most recognizable prominences appear as huge arching columns of gas above the limb (edge) of the Sun. However, when prominences are photographed on the surface of the Sun, they appear as long, dark, threadlike objects and are called **filaments**. Like sunspots, prominences are cooler (about 10,000 ½C) in relation to the much hotter background of the Sun's outer atmosphere (about 1,500,000 ½C). Prominences can also erupt from the Sun with a tremendous burst of energy.

If you have seen photographs of a solar eclipse, then you have probably noticed a bright halo around the Sun, called the **corona**. Sometimes parts of the corona appear to be missing. Logically, we call this area a **coronal hole**. Scientists believe that the **solar wind**, a million mile per hour gale that blows away from the Sun, originates in coronal holes. Unlike wind on Earth, the solar wind is a stream of ionized (electrically charged) particles speeding away from the Sun.

The Sun's corona changes with sunspot activity. When there are more sunspots, the corona appears to be held closely to the Sun; when there are fewer sunspots, the corona streams out into space in a shape that resembles the spike on a warlike, peaked helmet called **helmet streamers**. While helmet streamers are long-lived, their demise often occurs abruptly through massive and powerful eruptions called **coronal mass ejections (CMEs)**.



Courtesy of the Los Alamos National Laboratory

Artist's conception of a coronal mass ejection moving away from the Sun toward Earth.

These huge clouds of hot solar gas and magnetic fields are often associated with solar flares. They can cause **magnetic storms** when they hit Earth's magnetic field and damage human technological systems in space and on the ground. For example, in 1989, the Quebec province in Canada suffered an electrical blackout because many transformers were destroyed by a large magnetic storm. That one storm caused many millions of dollars worth of damage. A powerful solar flare erupted from the Sun about three days before the start of the storm at Earth. Even when the Sun is not too active, solar storms can cause problems. A magnetic storm on January 11, 1997 was blamed for the loss of a $270 million dollar AT&T communications satellite. This moderate storm was caused by a coronal mass ejection that erupted from the Sun even though there were no noticeable sunspots.

ACTIVITY 1 STUDENT WORKSHEET

Features of the Sun's Interior

Core - central part of the Sun where hydrogen fuses into helium to give off energy.
Radiation zone - energy from the Sun's core travels outward through this area.
Convection zone - hotter gases rise and fall as they are heated from the radiation zone below much like a boiling pot of water.

Procedure:

1. Use the following process to learn the features of the Sun. Working in groups of three or four, draw the Sun with as many features as you know about, and make a list of those features. Write down these ideas and copy the group diagram in the space below. When your group is done, send someone to get the materials for the activity.

2. In your group, read the description of our Sun ("Features of the Sun's Surface and Atmosphere") provided in your Student Guide. Compare what you read to your group's picture. As you read, locate the boldface words from the reading that are on the accompanying schematic diagram titled "The Sun" (Figure 1).

3. Cut out the accompanying labels that name the features of the Sun (There are more labels than you need in case some get lost.) Place labels of the Sun's features on the photographs in Figures 2 and 3 so that the arrow on the label points to the name of the feature where it is located. You are to identify as many different features in the time allowed, including locating the same feature on as many different photographs as possible.

Note: Identify a feature only once per photograph even though it may appear in several different places.

4. As a group, on a large sheet of paper, draw and color a sketch for the exterior features of the Sun that were identified on the photos. The drawings are to be as realistic as possible. Compare the new drawing to your initial drawing. How many features did you know about and how many were new? Write this information in the space provided.

5. Post your group's drawing somewhere in your room as directed by the teacher. When all the drawings are posted, you will take a "wisdom walk" (without talking, go around the room and view the other groups' drawings).

6. Find someone who was not in your group to pair up with. Spend a minute thinking on your own about what you saw in the diagrams of the Sun. Then discuss your observations and ideas with your partner. Record your ideas in the space provided, along with any questions you might have about features on the Sun.

7. In the space provided below, write a short essay that answers the "Problem" question(s) at the beginning of this activity.

Labels for the Sun's Features

Prominences →	Sunspots →	Granulations →	Corona →	Plage →
Prominences →	Sunspots →	Granulations →	Corona →	Plage →
Prominences →	Sunspots →	Granulations →	Corona →	Plage →
Prominences →	Sunspots →	Granulations →	Corona →	Plage →

Photosphere →	Filaments →	Chromosphere →	Solar Flare →
Photosphere →	Filaments →	Chromosphere →	Solar Flare →
Photosphere →	Filaments →	Chromosphere →	Solar Flare →
Photosphere →	Filaments →	Chromosphere →	Solar Flare →
Helmet Streamer →	Helmet Streamer →	Helmet Streamer →	Helmet Streamer →
Coronal Hole →	Coronal Hole →	Coronal Hole →	Coronal Hole →

Figure 1

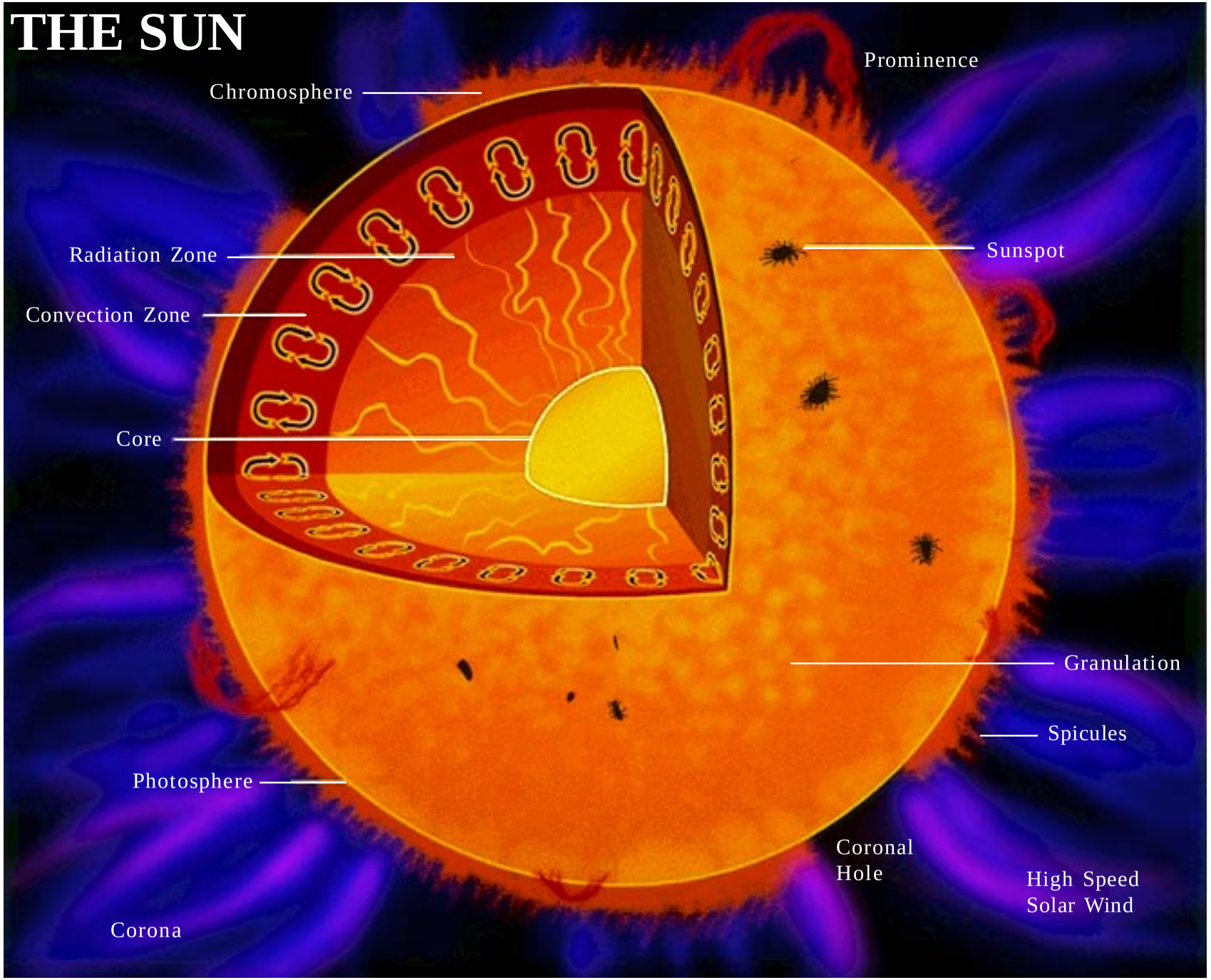
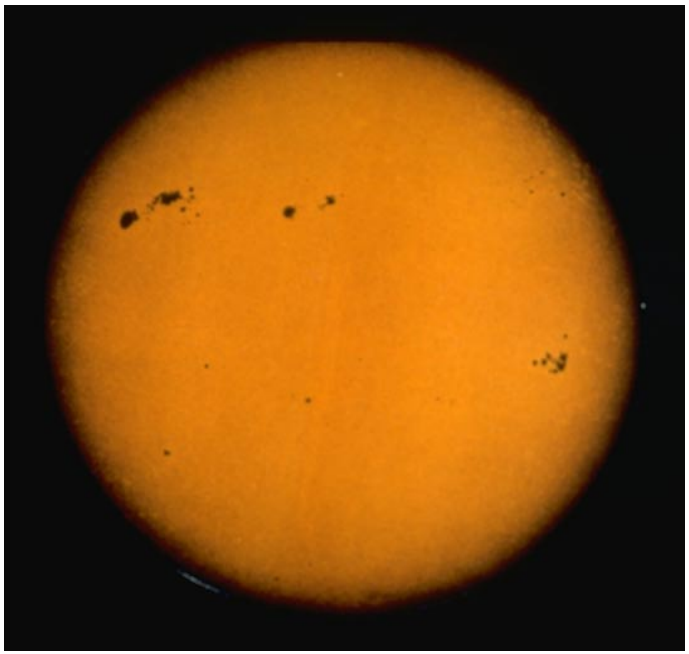

THE SUN
Prominence
Chromosphere
Radiation Zone
Sunspot
Convection Zone
Core
Granulation
Spicules
Photosphere
Coronal
Hole
High Speed
Solar Wind
Corona

Figure 2

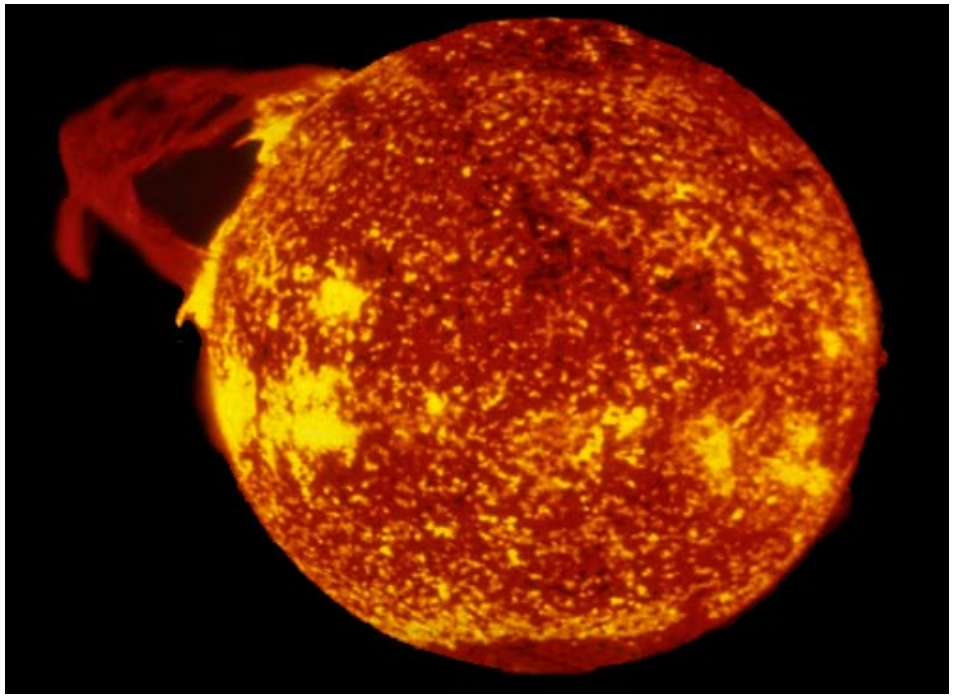


Visible Sun

(Courtesy, Yohkoh Telescope)

Solar Eclipse

(Courtesy, Steve Albers)



Extreme Ultraviolet

(Courtesy, Naval Research Laboratory)

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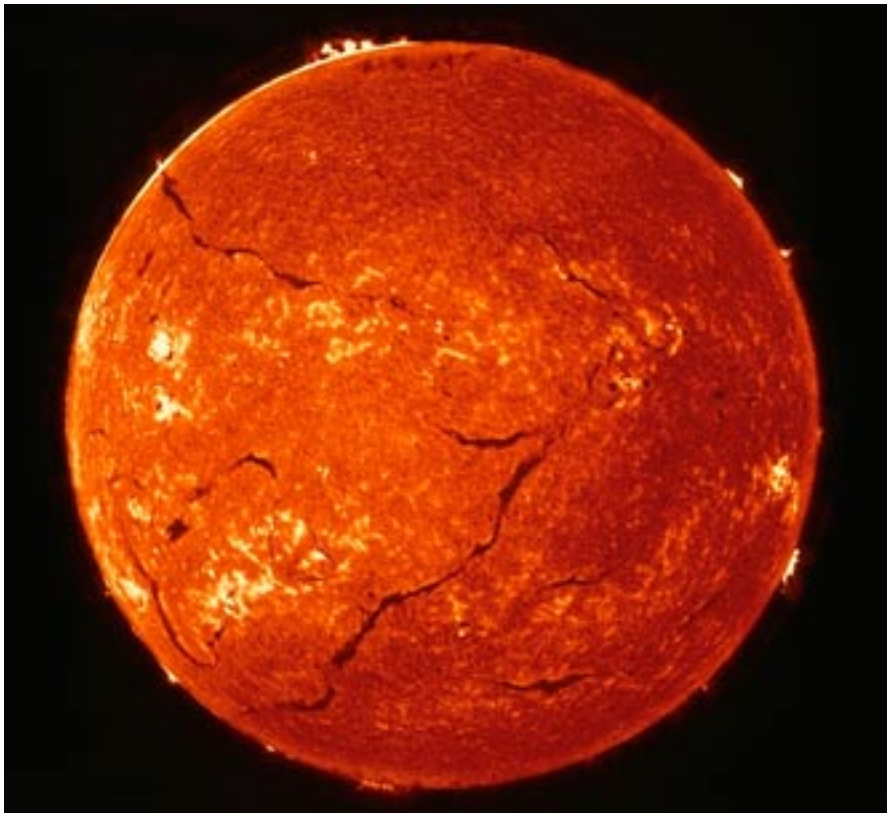
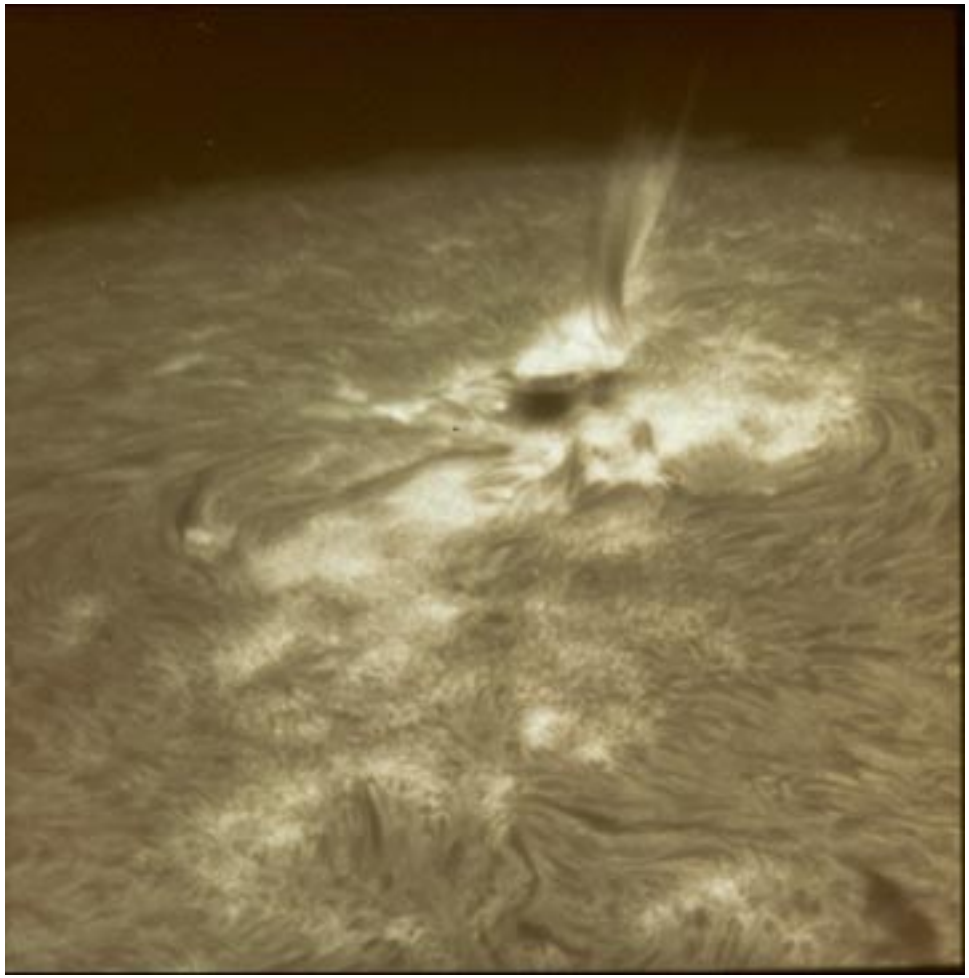
Figure 3



H-alpha sun

(Courtesy, NOAA/SEC)



Solar Flare

(Courtesy, National Optical Astronomy Observatory)

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