Solar Dynamics Observatory

Activity Name	Grades	Suggested Activity Time	Prep Time	Materials
Matching Pairs	5-8	10-15 min	5 min	Matching Pairs Handout (see pages 4-6)

Objectives- Students will be able to:

- Analyze images taken by the Solar Dynamics Observatory (SDO)
- Identify magnetic solar images that correspond to given extreme ultraviolet (EUV) light images
- Explain how high-level magnetic activity on the Sun corresponds to strong solar activity

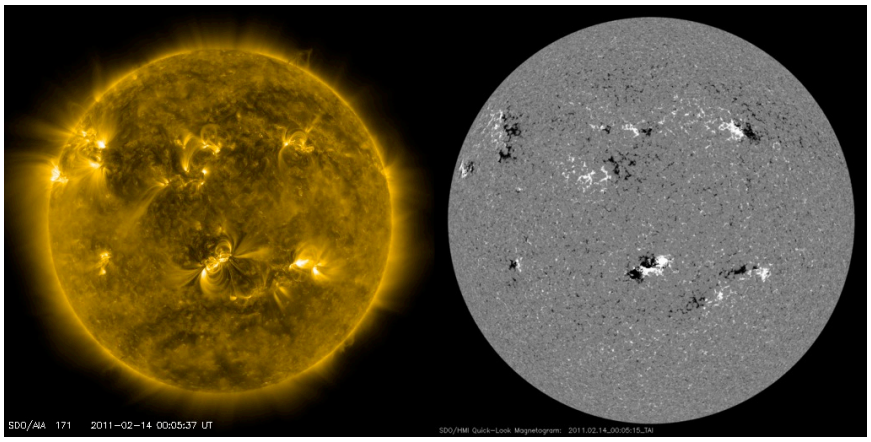
Description:
Students will analyze and compare images taken by the Solar Dynamics Observatory (SDO). They will be asked to match four magnetic solar images, or magnetograms, to their corresponding extreme ultraviolet (EUV) light images by studying solar features in the images. By activity's end, students will recognize that areas of high-level magnetic activity on the Sun correspond to extreme solar activity.

How to Prepare:
Print out the "Matching Pairs Handout" (see pages 4-6) on 8 ½ x 11-inch paper in color. One handout should be printed out for each group.

Background Information:
The Solar Dynamics Observatory (SDO) was launched on February 11, 2010 from Cape Canaveral, Florida. It is the first mission to be launched for NASA's Living With a Star Program, a program designed to understand the causes of solar variability and its impacts on Earth. SDO studies how solar activity is created, how it affects space weather, and how it influences life on Earth including humanity's technological systems. SDO hosts three scientific experiments: the Atmospheric Imaging Assembly (AIA), Helioseismic and Magnetic Imager (HMI), and EUV Variability Experiment (EVE). Each of these experiments perform several measurements that characterize how and why the Sun's activity varies. These three instruments observe the Sun simultaneously, performing the entire range of measurements necessary to understand solar variations.

In this activity, students will be comparing images from two of SDO's three instruments: AIA and HMI. The AIA images show EUV light being given off by the Sun (see image below left) and the HMI images, called magnetograms, show the strength of the Sun's magnetic field (see image below right). Magnetograms are gray in areas where there is no magnetic activity, and black and white in

areas of high-level magnetic activity (for more on magnetograms, refer to the Resources section below). When comparing AIA images and magnetograms that were taken at the same time, the black and white areas on the magnetogram correspond to bright active regions seen on the Sun in the AIA image. Students will need to understand this concept before starting the matching part of the activity.



The AIA image (far left) is shown in EUV light. The corresponding magnetogram (immediate left) shows levels of magnetic activity on the Sun.

The black and white areas on the magnetogram correspond to the bright active regions on the AIA image.

Vocabulary:

- active region	- extreme ultraviolet (EUV) light	- Solar Dynamics Observatory (SDO)
- electromagnetic spectrum	- magnetogram	- space weather

Directions:

1. Break students into small groups. Give each group a copy of the Matching Pairs Handout.
2. Tell students they are looking at pictures taken by NASA's Solar Dynamics Observatory (SDO), which studies the Sun's activity so we can better predict space weather (for more information, click on the NASA Space Place link under Resources). Explain that the yellow pictures were taken by SDO's AIA instrument, which captures the Sun in extreme ultraviolet (EUV) light. Ask students: What do you know about ultraviolet (UV) light? Where does it come from? What do you think extreme ultraviolet (EUV) light means?
3. Discuss with students that ultraviolet light from the Sun comes in long and short waves. The long waves are closest to visible light in the electromagnetic spectrum and the short waves are furthest from it; the short waves make up what scientists refer to as EUV light, which we cannot see (see Resources for more information). Explain that the yellow AIA images are pictures of some of the EUV waves being given off by the Sun. *(Note: This is not the real color of the Sun. A filter on SDO's camera creates this "false color".)*
4. Describe to students what a magnetogram is and what the black/white areas and gray regions indicate (see Background Information). Review the concept of magnetic fields with students. You can then point out that the black/white areas represent the opposite poles of a magnetic field on the Sun (see Stanford Solar Center link under Resources for more information).
5. Have students read over page one of the handout in their groups. Point out to students that the bright areas on the yellow AIA image are highly active regions on the Sun; these are areas where extreme space weather, like solar storms, can potentially originate. Ask them: What do you see on the magnetogram image in these same areas? Do the black and white areas on the magnetogram correspond to the bright active regions on the AIA image? Why? (Before the next step, make sure students understand that areas of high-level magnetic activity on the Sun correspond to the locations where active regions are found.)
6. Give students a few minutes to observe the images on pages two and three of the handout, and complete matching the AIA images to their magnetogram counterparts.

7. Ask students to present their answers and justify why they believe their matches to be correct. (Correct matches are images 1 and C, 2 and B, 3 and D, and 4 and A.)
8. (Optional) If you have access to a computer in your classroom or a computer lab, have students play with the Sun Slider website at http://www.teensolarinvestigators.org/sun_slider. This site will allow them to compare magnetogram images and EUV light images to each other in an interactive way.

Resources:

- NASA—Solar Dynamics Observatory: http://sdo.gsfc.nasa.gov
- NASA—Ultraviolet Waves: http://missionscience.nasa.gov/ems/10_ultravioletwaves.html
- NASA Space Place—Space Weather: http://spaceplace.nasa.gov/spaceweather/
- National Earth Science Teachers Association—What is Space Weather?: http://www.windows2universe.org/space_weather/sw_intro/what_is_sw.html
- Stanford Solar Center—Magnetograms: http://solar-center.stanford.edu/solar-images/magnetograms.html
- Teen Solar Investigators.org—Sun Slider: http://www.teensolarinvestigators.org/sun_slider

Standards addressed:

A. National Science Education Standards addressed:

5-8: *Content Standard B:* As a result of their activities in grades 5 – 8, all students should develop an understanding of transfer of energy, 6: The Sun is a major source of energy for changes on the Earth's surface. The Sun loses energy by emitting light. A tiny fraction of that light reaches the Earth, transferring energy from the Sun to the Earth. The Sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

9-12: *Content Standard B:* As a result of their activities in grades 9 – 12, all students should develop an understanding of interactions of energy and matter, 2: Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

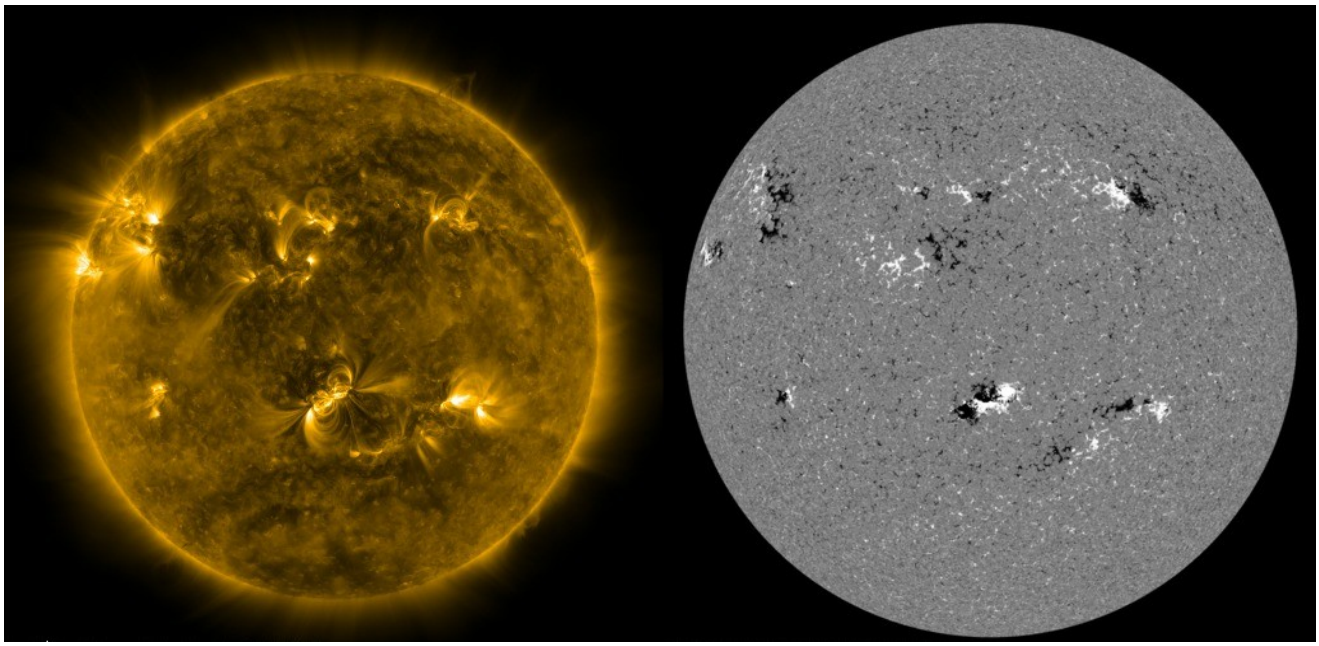
Matching Pairs:

Matching Ultraviolet and Magnetic Solar Images

Your mission:

NASA's Solar Dynamics Observatory team has mixed up some of its data! Help them by identifying which AIA images and magnetograms were taken at the same time.*

Example of a match:



AIA image shown in EUV light from 2-14-2011

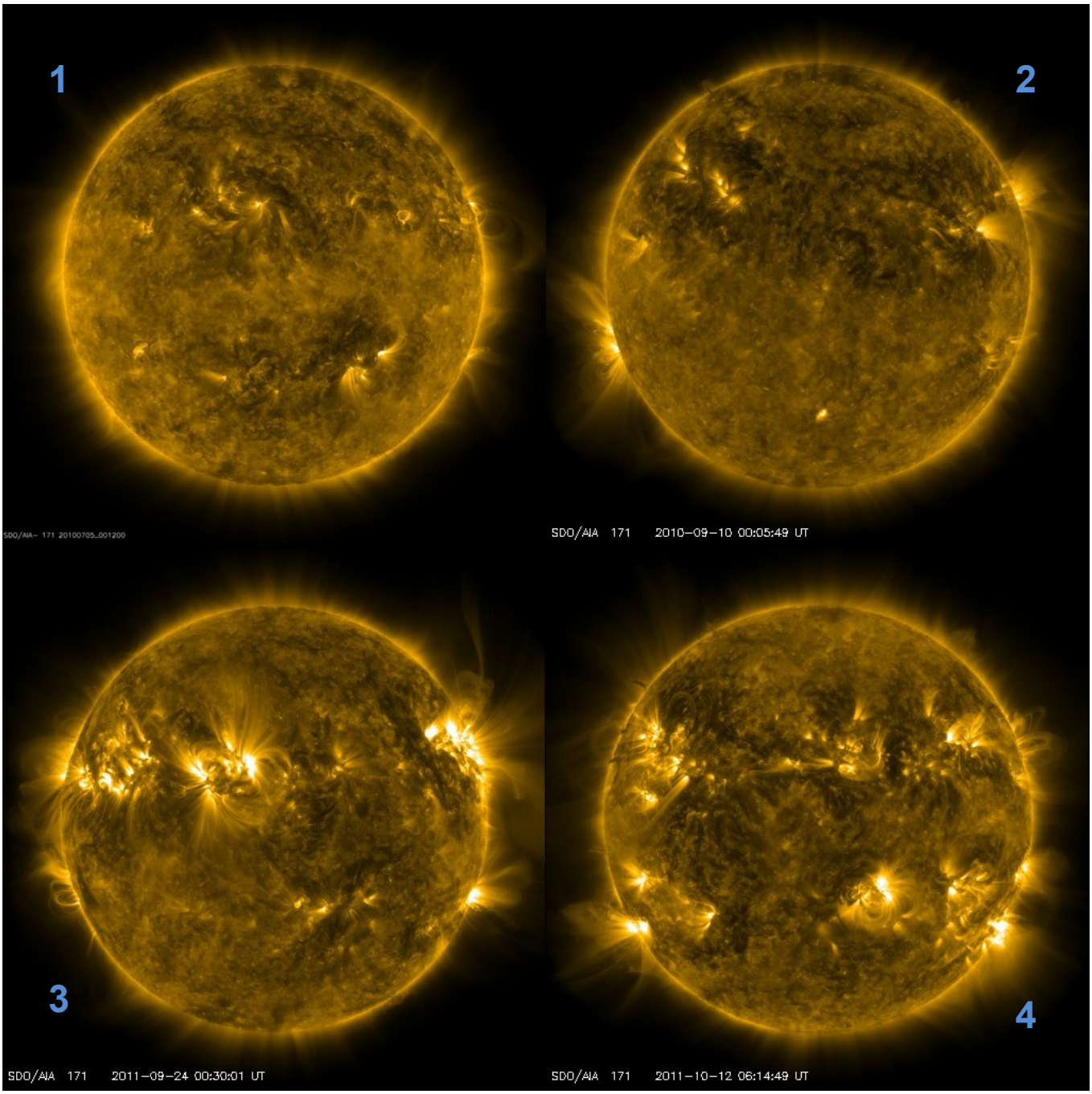
Corresponding magnetogram from 2-14-11

**Hint: Where the sun is really active on the AIA image (bright yellow areas), the magnetogram will show high levels of magnetic activity (black/white spots)!*

Matching Pairs:

Matching Ultraviolet and Magnetic Solar Images

AIA Images 1-4:



Matching Pairs:

Matching Ultraviolet and Magnetic Solar Images

Magnetogram Images A-D: