EXPERIENCE 3.3

Safe Solar Viewing
PROJECT AND RECORD YOUR OWN IMAGES OF THE SUN

Overall Concept
This experience provides one safe method, using binoculars, to let students project and examine an image of the Sun, including any sunspots on the Sun's surface.

Objectives
Students will
1. make a Sun projection instrument out of one half of a pair of binoculars (with safety guidance from the teacher);
2. project an image of the Sun onto a white sheet of paper and sketch the appearance of the Sun (including any sunspots and sunspot groups); and
3. come to understand that looking directly at the Sun is dangerous.

Advance Preparation
1. Before going outside, tape the lens cover to the opening of one side of the binoculars. If there is no lens cover, tape a piece of cardboard over the opening so no light can enter that side of the binoculars.
2. Extend the tripod to its full length and attach the binoculars securely to the tripod head. (Some binoculars have a place to screw in a tripod; if not, then tape the binoculars to the tripod head so that it is held tight but the tripod controls allow you to point the binoculars toward the Sun.)

MATERIALS
One per group:
- Binoculars (a single pair for the whole class can also work)
- Tripod for each pair of binoculars (with a way of attaching the binoculars)
- Roll of masking or duct tape
- Scissors
- 1 ft. x 1 ft. piece of cardboard
- White sheets of paper on a clipboard or other hard surface
3. Cut a hole in the center of the cardboard the same size as the binocular opening you did not cover. Slip the cardboard over the opening and tape it in place. See Figure 3.11 for how the setup should look when complete.

4. You will find it useful to practice using the equipment before using it with students.

**FIGURE 3.11**
A diagram of the binocular setup for Experience 3.3

**Procedure**

1. It is important to stress that students should never look directly at the Sun through binoculars or with their naked eyes. Permanent eye damage can occur without an immediate feeling of pain.

2. Explain that you (or the students) are going to project an image of the Sun using a pair of binoculars. This will allow them to observe the surface of the Sun without looking directly at it. They will look for small dark areas on the Sun called sunspots. These will be discussed and explained in more detail in the next experience. For now, students just need to know that some sunspots are round, while others have complex patterns as several spots together make a sunspot group.

3. Explain that the sunspots may seem like tiny specks, but most of the ones that we can see are larger than the Earth! Even when a sunspot seems small, it usually only becomes noticeable to the earthbound observer when it is about the size of the Earth.

**Safety note:** Remind students that it is not safe to look directly at the Sun.
4. Now take the students outside and help them point the binoculars roughly in the direction of the Sun. *Remember, under no condition should students look directly through the binoculars at the Sun!* Loosen the control knobs on the tripod. It often takes some practice to get the binoculars aimed directly at the Sun. One good indicator of how close you are to having them aligned is to watch the shadow of the binoculars on the ground. The shadow will be as small as possible when the binoculars are aimed at the Sun. When the binoculars are aimed properly, there will be a spot of bright light (the Sun's image) on the ground behind the binoculars.

5. Once you or the students get the bright area of light on the ground, tighten the tripod control knobs. Have a student hold the piece of white paper (on a clipboard, so it is held smooth even if there is wind) about two feet behind the binoculars so that the area of light falls on the paper. The area of light is an image of the Sun, but it may be out of focus. Adjust the focus knob on the binoculars until you get a sharp image of the Sun on the paper. You can also try moving the paper a bit closer or farther. (*Safety note:* Warn students not to put their hands close to where the light comes out of the eyepiece of the binoculars. The concentrated sunlight coming out can give you a little burn if your hand is near the eyepiece.)

*Teacher note:* Sometimes you may see only part of the Sun on the paper because the binoculars are not properly aligned with the Sun. If this occurs, carefully adjust the tripod so the full Sun comes into view.

6. Some students may think that the circular image of the Sun they are seeing is not the entire Sun but just a part of the Sun seen through the circular lens of the binoculars. This is more likely to be an issue when there are no sunspots on the Sun. To convince students that the image is not circular because of the lens, you can cover half the lens that's open (making the open lens the shape of a D). The image of the Sun will be dimmer because less light is now coming through the lens, but it will still be circular, not D-shaped.

7. As students examine the image of the Sun, they should notice that it is moving across the paper. In a few minutes, the Sun is out of view completely, and you will need to adjust the tripod to bring...
the Sun back in to view. Ask students why this is happening. *It's because the Earth is rotating, which is what causes the Sun to appear to move across the sky throughout the day.* You need to realign the binoculars on a regular basis to keep up with the Sun's changing position in the sky. *At first, this may take students a bit of time, but they will get better at it with practice.*

**Teacher note:** In general, students should get some practice early on gently moving the binoculars to compensate for the Sun's motion in the sky. One student could be moving the binoculars to keep the Sun in view while others sketch an image. (It takes the Sun about two minutes to move a distance across the sky equal to its own diameter.)

8. Once students have the Sun's image on the piece of paper, they should examine the Sun's entire surface carefully to see if they can find any dark spots. If they are not sure whether the spot is on the Sun, in the binoculars, or on the paper, they should lightly tap the binoculars. If the spot moves with the Sun's image, then it is a sunspot.

9. Have students make a drawing of the Sun on the piece of paper, sketching where they can see dark spots on the disk of the Sun. They should also record on the piece of paper the total number of sunspots seen and the date of the observation (and keep the paper for comparing with sketches made on other days).

10. If possible, students repeat their observations with the group daily, using a new piece of paper to record the location and number of spots. Back in the classroom, put the drawings side by side to compare the number and location of the spot and spot groups.

11. Ask students to discuss what they noticed about the drawings in their groups and write in their astronomy lab notebooks about their findings. Did the sunspots change from one day to the next? How did they change? Were there more or fewer sunspots? Did they change size? shape? position? Did the same sunspots move across the surface of the Sun over a period of days?

12. While students continue to make these daily observations, it's a good time to start them on Experience 3.4, "Discover the Sunspot Cycle," which will provide them with more information about sunspots and when there are fewer or more of them.