SUNRISES AT STONEHENGE

ACTIVITY B-4

GRADE LEVEL: 6-9

Source: Reprinted with permission from PASS (Planetarium Activities for Student Success), Vol.12 *Stonehenge.* Produced by the Astronomy Education Program of the Lawrence Hall of Science, University of California, Berkeley. Copyright ©1993 by The Regents of the University of California. Available through the *Eureka!* catalog, Lawrence Hall of Science, University of California, Berkeley, CA 94720-5200; (510) 642-1016

What's This Activity About?

Examples of horizon astronomy—using sunrise and sunset positions as a calendar—exist in the history of many cultures. One of the best known examples is Stonehenge, the ancient collection of monoliths in southern England, now believed to have been built and used over many centuries by perhaps three different groups of people. This activity simulates a detailed study of sunrise positions at Stonehenge over a year.

What Will Students Do?

Students will plot where the Sun rises as observed at Stonehenge for each month of the year 2000. They will measure *azimuth,* defined as the angle around the horizon from due north. Students then analyze the azimuth plot to see when the Sun rises furthest north and south, and when the sunrise azimuth changes most from month to month.

Tips and Suggestions

- This activity was originally designed as part of a planetarium program which simulated the giant stones of Stonehenge, giving students the impression of actually being at the site but it can also be done in the classroom.
- This activity can be used as a simple illustration of horizon astronomy, but it will be more significant if the history of Stonehenge is discussed as well.
- If students do study Stonehenge, they can create physical models of the site, and even use large pieces of butcher paper placed around the classroom walls to simulate the monoliths.

What Will Students Learn?

Concepts
Changing position of the Sun over the year
Azimuth

Inquiry Skills
Graphing
Inferring

Big Ideas
Patterns of Change
Models

In Class

1. Let's pretend that we are near Stonehenge in Southern England. We have a clear view of the horizon and can watch the Sun rise every day of the year.

If the students have already seen the Stonehenge planetarium program, ask them to recall what they learned about how the position of sunrise changes throughout the year:

What's the longest day of the year? (about June 21, the Summer Solstice.)

On the Summer Solstice, does the Sun rise to the north or the south of East? (The Sun rises to the north of East in the summer.)

What's the shortest day of the year? (about December 21, the Winter Solstice.)

On the Winter Solstice, does the Sun rise to the north or south of East? (The Sun rises to the south of East in the winter.)

2. We are going to make a chart that will show how the sunrise postions change throughout the year.

Hand out a blank sunrise chart to each student. (Do not hand out the tables yet.) Point out the words "Azimuth of Sunrise" along the bottom. Review concepts from Azimuth and Horizons *activity (p. 28):*

What does azimuth mean? (Azimuth means the direction in degrees, as marked on a compass.)

What is the azimuth of North? (0°) ***East?*** (90°) ***South?*** (180°)

If the Sun were to rise exactly in the Northeast (halfway between North and East), what would the azimuth of sunrise be? (45°)

3. ***How far to the North will the Sun rise on the Summer Solstice, as seen from Stonehenge?***

Ask a few students to share their guesses with the rest of the class. Then, show the students how to indicate their guesses on the chart. Find the month of June along the left, and the azimuth of the guess on the chart. Place a pencil dot in the box that indicates both the month of June and azimuth of sunrise. For example, if they think that the builders of Stonehenge will see sunrise exactly in the Northeast on June 21, they should put a dot in the box to the right of June, and above 45°.

4. ***Place a pencil dot showing the azimuth of sunrise for each of these four important dates***:

Summer Solstice, about June 21

Winter Solstice, about December 21

Spring Equinox, about March 21

Fall Equinox, about September 21

5. ***Use your pencils to join the four pencil dots with a smooth curve, showing how you think the sunrise point will change between the four important dates.***

Invite them to share their predictions with their neighbors. Invite some of the students to share their predictions with the whole class.

6. Here is a Table of Sunrise positions at Stonehenge.

Hand out the Table of Sunrise Positions at Stonehenge.

The table shows the actual azimuth of sunrise as we would see it if we made observations at Stonehenge today. ***Use a colored pencil or pen to plot each position on your chart with an "x," and then to use the pen to connect the x's with a smooth line.***

7. ***Compare your paper with your neighbors'.***

Check that they have all plotted the positions of sunrise correctly. Lead a discussion to help the students interepret their results.

How close did your predictions come to the actual observations?

How far to the North did the Sun rise on the Summer Solstice? How far to the South did it rise on the Winter Solstice? Is that more or less than you predicted? (Summer 49°, Winter 128°)

When does the Sun rise due East? (On September 21 and March 21).

Do you think the Sun goes through the same pattern every year? If so, how do we know? (Ancient peoples around the world saw the same pattern of the Sun every year that we still see today!)

The exact dates of solstices and equinoxes changes from year to year, but are always within a day or two of March 21, June 21, September 21, and December 21. This is because the length of the calendar year (365 days) is not exactly the same as the solar year 365.26 days—this is also why we need leap year. For example, in the year 2000, the Summer Solstice will actually occur on June 20, and the Winter Solstice on December 21. You may wish to add that modern measurements indicate that even the azimuth angles change very slightly over the centuries because of slight changes in the tilt of the Earth's axis with respect to its orbit.

Table of Sunrise Positions at Stonehenge in the year 2000

Latitude: 51°17' N

Date	Time	Position	Date	Time	Position	Date	Time	Position
01/20	8:03 am	122°	05/20	4:11 am	55°	09/20	5:54 am	87°
02/20	7:14 am	106°	06/20	3:53 am	49°	10/20	6:43 am	106°
03/20	6:11 am	88°	07/20	4:18 am	54°	11/20	7:36 am	121°
04/20	5:03 am	69°	08/20	5:05 am	69°	12/20	8:12 am	128°

Chart of Sunrise Positions (Year:_______ Latitude:________)

Jan	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
Feb																			
Mar																			
Apr																			
May																			
Jun																			
Jul																			
Aug																			
Sep																			
Oct																			
Nov																			
Dec																			
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180

(North) (East) (South)

Azimuth of Sunrise

Going Further

1. It is very interesting to explore more precisely the day to day change in the azimuth of sunrise. For this purpose, the table below shows the azimuth of sunrise on two or more successive days for each month of the year. Make a copy of the table for each student. Explain that these tables are more precise because the azimuths are given with degrees *and* minutes (minutes indicated by the symbol " ' "). There are 60 minutes in each degree. After the students have studied the table for a while, ask

During which months does azimuth of sunrise change the most from one day to the next? (March and September)

During which months does the azimuth of sunrise change the least? (June and December)

What are the exact dates of the solstices for the year 2000? (December 21 and June 20)

2. Instead of handing out the sunrise tables, have the students create their own, using a computer with astronomical "planetarium" software that can compute precise sunrise positions. For example, the data compiled on page 45 was generated by the *Voyager* program (from Carina Software, 830 Williams St., San Leandro, CA 94577; 510-352-7328) for Macintosh computers. An appropriate program for IBM-compatible computers is *AstroInfo*, which gives daily Sun and Moon risings and settings, with azimuth angles. It is available from Zephyr Services, 1900 Murray Ave., Dept. A, Pittsburgh, PA 15217; phone 800-533-6666. *NIGHTSKY*, also for IBM-compatibles, is a similar program to Voyager in that it produces star charts as well as tables. It is available from Southwest Astronomy, 4242 Roma NE, Albuquerque, NM 87108. *NS Lito* (a simple version of *NIGHTSKY*) is available as freeware on computer services such as Compuserve.

3. Make a similar sunrise position chart for another year to verify that it is essentially the same shape.

4. The latitude of Stonehenge is 51°17' N. Use a computer program to generate a table of sunrise positions for the latitude of your school.

More Sunrise Positions at Stonehenge in the year 2000

Latitude: 51°17' N

Date	Time	Position	Date	Time	Position	Date	Time	Position
01/20	8:03 am	122°09'	06/19	3:53 am	49°06'	09/22	5:57 am	88°56'
01/21	8:03 am	121°46'	06/20	3:53 am	49°03'	09/23	5:58 am	89°27'
02/20	7:14 am	106°40'	06/21	3:54 am	49°06'	09/24	6:00 am	90°09'
02/21	7:12 am	106°05'	06/22	3:54 am	49°07'	10/20	6:43 am	106°02'
03/18	6:16 am	90°05'	06/23	3:54 am	49°08'	10/21	6:45 am	106°41'
03/19	6:13 am	89°19'	06/24	3:55 am	49°18'	11/20	7:36 am	121°37'
03/20	6:11 am	88°45'	07/20	4:18 am	54°34'	11/21	7:38 am	122°04'
04/20	5:03 am	69°57'	07/21	4:19 am	54°52'	12/19	8:11 am	128°07'
04/21	5:01 am	69°24'	08/20	5:05 am	69°10'	12/20	8:12 am	128°13'
05/20	4:11 am	55°22'	08/21	5:06 am	69°37'	12/21	8:12 am	128°14'
05/21	4:10 am	55°03'	09/20	5:54 am	87°43'	12/22	8:13 am	128°13'
06/18	3:53 am	49°09'	09/21	5:55 am	88°14'	12/23	8:13 am	128°07'
						12/24	8:13 am	128°00'