Many scientists who have studied Stonehenge agree with Gerald Hawkins that the stones mark sunrises and sunsets on important days of the year. However, few agree with Hawkins that Stonehenge also marks the extreme rising and setting positions of the Moon, since the evidence for Moon alignments is weaker than for the Sun. In this activity, the cycles of the Moon unfold in stages for your students. This activity is best done after the Stonehenge planetarium program, and after the previous classroom activity, "Sunrises at Stonehenge".

Many Moonrises

Materials

For each student:

- 1 Table of Moonrises for January, 1993 (master on p. 3)
- 1 Table of Northern Moonrise Extremes for 1993 (master on p. 3)
- 1 Table of Northern Moonrise Extremes, 1994-2015 (master on p. 3)
- 1 Chart of Moonrises for January 1993 (master on p. 4)
- 1 Chart of Northern Moonrise Extremes, 1993-2015 (master on p. 5)
- 1 pencil
- A colored pen or pencil
- Overhead transparencies of the tables and charts

Before Class

1. Photocopy each of the above sheets for each student.
2. Use a paper cutter to separate the Tables so that they can be handed out separately.
3. Plot the points on each chart yourself so that you see the overall patterns.

In Class

1. Ask your students to recall how the sunrise position changes over time.

   How long is the sun's cycle; that is, how long until the pattern of sunrises and sunsets repeats itself?

   When is the sunrise farthest north? When is it farthest south?

2. Let's try to predict how the moonrise position might change over time.

   Hand out a blank Chart of Moonrises for January 1993 to each student.

   Announce the position of moonrise on January 1 (from the Table of Moonrises for January, 1993). Ask each student to mark this position on the chart. Check to see the position is marked correctly.

   Does the Moon actually rise every day of the month? [We may only notice moonrise when it occurs in the evening.]

   Ask your students if they have ever seen the Moon in daytime, or ever seen it rise in the daytime. If students are very skeptical, you may wish to assign them to look for the Moon in the daytime on the next appropriate date. Seeing a daytime moonrise is an interesting challenge.

Have each student draw a vertical line or curve that shows his or her prediction for how the position of moonrise will change throughout January 1993.

3. Hand out a Table of Moonrises for January 1993 to each student.

Have them plot the moonrise position for each day on the chart.

How close was your guess? When and where was the northerly extreme?

When and where was the southerly extreme?

Unlike the Sun, which takes a full year to go from most northerly sunrise to most southerly and back again, the Moon goes through such a cycle in only a month.

But is the cycle the same each month? Each year? Does the Moon go to

the same extremes each month, just as the Sun does each year?

4. Hand out a Table of Northern Moonrise Extremes for 1993 to each student.

This is a Table of Northern Moonrise Extremes for 1993.

Please look at your Table of Moonrises for January of 1993 to find the first two moonrise extremes of 1993 (for January and February). Enter them in the two blank spaces at the beginning of your Table of Northern Moonrise Extremes for 1993. Does the Moon rise at the exact same northern extreme each month? [No.] How is it changing? [The northern moonrise extreme seems to be creeping south!]

5. Hand out a blank Chart of Northern Moonrise Extremes for 1993–2015.

Have the students first fill in the average position of the northern extreme moonrises for 1993 in the first blank space in their table. They can estimate the average from the Table of Northern Moonrise Extremes for 1993. Challenge the students to guess (draw on the blank chart) the pattern of extreme northern moonrises for the period 1993-2015.

6. Hand out a Table of Northern Moonrise Extremes for 1993-2015 to each-student.

Have them plot the northern moonrise extreme positions on the chart. How close were their guesses? Ask them to describe the pattern.

Look carefully at the data.

Is there a year in which the numbers appear to begin repeating themselves?

[The years 1994-1997 match the years 2012-2015 to within a degree.]

This larger pattern of moonrise positions repeats itself about every 18 years. This cycle is helpful in predicting eclipses of the Sun and Moon.

Table of Moonrises for January 1993 at Stonehenge

Date	Time	Azimuth
01/01	11:10 am	73°
01/02	11:31 am	66°
01/03	11:57 am	60°
01/04	12:30 pm	55°
01/05	01:16 pm	52°
01/06	02:07 pm	51°
01/07	03:15 pm	53°
01/08	04:33 pm	58°
01/09	05:56 pm	65°
01/10	07:21 pm	74°
01/11	08:45 pm	83°
01/12	10:11 pm	93°
01/13	11:28 pm	102°
01/15	12:48 am	111°
01/16	02:06 am	118°
01/17	03:19 am	124°
01/18	04:26 am	127°
01/19	05:24 am	128°
01/20	06:12 am	127°
01/21	06:50 am	123°
01/22	07:21 am	119°
01/23	07:45 am	112°
01/24	08:06 am	106°
01/25	08:24 am	98°
01/26	08:41 am	91°
01/27	08:58 am	83°
01/28	09:16 am	76°
01/29	09:36 am	69°
01/30	09:59 am	67°
01/31	10:28 am	57°
02/01	11:04 am	53°
02/02	11:51 am	51°
02/03	12:51 pm	52°
02/04	02:02 pm	55°
02/05	03:23 pm	61°
02/06	04:48 pm	69°

Table of Northern Moonrise Extremes for 1993 at Stonehenge

Date	Northern Moonrise Extreme
01/06	
02/02	
03/01	53°
03/29	53°
04/25	53°
05/22	53°
06/19	53°
07/16	53°
08/12	53°
09/08	54°
10/06	54°
11/02	54°
11/29	55°
12/26	55°

Table of Northern Moonrise Extremes at Stonehenge, 1993-2015

(Latitude 51°17')

1993		2001	51°	2009	45°
1994	55°	2002	48°	2010	48°
1995	58°	2003	45°	2011	51°
1996	60°	2004	42°	2012	54°
1997	60°	2005	42°	2013	57°
1998	58°	2006	40°	2014	59°
1999	57°	2007	42°	2015	60°
2000	53°	2008	44°		

Chart of Moonrise Positions at Stonehenge in January 1993

(Latitude 51°17')

	(North)										(East)									(South)
Jan		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				
21		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
22																				
23																				
24																				
25																				
26																				
27																				
28																				
29																				
30																				
31																				
Feb 1		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
2																				
3																				
4																				
5																				
6																				
7																				

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

(North) (East) (South)

Azimuth of Moonrise

Chart of Northern Moonrise Extremes at Stonehenge 1993–2015

(Latitude 51°17')

	(North)									(East)									(South)
		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1993																				
1994																				
1995		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
1996																				
1997																				
1998																				
1999																				
2000		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
2001																				
2002																				
2003																				
2004																				
2005		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
2006																				
2007																				
2008																				
2009																				
2010		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
2011																				
2012																				
2013																				
2014																				
2015																				
		0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
		(North)									(East)									(South)

Azimuth of Moonrise

Going Further

1. Have your students try to predict the pattern of southern moonrise extremes on their charts. They can then use the tables below to plot the southern moonrise extremes on their charts and see how close their predictions were.

What is the pattern of southern Moonrise extremes?

1993 Moonrise Extremes at Stonehenge

Date	Northern	Southern	Date	Northern	Southern
02/15		128°18'	07/28		126°18'
03/01	52°38'		08/12	53°14'	
03/14		127°28'	08/25		126°37'
03/29	52°30'		09/08	53°54'	
04/10		127°34'	09/21		125°59'
04/25	52°56'		10/06	54°05'	
05/07		126°57'	10/18		124°56'
05/22	53°24'		11/02	54°24'	
06/04		127°20'	11/15		125°45'
06/19	52°54'		11/29	54°36'	
07/01		127°07'	12/13		125°48'
07/16	53°22'		12/26	55°04'	

2. Instead of handing out the moonrise tables have the students create their own, using a computer with astronomical "planetarium" software that can compute precise moonrise positions. For example, the data compiled on pages 46-47 was generated by the Voyager program (from Carina Software, 830 Williams St., San Leandro, CA 94577; 510-352-7328) for Macintosh computers. For IBM-compatible computers, AstroInfo 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. Moontimes, also from Zephyr, is excellent for lunar computations (for IBMcompatibles). 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 Services, 1900 Murray Ave., Dept. A, Pittsburgh, PA 15217; phone 800-533-6666. NS Lito (a simple version of NIGHTSKY) is available as freeware on computer services such as Compuserve.

3. Chart moonrises for another latitude.

4. Invite your students to discuss whether they believe ancient peoples like those at Stonehenge could have determined such long-term patterns as the moonrise cycle. Factors which make this difficult are the weather, which may make many moonrises invisible, and the need to keep information intact over many years.

How could pre-literate cultures do this? Possible solutions are keeping information in graphic form (charts) or in oral tradition (as chants or incantations). What other examples can students discover of long-held complex information from ancient times?

Southern Moonrise Extremes at Stonehenge 1994-2015 (Latitude 51°17')

1994	125°
1995	122°
1996	121°
1997	119°
1998	122°
1999	124°
2000	126°
2001	129°
2002	132°
2003	135°
2004	136°
2005	137°
2006	140°
2007	138°
2008	137°
2009	135°
2010	131°
2011	129°
2012	126°
2013	124°
2014	122°
2015	120°