Halloween Astronomy Curriculum
45 to 70 minutes, for 6th-8th grades

Notice

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Objectives

Students will learn:
- Some history of and mythology about Halloween and its precursors
- Some constellations visible on Halloween
- Definitions of the terms “equinox,” “solstice,” and “cross-quarter day”
- How solstices and equinoxes relate to the seasons on Earth

Materials needed

- Flashlight
- Light and laser pointers
- Images of rise/set/maximum altitude arrows in different colors for Halloween, December solstice, March equinox, June solstice, and September equinox **OR** sticky notes (in five different colors) and a black marker
- Digitarium® system set for about 2 pm on Halloween; latitude, longitude, and sky time set for your current location; atmospheric effects and landscape turned on

I. Introduction *(10 to 15 minutes)*

A) Inform students that you'll be exploring the astronomical significance of Halloween. Ask students what they associate with Halloween. ***[****Trick or treating, costumes, etc.****]*** Define astronomy, and ask students if they can think of any connections between astronomy and Halloween. If not, they'll be learning about some today.

B) Halloween's origin can be traced back thousands of years, to about the fifth century BCE. Briefly tell students about the Celts, in particular: The Celts were composed of several distinct groups of people in different parts of Europe. This lesson will focus on the Celts who lived in what is now Ireland, Scotland, and Wales.

The Celts divided the year into two parts, light and dark. On or near October 31, they observed the transition from the light part of the year to the dark with a festival called Samhain (typically pronounced SOW-in). The name Samhain means "summer's end." Samhain served as the Celts' New Year's Eve, and it marked the final harvest of the year and the beginning of winter.

Samhain represented one of two "seasonal seams," times when the border between our world and the supernatural world would break open, allowing just about anything to happen. The other seasonal seam was Beltine (also spelled Beltane or Beltaine) on May 1, which we will briefly discuss later.

The Celts believed that the ghosts of the dead came back to Earth on Samhain to cause mischief and damage crops. People would wear disguises to try to hide themselves from the dead. Apples were buried along roadsides to provide sustenance for spirits without living relatives, and people would go door to door asking for contributions of food from their neighbors.

It was believed that having the spirits of the dead back on Earth helped the Druids (Celtic priests) make more accurate predictions about the future. On Samhain the Druids built huge sacred bonfires, and people would gather to burn crops and sacrifice animals to the Celtic deities. People also extinguished their hearth fires and then relighted them from the central bonfire. They left their home doors open so that the spirits of the dead could enter to pay a visit.

Samhain was a time that people feared. As Dr. E.C. Krupp writes in Beyond the Blue Horizon, Samhain...

> ... was a genuinely terrifying moment in the annual cycle. As one of the year's two seasonal seams, it was a time when stitches could snap, and through that rip in the protective fabric of ordinary reality, the agents of chaos could emerge. Exploding from the dark otherworld of malicious spirits, the dead and their allies threatened the established natural order. An encounter with the spirits on Samhain night guaranteed traffic with hags, monsters, witches, and fairies. Powerful supernaturals who commanded magical forces, the Celtic fairies could help mortals or lure them to their doom.

Samhain was a precursor to Halloween. It took several more centuries for the holiday to get its current name, as a result of actions taken by the Catholic church. In 835 CE, the Catholic church named November 1 as All Saints' Day. This was a day to celebrate both known and unknown saints. Halloween of course is the day before All Saints' Day, so it is known as the Eve of All Hallows, or Halloween for short.

Discuss briefly with the students how Halloween is similar to and different from Samhain. ***[Note:*** *See the list of background resources at the end of this lesson for*

more information about the Celts, Samhain, and other topics.]

C) Inform students that Halloween is what astronomers call a cross-quarter day. Introduce and define the terms solstice, equinox, and cross-quarter day. "Solstice" means "sun stops," and the summer and winter solstices respectively mark the longest and shortest days of the year. The summer solstice happens on or near June 21, the winter solstice on or around December 22.

"Equinox" means "equal night," and the spring and fall equinoxes have almost exactly equal amounts of light and darkness; on these days the sun rises due east and sets due west. The spring equinox occurs on or near March 21, the autumnal equinox on or near September 23.

"Cross-quarter days" fall approximately midway between the solstices and equinoxes. See the image below to help you visualize the sun's positions on the solstices, equinoxes, and cross-quarter days. ***[****Note: NCP stands for North Celestial Pole, SCP for South Celestial Pole.****]***

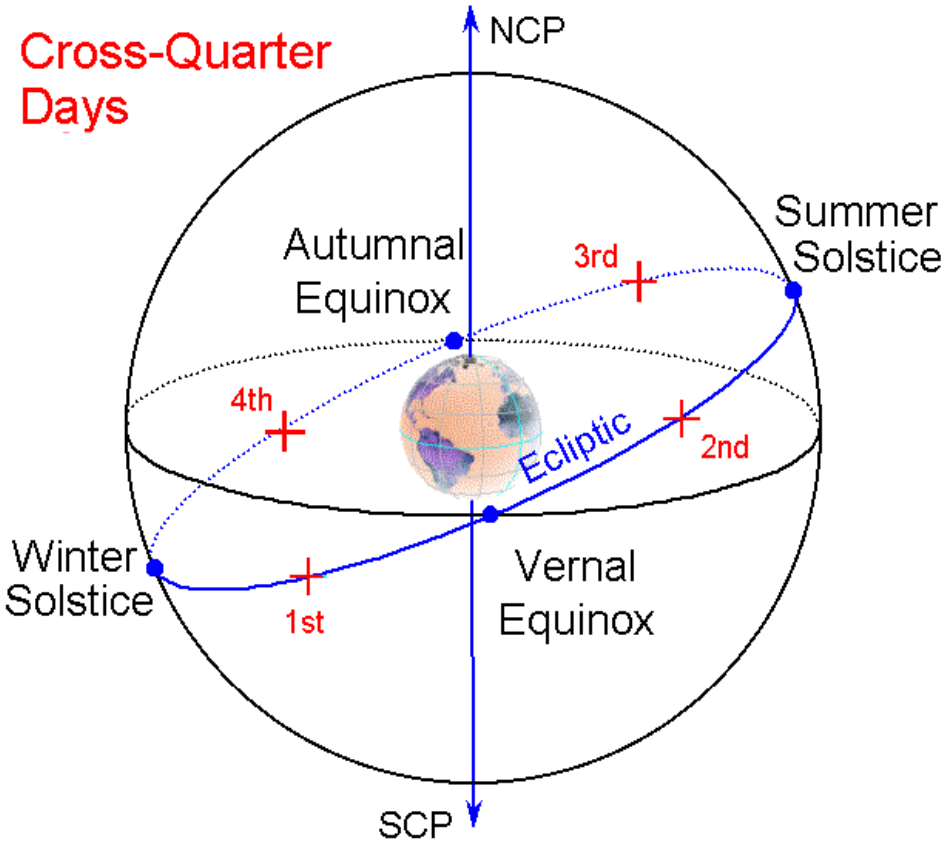

Image Credit: NASA

In the U.S., we use solstices and equinoxes to mark the beginnings of seasons. The Celts considered cross-quarter days to be the beginnings of the seasons, as do many other cultures. As you reveal the dates of the cross-quarter days, ask students if the date is familiar for any reason.

- February 2: The Celts called this day “Imbolg,” which probably meant “ewe's milk,” a reference to the lambing season and the approach of spring. In the USA, this is Groundhog Day, when we use a mammal's ability to see or not see its shadow to guess how many weeks of winter remain.
- May 1: The Celts held a festival called Beltine; as mentioned earlier, this was the second seasonal seam, marking the transition from the dark half of the year to the light. As they did with Samhain, bonfires played an important role in Beltine. In fact the name “Beltine” seems to mean “brilliant fire,” likely a reference to the sun. In the USA this is May Day, a celebration of spring.
- August 1: The Celts celebrated Lammas (a.k.a., Lughnasadh) on or near this day; it marked the start of the wheat harvest. The name means “loaf-mass,” a reference to the custom of bringing to church a loaf made of wheat from the new harvest. It is not associated with any particular holiday in the USA.
- And the fourth cross-quarter day is...? Right, October 31.

D) Explain to students that you'll learn more about Halloween and astronomy inside the dome. Review rules, expectations, etc, and enter the dome.

II. Introduction to the Halloween Sky *(10 to 15 minutes)*

A) ***[****As students enter, seat them facing roughly south, since they'll be looking in that direction for much of the lesson.****]*** Inform students that you're starting your observations at 2 pm on Halloween afternoon. Point out the date and time bar and encourage students to keep track of the sky time. Speed up time until about midnight, then turn off the atmospheric effects and landscape.

Inform students that it will be helpful for the rest of the lesson if we know which way is which in the dome. In the northern hemisphere, one star is particularly helpful for navigation: Polaris, the north star. Share the tip of finding the Big Dipper ***[****let a student use a LIGHT pointer to point it out****]***, then using the 'pointer stars' to find Polaris. After finding the north star, review the other directions, and bring up the cardinal points to help students remember which direction is which.

B) Introduce some other constellations/groups of stars that we can find on Halloween. Turn on the label and artwork for each constellation as you introduce it. At midnight on Halloween:

- Orion the hunter is in the eastern sky. ***[****Let a student use a LIGHT pointer to point it out, then select a star in Orion and turn on the label and artwork.****]***
- Next to Orion is Taurus the bull ***[****select a star in Taurus and turn on the label and art****].***

- In Taurus' shoulder is a tiny group of stars that was very important to the Celts. ***[Circle it with your laser pointer.]*** Does anyone know what this is? Right, it is an open star cluster called the Pleaides, also known as the Seven Sisters or M45. ***[Turn off constellation art and labels, then select and zoom in on the image of the Pleiades.]*** The Celts considered the Pleiades a window into the supernatural world. When this group of stars was directly overhead at midnight and the moon was full, it was time to celebrate Samhain. ***[Zoom out to the sky.]***

  You can see that the Pleiades are not directly overhead in our planetarium, even though we have our sky set for just about midnight on Halloween. Why aren't the Pleiades overhead? Primarily because of something called precession of the equinoxes. This is the wobble of the earth on its axis, much like a top wobbles as it slows down. Precession is a very slow process; one wobble takes almost 26,000 years. It causes many interesting changes, but unfortunately we won't have time to get into them here. ***[See background resources for precession information.]***

- If you have time, the following constellations are also visible at midnight on Halloween: Pegasus; Andromeda (M31, the Andromeda Galaxy, is a great zoom target); Cassiopeia; Cepheus; Cetus; Gemini; Auriga; Cygnus; and more.
- If time allows, discuss visible planets students can look for as they're trick or treating.

III. Solstices, equinoxes, cross quarter days *(20 to 30 minutes)*
For more information, see the "Solstice and Equinox" lesson plan freely available on our website: http://DigitalisEducation.com/curricula.html

A) Briefly review the definitions of the terms "solstice," "equinox," and "cross-quarter day." Halloween is an example of which of these? Right, a cross-quarter day. We'll start our observations about the sun's positions on Halloween.

We're currently past sunset on Halloween, so we'll jump back one day to about midnight on October 30/31. Inform students that soon you will speed up time to get to sunrise on Halloween. Ask students to predict where along the horizon they expect the sun to rise, leave atmospheric effects and landscape off, and speed up time until the sun rises. Use the image of the arrow for the Halloween sunrise position to mark where the sun actually rose, **OR** write the date on a sticky note, and attach the sticky note to the dome. ***[If time allows, have students record predicted and actual positions of the sun on each day. See the end of this lesson for a sample chart.]***

Not only is the position of the rising or setting sun important on solstices and equinoxes, the maximum altitude reached each day is important, too. At about what time each day does the sun reach its highest point? Correct, about noon. In what part of the sky does it reach its maximum altitude? For us here in the northern hemisphere, when it is due south.

Turn on the meridian, and ask students to use the degree markers to predict the maximum altitude the sun will reach on Halloween. Take several guesses, then speed up time until the meridian divides the sun vertically. Use the arrow image or a sticky note to mark the maximum altitude of the sun on Halloween. ***[Decide which part of the sun—top edge, middle, or bottom edge—will determine maximum altitude, and use that part of the sun for all five dates.]***

Lastly let's have a sunset. Have students point to the area along the

horizon where they expect the sun to set, then speed up time until the sun has almost completely disappeared below the horizon. Again, use the arrow image or a sticky note to mark the sun's setting position along the horizon.

B) Ask students what comes next in our exploration: an equinox, solstice, or another cross quarter day? Right, next is the winter solstice, which happens on or about December 22. Remind students what the word solstice means, and take ideas on what "sun stop" might tell them about the sun's positions and path that day. In what ways do they expect the sun's path on the winter solstice to differ from Halloween?

Jump forward in time until you reach 4 am on December 22, then repeat the cycle above. Take predictions on sunrise position, maximum altitude, and sunset position. ***[****If you are using sticky notes, use a different color for the winter solstice from the color you used for Halloween.****]***

C) Inform students that in the interest of time, you'll be skipping the other three cross quarter days and just focusing on the equinoxes and solstices. After the winter solstice, the next date to explore will be...? Right, the vernal or spring equinox (Northern hemisphere terminology). What does equinox mean? What do they think the term "equal night" has to do with the sun's path on that day? ***[****Speed up time to about midnight before changing your date, so that students don't get a sneak peek at where the sun will set.****]***

Jump forward in time until 4 am on March 21 ***[****pause briefly at Imbolg, February 2, to remind them about that cross-quarter day****]***, then repeat the cycle for sunrise, maximum altitude, and sunset. ***[****Try to use yet another color sticky note.****]***

D) What comes next in the cycle? The summer solstice, which occurs on or around June 21. Any predictions on what the sun's path will look like on this date? Jump forward in time until 4 am on June 21 ***[****pause briefly at Beltine, May 1, to remind them about that cross-quarter day, the other "seasonal seam"****]***. Repeat the cycle for sunrise, maximum altitude, and sunset. ***[****Try to use yet another color sticky note. You may not be able to reach high enough to attach the sticky note at the sun's maximum altitude on this date. If you cannot reach, write the maximum altitude in large numbers near the date, and attach the sticky note on the meridian at the horizon.****]***

E) We have one last date before we get back to Halloween. It is the autumnal equinox, which occurs on or about September 23. Jump forward in time to about 4 am on September 23 ***[****pause at August 1 to remind them of the cross-quarter day Lammas****]***, and repeat the cycle above for sunrise, maximum altitude, and sunset.

F) After you have charted the sun's path for all five dates, use your laser pointer to trace the path of the sun on each date (i.e., connect the rising arrow, maximum altitude arrow, and setting arrow with your pointer in a smooth arc). Have the students follow the laser pointer's arc with one arm to highlight the path of the sun.

If you are using sticky notes, turn on the atmospheric effects, and reverse time to get the sun above the horizon ***[****positioning the sun in the south-southwest typically works well****]***. This should give students enough light to be able to read the sticky notes. "Connect" the sticky notes with your laser pointer to highlight the path of the sun on each date, and have students trace the arc with a hand. Ask students for their

thoughts about the changing path of the sun throughout the year. Have they observed this in the real sky?

G) **OPTIONAL:** Run a software script demonstrating how the sun's rising position changes over the course of a year. ***[****Digitarium® customers should contact Digitalis for ideas on easily creating such a script for your location.****]***

H) **OPTIONAL:** If time, permits, discuss other interesting astronomy events that have or will occur on/near Halloween. For example, on November 1, 2005, Mars was the closest to Earth that it will be until the year 2018—only about 42,000,000 miles/69,000,000 kilometers away.

I) Prepare students to exit, and ask them to regroup outside the dome.

IV. Conclusion ***(5 to 10 minutes)***

A) After all have exited the dome and been seated on the floor, review the major concepts of the lesson. What did the students learn about the history of Halloween? What is a cross-quarter day? A solstice? An equinox? What constellations can they expect to see on Halloween night? What tiny group of stars helped the Celts determine when to celebrate Samhain?

B) If time allows, use five students to demonstrate the path of the sun throughout the year. ***[****For details on this demonstration, see section IV of the Solstice and Equinox lesson plan freely available at DigitalisEducation.com/curricula.html****]***

Observation Chart of the Sun's Path

Date	***Position at Sunrise***		***Maximum Altitude***		***Position at Sunset***	
	Predicted	Actual	Predicted	Actual	Predicted	Actual
Halloween (October 31)						
Winter Solstice (on/near Dec 22)						
Spring Equinox (on/near Mar 21)						
Summer Solstice (on/near Jun 21)						
Fall Equinox (on/near Sept 23)						

Notes/General Observations:

Background resources

Websites

Halloween and astronomy
http://www.history.com/minisites/halloween/viewPage?pageId=713
http://www.islandnet.com/%7Esee/weather/almanac/arc2003/alm03jan.htm
http://science.nasa.gov/science-news/science-at-nasa/2005/27oct_halloween/

The Celts/Celtic Mythology
http://www.britainexpress.com/History/Celtic_Britain.htm
http://www.ibiblio.org/gaelic/celts.html
http://en.wikipedia.org/wiki/Nera_%28mythology%29
http://en.wikipedia.org/wiki/Cath_Maige_Tuireadh

Cross-Quarter Days
http://en.wikipedia.org/wiki/Cross-quarter_day (Has links to more info on all four Celtic festivals)
http://www.astronomy.ohio-state.edu/~pogge/Ast161/Unit2/time.html
http://www.naic.edu/~gibson/cal/
http://www.clarkfoundation.org/astro-utah/vondel/crossquartermay.html
http://www.chalicecentre.net/samhain.htm
http://www.irelandforvisitors.com/articles/samhain.htm
http://en.wikipedia.org/wiki/Samhain
http://www.imbas.org/articles/samhain.html

Seasons/Solstices/Equinoxes
http://www.archaeoastronomy.com/seasons.html
http://en.wikipedia.org/wiki/Solstice
http://www.badastronomy.com/bad/misc/badseasons.html
http://www.physicalgeography.net/fundamentals/6h.html

Precession of the Equinoxes
http://en.wikipedia.org/wiki/Precession_of_the_equinoxes
http://www-istp.gsfc.nasa.gov/stargaze/Sprecess.htm
http://csep10.phys.utk.edu/astr161/lect/time/precession.html

Books

Beyond the Blue Horizon, Dr. E.C. Krupp, © 1991. New York: Harper Collins Publishers.