Brian Moriarty | Lectures & Presentations | What's Eating the Moon?

What's Eating the Moon? (2003)

This plantarium program was presented to over 1,200 middle school audiences by the McAuliffe/Challenger Center at Framingham State University between 2003-06.

I wrote the script in conjunction with the McAuliffe Center staff, produced all of the visual assets and soundtrack, and engineered/built a custom Dolby Digital audio system to drive the automation of the vintage Spitz 512 star projector, 480p widescreen video, 12 slide projectors, auxiliary visual effect systems and dome lighting.

The marvelous narration is by Helen Listani, with an original music score by Bruce Mattson.

The script was updated regularly to accomodate locally visible eclipses as they occurred. This is the final revision before the show was retired.

This soundtrack audio was downmixed from the original 4.1 surround dome master.

Running time of the main program is 33:11, with exit music continuing for an additional 22 minutes.

A transcript of the recording follows.

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FX: City street sounds, fading to rural evening ambience.

Sunset. Wednesday, February 20th, 2008, only a few years from today.

The twilight hour is at hand. Street lights are coming on. Families are settling down for an evening of dinner, television and homework.

Yet despite the cold winter air, not everyone is staying indoors tonight.

In open fields and on scattered hilltops, skywatchers are gathering with binoculars, cameras and telescopes.

As the sun sinks below the horizon, stars emerge in the gathering dusk.

The first to appear is Sirius, brightest of all evening stars. Near it are Rigel and Betelgeuse, the foot and shoulder of Orion.

Mars, the Red Planet, looms high in the South.

And low in the Eastern sky, a mounting glow challenges the darkness.

Lenses turn to focus on a familiar silver disc as it rises, full and round, above the treetops.

For astronomers and students across the Western hemisphere, months of anticipation are about to culminate in an eerie spectacle.

In just a few hours, something strange will happen to the Moon.

MUSIC: Main theme.

It begins at forty-three minutes past eight o'clock.

The Moon is still full, but it isn't round anymore. The silver disc is disfigured by a black shadow, slowly creeping across the left edge.

It looks as if something has taken a bite out of the Moon!

As the minutes pass, more and more of the Moon's surface is swallowed by the spreading gloom. Faint stars become visible as the brilliance of the moonlight softens and fades.

A few moments after ten o'clock, the familiar Moon disappears.

All that remains is a faint red orb, the color of rust ...

or blood.

Weather permitting, *this* is what you will see in the skies over Massachusetts on the night of February 20th, 2008.

It will also happen in the year 2010, on the 21st of December, and again on September 27th, 2015.

Why will the Moon become dark on these nights? How do we know when it will happen?

The answers to these mysteries lie not in the future, but in the past.

To find them, we must stop the celestial clock and travel backward in time: 2500 years, and across the Atlantic Ocean, to the land of the Middle East, and the dawn of astronomy.

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FX: Primitive horn and drumming.

Ancient people were expert at watching the sky.

They had to be. They were farmers.

All of their food, for themselves and their animals, had to planted, grown and harvested by hand.

Their primitive agriculture depended upon the regular cycles of the Sun and the Moon.

The Moon was especially important.

Its ghostly radiance marked the passage of seasons, and the movement of tides.

Except for fire, it was their only source of light at night.

So they studied the Moon with great care, and worshipped it as a Goddess.

The Moon they watched is the same as the one we know. Its shape and location in the sky are different every night.

On some evenings, you can't see any Moon at all. The night is ruled by the stars.

FX: Stylus marks on stone.

After one or two dark evenings, a thin silver crescent becomes visible near the setting Sun in the West. Each night, the crescent grows larger, and appears a little higher in the twilight sky.

After seven nights, the crescent has broadened to a half-circle, visible high in the South at sunset.

More nights pass. The Moon continues to grow, its shape changing to a broad oval.

Two weeks after the first crescent, a round, full Moon rises in the East as the Sun sets in the West.

The Full Moon is visible all night long. It is bright enough to cast shadows on the ground. By midnight, it stands high in the Southern sky, its silver radiance washing out all but the brightest stars and planets.

The night ends with the Full Moon setting in the West as the Sun rises in the East.

For the next fourteen days, the Moon rises later and later after sunset. The round disc flattens to an oval, then a half-circle, shrinking to a thin crescent, rising just before the dawn.

Finally, the Moon is lost in the glare of the morning Sun, and the ancient cycle begins again.

It takes about twenty-nine and a half days for the Moon to go from one dark phase to the next. This regular cycle is the origin of the unit of time we call a *month*.

Ancient people used the monthly cycle to determine the best time to plant crops, when to travel at night, and to plan their days of worship.

Even today, many cultures base their holidays on the cycles of the Moon.

Muslim cultures begin each month with the first sighting of the crescent Moon. The Hebrew New Year, Rosh Hashanah, also begins on a new Moon. And Easter always falls on the first Sunday following the first full Moon after

the first day of Spring.

The changes of the Moon seem as regular and predictable as a clock … except on those strange nights when the Moon turns red!

FX: Alarmed crowd.

When ancient people saw the full Moon disappear, they were filled with wonder, and also with fear.

Some of them believed that the Moon was being swallowed by a dragon in the sky. They shouted, and beat on drums, and fired arrows into the sky to scare the dragon away.

They must have wondered: Where does the dragon live? Why does it eat some full Moons, but not others? Most important: Would the dragon come again, and when?

To solve these riddles, ancient sky-watchers began to keep careful records of the dragon's appearances.

The date, time and duration of each dragon-moon were carefully engraved onto tablets of stone. These records were passed down, generation after generation.

After hundreds of years of faithful observation, measurement and record-keeping, the ancient astronomers noticed a *pattern* in the dragon-moon's appearances.

The number of months between one dragon-moon and the next was always changing. But, when a dragon-moon did appear, another one always followed it exactly 223 full Moons later!

This 223-moon cycle was one of the greatest discoveries of ancient astronomy. It allowed sky-watchers to accurately predict when the full Moon was going to turn red. At last, they could prepare themselves for the terrifying spectacle.

The dragon in the sky had been tamed. They could not stop it from coming. But it would never surprise them again.

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FX: War drums, shouting crowds.

But the triumph of the ancient astronomers did not last long. The kingdoms they lived in were conquered by invaders.

After many wars and changes in government, the world of the astronomers was swept away, and their knowledge was lost to history.

For nearly two thousand years, the secret pattern of the dragon-moon was forgotten.

Then, in the year 1691, a British astronomer noticed the pattern again.

By studying the record of past lunar events, Sir Edmund Halley rediscovered the lost cycle of 223 moons. He called this cycle the **saros**, and showed how it could be used to preduct the occurence of red Moons with unfailing accuracy.

Sir Halley went on to discover many other astronomical cycles, including the period of a famous comet which now bears his name.

In the centuries since Sir Halley's discovery, astronomers have developed new ideas about the Moon and sky.

We no longer believe that sky-dragons are eating the Moon. Instead, we understand that the Earth and Moon are spheres, moving through space under the influence of gravity. Together with the Sun, the Earth and Moon form an elegant **system** of mass and motion, light and shadow.

Let's follow the Moon through an entire month to see what really happens.

We often speak of the Moon as "shining." But the Moon doesn't shine by itself. What we call "moonlight" is actually sunlight, illuminating the Moon's surface.

Because the Moon is a sphere, exactly half of its surface is illuminated by the Sun at any one time.

The Moon orbits around the Earth in a path that is almost circular. When the Moon's path brings it between the

Earth and the Sun, the side of the Moon illuminated by the Sun is facing away from us. The side facing the Earth is in shadow, and so close to the Sun's brilliant glare that we can't see it.

This dark phase of the lunar cycle is what we call the **new Moon.**

Let's travel forward in time a couple of nights. Watch how the Moon advances in its orbit around the Earth.

A few evenings after the new Moon, a small portion of the Moon's illuminated side is visible to us just after sunset. We call this the **first crescent** phase of the Moon.

As we continue moving forward in time, more and more of the Moon's illuminated side becomes visible to us, and the Moon appears higher in the sky after sunset. The growing moon is said to be **waxing.**

About seven nights after the new Moon, the Moon, Earth and Sun form a right angle in space. The Moon appears high in the South at sunset, and half of the Moon's illuminated surface is visible to those on Earth.

One quarter of the Moon's cycle is complete, so we call this the **first quarter** phase.

More nights pass. The Moon continues to wax, its form changing to the oval-shaped **gibbous** phase.

Fourteen nights after the new Moon, the Moon, Earth and

Sun form a straight line in space. Now the illuminated side of the Moon is entirely visible. Observers on Earth see a full, round Moon all night, rising in the East at sunset, high in the South at midnight, and setting with the dawn.

On subsequent nights, the Moon rises later after sunset. Less and less of its illuminated side is visible as it orbits the Earth. The shrinking Moon is said to be **waning.**

Twenty-two nights after the new Moon, the Moon, Earth and Sun again form a right angle in space, and a half Moon appears high in the South as the sun is rising. This is the **last quarter** phase.

After twenty-seven nights, the Moon appears as a thin crescent again, just above the sunrise in the East. Then the Moon disappears in the glare of the Sun, and the cycle begins again with the next new Moon.

Now you know why the Moon changes its shape and location in the sky.

But what about the sky-dragon?

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Remember that the Moon doesn't shine by itself. We see it because it is illuminated by the Sun.

In order for the Moon to grow dark, some object has to prevent the Sun's light from reaching the lunar surface. Something has to *block* the Sun.

That something is the Earth.

When you shine a distant light on a sphere, a long, cone-shaped shadow is cast into space.

As the Moon's orbit carries it around the Earth, it sometimes passes into the Earth's shadow-cone. When this happens, the Earth temporarily blocks the Sun's light from reaching the Moon.

We call this rare event an **eclipse of the Moon,** after the ancient Greek word ἔκλειψις *(ékleipsis)*, which means to hide, or disappear.

A lunar eclipse can only happen on the night of a full Moon, because that is the only time that the Earth can come directly between the Sun and the Moon.

From our perspective, here on Earth, a lunar eclipse seems to turn the Moon red. What would you see if you were standing on the Moon during a lunar eclipse?

For one thing, you wouldn't have to worry about the weather spoiling your view. The Moon doesn't have any weather. It has no atmosphere.

The blue Earth wanes to a narrow crescent as the Sun draws closer to it in the lunar sky. The edge of the Earth's curve dims the blinding sunlight as it moves across the Sun's disc.

Then, with a final flash, the Sun vanishes behind the Earth.

All that remains is a brilliant ring of crimson: the light of the Sun, scattered by the Earth's atmosphere.

Observers on Earth can see this crimson glow illuminating the surface of the Moon.

That is why the Moon appears red during a lunar eclipse.

So the sky-dragon of the ancient astronomers wasn't a dragon after all. It was just a shadow: the shadow of the Earth, cast upon the full Moon.

But the Earth isn't the only sphere casting a shadow in space. The Moon also has a shadow.

Is it possible for the Moon to cast its shadow upon the Earth?

The answer is *yes*.

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When the Moon is new, its orbit carries it between the Earth and the Sun.

Occasionally, under the right conditions, the tip of the Moon's shadow will sweep across the surface of the Earth.

When this happens, observers beneath the Moon's shadow experience the wonder and beauty of nature's most awesome spectacle: an **eclipse of the sun.**

The Moon is much smaller than the Earth, so the cone of its shadow is very narrow. The part of the Moon's shadow-cone that touches the Earth is only a few hundred miles wide. So the number of people who can see a solar eclipse at one time is relatively small.

But no one who witnesses an eclipse of the sun is likely to forget it.

It takes about seventy minutes for the Moon to cover the Sun's disc.

As the daylight fades, the wind dies down. The sky turns indigo. Birds begin to sing their evening songs.

With a final brilliant flash, the sun is gone.

A glorious halo appears around the Moon: the Sun's **corona,** usually hidden by the brilliance of the solar glare.

Stars and planets appear in the violet sky, and for a few breathtaking minutes, day turns to night.

FX: Alarmed crowd.

Imagine the terror of ancient people when they saw *this* in the sky!

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Why don't we see a solar eclipse on *every* new Moon, and a lunar eclipse on every full Moon?

The orbit of the Moon around the Earth isn't in the same plane as the Earth's orbit around the Sun. It's tilted about five degrees.

An eclipse can only occur when the Moon crosses the plane of the Earth's orbit at the same time that its phase is new or full.

This coincidence happens only a few times each year.

Modern astronomers have measured the motion of the Moon around the Earth with great precision. The Moon's rising, setting and phases can be calculated decades in advance.

We can also predict when lunar and solar eclipses will occur, where they will be visible, and how long they will last.

That is how we know that a lunar eclipse will occur in the skies of Massachusetts at exactly ten o'clock on the evening of February 20th, 2008.

But what about the next *solar* eclipse?

Many total solar eclipses will pass over the United States in the coming decades.

On August 21st, 2017, the Moon's shadow will darken our continent from Oregon to South Carolina. Less than seven years later, on April 8th, 2024, a solar eclipse will sweep across the heart of America from Texas to Maine.

Eclipses in 2045, 2052, 2071 and 2078 will crisscross the United States and Mexico.

What about here, in Massachusetts? When is the next time *we* will stand in the shadow of the Moon?

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Dawn. Monday, May 1st, 2079, less than seventy-five years from now.

Vega shines almost directly overhead. Jupiter and Saturn stand watch over the South.

And low in the East, a mounting glow challenges the darkness.

But this dawn is unusual.

The Sun *is* rising. But its light is feeble, dim and ominous.

What's wrong with the sunrise?

At ten minutes before six o'clock, a strange sight appears on the horizon.

Instead of a round Sun, we see a bright orange crescent, narrowing as it ascends.

The new Moon is rising in front of the Sun!

The crescent becomes smaller and smaller as it clears the treetops.

At exactly six minutes past six o'clock, the Sun disappears behind the Moon. For two minutes and ten seconds, the skies of Massachusetts fade into twilight.

The scientific **model** of the Earth-Moon-Sun system we have created allows us to **explain** the patterns of the Moon's changing appearance, and to **predict** solar and lunar eclipses with incredible precision.

Based on centuries of **observation, measurement** and **record-keeping,** we can pinpoint exactly where and when this sunrise eclipse will occur with an error of less than five seconds.

Many things will happen to our world in the 21st century. Great discoveries will be made. Knowledge will be gained … and lost.

But nothing in the affairs of human history will prevent this mysterious conjunction of the Moon and Sun on the first of May, 2079.

Some of you may be here to see it happen.

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