

# *Starry Dome: Astronomy in Art and the Imagination*

## **Allen Memorial Art Museum Teacher Resource Packet**

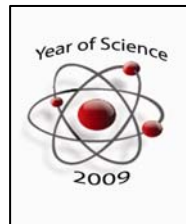


**Joseph Wright of Derby**  
(British, 1734 – 1797)  
*Dovedale by Moonlight*,  
ca. 1784 – 1785  
Oil on canvas

*From the earliest times of Plato and Aristotle, scientists valued the aesthetic qualities of harmony and symmetry in their conception of an earth-centered universe. These ideals increasingly led astronomers to posit elaborate, convoluted explanations in order to reconcile their theories with the cyclical movements they charted*

*in the sky. Seeking to restore clarity and a simple elegance to scientific discourse, in 1543, Nicolaus Copernicus proposed a radical notion—that the sun, not the earth, was the center of the known universe. In 1609, Galileo became the first astronomer to use a telescope, leading scientists to rely increasingly on visual tools of observational illustration and detailed star charts. Although Galileo faced persecution for his findings, a passion for knowledge led both scientists and artists to continue questioning the traditional ideologies of Greek philosophers and the Christian Church, as when the Renaissance artist Leonardo da Vinci scribbled in a sketchbook, “il sole non muove (the sun does not move).”*

*Drawn from the Allen Memorial Art Museum’s collection and the Oberlin College Library, this show explores how artists from diverse times and cultures have approached the skies as a source of visual inspiration and as a way of grappling with space, scale, place, and origin. The exhibition, curated by Anna-Claire Stinebring (OC '09), supports the Oberlin College course “Introductory Astronomy” and celebrates the Year of Science and International Year of Astronomy. Funding was provided by the Andrew W. Mellon Foundation.*



*This resource packet provides background information on many of the topics and scientific ideas represented in the exhibition, as well as information on specific works in the show. You can browse the packet as a whole, or click on the topics listed in this index to take you to a specific section.*

*For more information, or to schedule a tour of this exhibition or the AMAM galleries, please contact Jason Trimmer, Curator of Education, at [jtrimmer@oberlin.edu](mailto:jtrimmer@oberlin.edu), or phone (440) 775-8671.*

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## **The Science of Astronomy**

*Astronomy comes from the Greek words for 'star' and 'law.' As a science, it focuses primarily on the study of space, its objects, and phenomena outside of the Earth itself.*

### **The Development of Astronomy**

Astronomy is considered one of the oldest sciences. The study of the stars and planets began more or less concurrently with the oldest of human civilizations. At the beginning, astronomy was based on observational evidence taken solely with the naked eye. Many of the world's oldest calendars are based on these observations and were used to regulate agricultural cycles.

Some record of astronomy has been found in nearly all of early human civilization. Greek, Islamic, Mayan, and Roman cultures are all notable for their contributions and understanding of astronomy and the way it has affected Western culture. The Greeks' understanding of the world was codified into their mythology, a great deal of which centered around the heroes and gods becoming part of the night sky, the best example of which is Orion. Likewise, they contributed a great deal to the understanding of the basic motion of the heavenly bodies. Ptolemy, a Roman of Greek and Egyptian origin living in Egypt, was an astrologer, geographer, and mathematician. His work, the *Almagest*, is the only extant ancient treatise on astronomy. It called on Babylonian and Greek sources to create a system of geometric prediction for the motion of the planets, allowing ancient astronomers to project planetary motion into the future. Ptolemy's model, which came to dominate the understanding of the Solar System, was geocentric. A geocentric model places the Earth at the center of the planets' orbits, instead of the Sun.

Astronomy in the Middle Ages in the West was dominated by the Catholic Church. The Church affirmed Ptolemy's geocentric model as supporting the supremacy of man in a universe designed by God. The Islamic world, however, was making rapid advances and many of the star names still used were assigned during this time period.

The Renaissance brought major changes in the world of astronomy. Nicolaus Copernicus forwarded a heliocentric model of the Solar System, asserting that the Sun was the center of the universe, rather than the Earth. Taken up by Galileo Galilei, the heliocentric model was taken to be a challenge to Church doctrine. Similarly, Galileo's observations of the moon, taken with the aid of one of the world's first telescopes, aided in forwarding a scientific rather than religious or mythological interpretation of the heavenly bodies. It was Galileo's sketches of the moon, which showed a cratered and imperfect face that caused him to be indicted by the Catholic Church for heresy. Previously, the moon was held to be an ideal and flawless orb created by God. Johannes Kepler, forwarding the work of Copernicus and Galileo, devised the system by which the planets orbit around the Sun, asserting that the orbits were elliptical rather than circular. Isaac Newton's explanation of gravity allowed the orbits to then be explained mathematically.

The Scientific Revolution, largely considered as beginning with the works of Copernicus, shifted the focus of astronomy away from church domination and dogma and into the realm of empirical data and the use of the scientific method. This allowed the expansion

of the field in the 20<sup>th</sup> and 21<sup>st</sup> century to allow for the incorporation of the new field of astrophysics to the traditional study of astronomy. The existence of black holes, quasars, and pulsars the big bang theory and theories of the expansion of the universe have all evolved within this merger and continue to be the focus of modern day astronomy.

2009 was declared the International Year of Astronomy, commemorating the 400<sup>th</sup> year of Galileo's work and the 40<sup>th</sup> anniversary of the landing on the moon.



**Tycho Brahe** (Danish, 1546 – 1601)  
*Opera omnia: Astronomiae instauratae  
progymnasmata*, 1602;  
*De mundi aetherei*, 1588  
Frankfurt, 1648  
Oberlin College Library Special Collections

As court astronomer to Holy Roman Emperor Rudolph II in Prague, Tycho Brahe developed sophisticated and precise instruments for studying the skies, such as the giant sextant shown here in a collected volume of his written works.

Although Brahe remained committed to the theory of an earth-centered universe, first posited by Aristotle and revised by Claudius Ptolemy in the 2<sup>nd</sup> century C.E., he invented his own revised model. The Tychonian system posited that the sun and moon rotate around the earth while the remaining planets revolve around the sun, an arrangement that more accurately described the observed movements of the sun, moon, and planets than the Ptolemaic model.

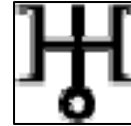


**Galileo Galilei** (Italian, 1564 – 1642)  
*Systema cosmicum*, 1632  
Leiden, 1699  
Oberlin College Library Special Collections, Frederick  
B. Artz Bequest

This Latin edition of Galileo's 1632 masterpiece, known in English as the *Dialogue Concerning the Two Chief World Systems*, is structured as a debate among three fictional characters who, in turn, defend the Aristotelian, Ptolemaic, and Copernican models of the universe. Galileo's bias towards Copernicus's heliocentric, or sun-centered, system contradicted the views of the Church and led to his trial before the Inquisition in Rome in 1633. Galileo was deemed a heretic, not only for his scientific theories but also for weaving the opinion of his patron, Pope Urban VIII, into the argument of Simplicio, the book's simple-minded Ptolemaic defender.

**Francesco Bartolozzi** (Italian, 1727 – 1815)  
after **Benjamin West** (American, 1738 – 1820)  
*The Genius of Light Awakens Science and Art*, 1789  
Engraving with etching  
Friends of Art Endowment Fund, 1982.96

Francesco Bartolozzi's print, after Benjamin West's allegorical murals in the Queen's Lodge at Windsor, celebrates British advancements in the arts and sciences under King George III and glorifies the Enlightenment values of reason and knowledge. On the right, a woman peers through a Newtonian reflecting telescope at the H-shaped astrological symbol for the planet Uranus, which British astronomer Sir William Herschel discovered in 1781 using a reflecting telescope he built himself.



## Astronomical Tools

### Astrolabe

An astrolabe is an ancient astronomical instrument used to figure out the position of the Sun and stars in the sky. There are a number of different astrolabes, but the most popular type is the planispheric astrolabe. A planispheric astrolabe features the celestial sphere projected onto the plane of the equator. This astrolabe was used to show how the sky looks at a specific place at a given time. To use an astrolabe, you adjust the moveable components (like the hands on a clock) to a specific date and time. Once set, the visible sky is represented on the instrument. It can be used to find the time during day or night, predict celestial events such as Sunrise, and help determine different celestial positions. Astrolabes were some of the first basic astronomy educational tools and were used in cultures throughout the world. In the medieval Islamic world, like the reproduction in the Allen's collection, the astrolabe was used primarily for astronomical studies, while in Europe they were used primarily for horoscopes, as well as astronomy and navigation.



**Persian?**, 19<sup>th</sup> – 20<sup>th</sup> century  
after **Abd al-A'imma** (Persian, active ca. 1678 – 1722)  
*Astrolabe*, 19th - 20th century  
Filigree brass; imitation of 1709 original  
R. T. Miller, Jr. Fund, 1945.35A-D

The astrolabe, an instrument that measures the positions and altitudes of planets, stars, and the sun, originated in ancient Greece and was perfected by medieval Arab astronomers. In the Islamic world, which greatly valued both astronomy and astrology, astrolabes had added religious significance for their ability to calculate the direction of Mecca for daily prayers. The front of an astrolabe includes a

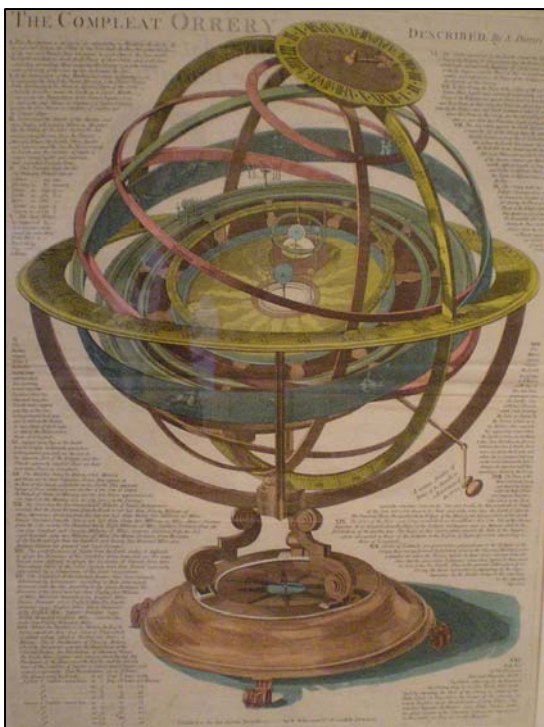
removable, recessed plate with stereographic projections of the northern celestial hemisphere. Layered on top is a rotating *spider* adorned with pointers to indicate key stars on the disk below. The example on view, however, is a nonfunctional forgery in the style of a renowned Persian astrolabist. Instead of accurate pointers, this astrolabe uses stylized flourishes that do not line up realistically with the stars below.

## Orrery



An orrery is a device that illustrates the relative positions and motions of the planets and moons in the Solar System according to the heliocentric model. At the center of the device is the Sun, with planets on the ends of the arms. The device is mechanized much like a clock. The Antikythera, an ancient Greek device, is considered to be one of the first orreries. The first modern orreries were created in the 18<sup>th</sup> century. Joseph Wright of Derby, who created the work *Dovedale* by

*Moonlight* in the Allen's collection, is well known for his painting, "A Philosopher Lecturing on the Orrery" ([not included in exhibition] see left: Collection, Derby Museum and Art Gallery.) These instruments essentially serve as models of the Solar System and the way the planets circle around the Sun.



**Anonymous** (British, 18<sup>th</sup> century)  
*The Complete Orrery Described, after [Samuel] Dunn, late 18<sup>th</sup> century*  
 Hand-colored engraving  
 Oberlin College Library Special Collections

An orrery is a model of the solar system with moving parts. By the turn of a handle, the device reenacts the planets' rotation around the sun and that of the moons around the planets. The orrery depicted in this print includes only the first six planets up to Saturn and must therefore date from before 1781, when Uranus was discovered.

## Telescope

A telescope is an essential component to the history of modern day astronomy. The telescope was invented at the beginning of the 17<sup>th</sup> century in the Netherlands. The earliest telescopes experimented with the use of mirrors and paralleled major advances in the creation of new and different kinds of lenses. The most common and oldest telescope is the optical telescope. The optical telescope works by gathering and focusing light from the visible light spectrum- the same range that is available to the human eye. These telescopes increase the size and brightness of objects in the sky, through employing a number of curved optical elements to filter light down to a single point. Optical telescopes can either refract or reflect light, depending on the type of lens used. In the refracting telescope, parallel rays of light pass through a convex lens that refracts the light before converging through the magnifying lens that makes up the eye piece. Reflecting telescopes rely on mirrors and lenses to focus the rays of light on the center of a concave mirror. The telescope allowed scientists to study extraterrestrial objects in a completely new way and lead to things like Galileo's treatise on the moon and its craters.



**Albrecht Dürer** (German, 1471 – 1528)  
*The Virgin on a Crescent with a Crown of Stars*,  
1508

Engraving

Gift of the Max Kade Foundation, 1968.62

Christian iconography traditionally depicted the Virgin Mary astride a pristine, translucent moon to emphasize her immaculate nature, as in this sixteenth-century print by Albrecht Dürer. However, in 1610 Galileo published lunar engravings based on telescopic observations, which revealed for the first time a cratered moon surface. Intellectuals and artists associated with the Church resisted Galileo's findings, believing them an affront to both the idea of the heavens' perfection and Mary's purity.

## The Moon

The Earth's moon has long been an object of fascination for humans. It orbits the Earth at a distance thirty times the diameter of the Earth, and makes a complete orbit every 27.3 days. In addition to circling the earth, the moon is in synchronous rotation- meaning it is rotating on its own axis. As a result, only one side of the moon consistently faces the Earth. This is where the idea of a 'dark side' of the moon comes from. However, the 'dark side' is in fact the far side, and is illuminated exactly as often as the near side, which faces the earth. While a number of other moons exist in our Solar System, the Earth's moon is its only one. The word "moon" is originally Germanic, and takes its basis from Latin for month.

A number of theories exist for the origin of the moon. The first suggests that the Moon broke off from the Earth's crust early on in its development, leaving behind a crater that is thought to be the Pacific Ocean. Other theories suggest that the Moon was an independent body that was captured by the Earth's gravitational pull. The prevalent theory suggests that the Moon was formed from a giant collision during the Earth's formation. A planetary body, roughly the size of Mars, is thought to have collided with Earth, dislodging enough material to form the Moon. This giant impact theory is generally held as the way in which many major planetary bodies have been formed.

The Moon's surface now is covered with these impact craters. These craters are what give the Moon its rough appearance from Earth and create what we call the man in the moon. There are about a half a million craters on the surface and the most major impact events are used to date the geological cycles of the Moon. The Moon is also covered in lunar seas, or *maria*. These were once thought to be filled with water, much like the seas and oceans on Earth. However, with the advent of more powerful telescopes, the seas are now known to be solidified pools of ancient basaltic lava. This lava flowed into the impact craters, filling them and creating the smooth basins we see today. The near side of the moon contains the majority of these maria, with fewer than 2% on the far side. The Moon is also home to major mountain ranges, created from the outer rims of the impact craters. It has virtually no atmosphere.

The phases of the moon are known as the synodic period and repeat roughly every 29 days. When the Moon appears to be increasing, it is called waxing. The waxing of the Moon culminates in a Full Moon, which is when the Moon appears completely illuminated and round. When it is moving from full to new moon, it is said to be waning. The New Moon is the point at which the Moon is barely visible from the Earth.

The tides of the Earth's bodies of water are determined by the gravitational pull of the Moon. As the Moon rotates around the Earth, the oceans' waters are pulled in an elliptical pattern towards it, relative to the Earth. The effect is something like water splashing around in a basin. As water is pulled in one direction, it appears to be receding from the far side- creating low tide. When water is being pulled on the near side of the Earth to the Moon, the oceans pull towards the shore in what is known as high tide.

The Moon is the only other body in the Solar System that humans have visited. The U.S. and Soviet space programs were created during the Cold War and represented a key part of international politics. The U.S. Apollo space mission culminated in the first successful moon landing on July 20, 1969 by Apollo 11.



**Joseph Cornell** (American, 1903 – 1972)  
*Phases de la Lune (Phases of the Moon)*,  
1957 - 1959

Mixed media

Gift of Ruth C. Roush, with Special  
Acquisitions Fund and R. T. Miller, Jr.  
Fund, 1977.73

Influenced early in his career by  
Symbolism and Surrealism, Joseph  
Cornell is best known for constructing box

assemblages using collaged materials and eclectic found objects. Inspired by contemporary astronomical discoveries, which he followed in popular magazines such as *Scientific American*, Cornell frequently addressed themes of constellations and star charts, famous astronomers, and celestial navigation. In *Phases de la Lune* Cornell combined eighteenth-century diagrams of the phases of the moon with everyday objects such as an “Il Sole” antipasto can lid, which forms the smiling metal disk of the sun, to create an enigmatic, compressed universe.

**Joseph Wright of Derby** (British, 1734 – 1797)

*Dovedale by Moonlight*, ca. 1784 – 1785

Oil on canvas

R. T. Miller Jr., Fund, 1951.30

A product of the Enlightenment, Joseph Wright of Derby was captivated by its promises of scientific and industrial progress. He famously explored dramatic light effects – often for symbolical purposes – in scenes of erupting volcanoes, candlelit scientific experiments such as *A Philosopher Lecturing on the Orrery* (1766), and luminous, nocturnal landscapes such as *Dovedale by Moonlight*. The delicately detailed full moon and rock formations in the present painting reveal the artist’s interest in realistically rendering geological and astronomical phenomena. Nevertheless, Wright rarely sketched outdoors and would have executed this idealized scene in his studio, as was typical for the period.



**Johann Baptista Homann**  
(German, 1664 – 1724)

after maps by astronomers:

**Johannes Hevelius**

(Polish, 1611 – 1687) and

**Giambattista Riccioli**

(Italian, 1598 – 1671)

*Tabula selenographica*, ca.  
1730

Hand-colored engraving

Oberlin College Library

Special Collections

This engraving presents side-by-side the work of two seventeenth-century contemporaries who contributed greatly to

selenography, the study of the moon’s surface. Johannes Hevelius, on the left, was the first to produce an entire atlas of the moon’s topography as it appears at every lunar phase. Giambattista Riccioli, on the right, refined a nomenclature for lunar geography based on “lands” (terra) and “seas” (mare) named after perceived psychological effects of the moon such as serenity or madness. Riccioli’s system also named lunar craters after astronomers who had made significant discoveries regarding the moon.



**Tsukioka Yoshitoshi** (Japanese, 1839 – 1892)

*Little Prince Usu*, from the series *One Hundred Aspects of the Moon*, ca. 1885 – 1892

Color woodblock print

Gift of Sarah G. Epstein (OC 1948), 1997.41.72

Although the sun has long been a political symbol in Japan, with Imperial rulers claiming descent from the Shinto sun goddess Amaterasu, moon imagery has been more prevalent in Japanese poetry and art. Tsukioka Yoshitoshi’s *One Hundred Aspects of the Moon* series connects historical, literary, folkloric, and contemporary theatrical themes through the overarching motif of the moon. Each scene is

charged with great psychological intensity, the cycling moon phases appropriately mirroring shifting themes of adventure, deception, passion, and madness. Here, the diminished light of a waning gibbous moon helps to conceal the early Japanese hero Prince Usu.

## **The Sun**

The Sun is a star located at the middle of our Solar System and was formed nearly 5 billion years ago when a nearby hydrogen cloud collapsed. The Sun's existence is what makes life on Earth possible, providing us with plant life via photosynthesis [the process through which plants convert solar energy into food] and controlling our weather systems. In fact, Sunlight is Earth's primary source of energy. Stars undergo an evolution from creation to death. Our Sun is about halfway through its life, and will likely become a red giant at the end of its existence.

Our Sun is a specific type of star, called a yellow main sequence star. Rather than forming into a solid object, like the terrestrial planets closest to it, the Sun is plasmatic and rotates faster at its equator than its poles. The Sun consists of a few key layers that govern the way it behaves. These layers are created by the temperature and pressure increases as you move towards the center. Helium and hydrogen, the two primary gases found in the Sun, begin to act differently under these changing conditions creating the characteristics of each layer. The innermost layer of the Sun is its core. The core of the Sun is super dense but remains a gas because of its extremely hot temperature. Here, fusion reactions take place in the form of gamma rays and neutrinos. This nuclear fusion changes hydrogen into helium, creating a higher concentration of helium in the core. The solar envelope is outside of the core and is surrounded by a convective envelope. This envelope helps to put pressure on the core and maintain its temperature. The photosphere is the layer of the Sun that emits visible light. It is the color of the gases at this layer and they way they interact with heat and pressure that create the visible color of the Sun. Sunspots are dark spots on the photosphere, some of which are as big as the Earth itself! The Sun's magnetic field is responsible for creating the cooling temperatures which make the spots appear darker as well as creating the cycles of Sunspots which affect Earth's outer atmosphere. The outermost layer of the Sun is known as the corona. The corona is visible only during eclipses and is a low density plasma cloud. The bright light emanates from the Sun makes it impossible to look directly at the Sun for long periods of time and can cause temporary blindness. Even when the Sun is eclipsed, it is best observed through UV tinted glasses.

Along with the Moon, the Sun has been a major part of human civilization since its beginning. Many of the most famous early archaeological sites are dedicated to the Sun and are meant to track its motion and honor it. Worship of the Sun was central to American Pre-Colombian civilization and Egyptian societies as well as inspiring various gods and goddesses in other cultures. Our modern word 'Sunday' is in reference to the Sun itself. See mythology for more about Sun gods and goddesses.



**Utagawa Kuniyoshi** (Japanese, ca. 1797-1861)

*The Descent of the Star Ichi on the Thirteenth Night of the Ninth Month,* from the series *Koso goichidai ryakuzu* (*A Short Pictorial Biography of the Founder of the Nichiren Sect*), mid-1830s

Color woodblock print

Mary A. Ainsworth Bequest, 1950.536

Kuniyoshi's series narrates the life of Nichiren, a thirteenth-century Buddhist monk. A controversial figure who advocated greater austerity within Buddhism, Nichiren blamed contemporary catastrophes such as typhoons and earthquakes on the popularity of other Buddhist sects. Kuniyoshi's interpretation of events emphasizes how astronomical bodies and meteorological phenomena supernaturally interceded on Nichiren's behalf, as when the sun's powerful rays saved the monk from death by miraculously destroying his would-be executioners' weapons. In this image, the Buddha appears to Nichiren in the form of the Star of Wisdom.



**Federico Zuccaro** (Italian, ca. 1541 – 1609)

*The Lord Creating the Sun and Moon,* ca.1566 – 1569

Pen and brown ink over black chalk with brown and gray wash and white heightening

Gift of Robert Lehman, 1947.2

In the Book of Genesis, God creates light and dark, in the form of day and night, separately from the sun and moon. The latter are envisioned as suspended in a firmament above the earth, a finite space ending in the highest levels of the stars. Significantly, the biblical scriptures do not touch upon the perfection of the heavens, a concept Christianity adopted from Aristotle's theories. Zuccaro's drawing, which quotes Michelangelo's Sistine Chapel ceiling, was a study for a fresco in the chapel of the Palazzo Farnese, Caprarola.

## Comets

A comet is a relatively small extraterrestrial body, made up of a mass of particles, gases, and ice. An asteroid, in comparison, is an extraterrestrial body composed of rock and metal. Comets are captured by the gravity of Sun and orbit it in a highly elliptical pattern. Comets are some of the largest non-planetary objects in our Solar System, and they can measure up to ten miles across with tails that can extend millions of miles into space. As the comet moves closer to the Sun, the heat causes the outer ice to turn into gas and the particles released become the tail that follows the comet.

Comets, because of the way they circle the Sun, can take anywhere from a few years to a few hundred years to complete their orbits. From the Earth, it is difficult to spot a comet before it enters into Jupiter's orbit, since they can travel so far away. Many of the long period comets, or comets that take a long time to travel around the Sun, originate in the Oort Cloud at the end of our Solar System. A comet can come to many different fates. If it is traveling fast enough, it can leave the Solar System. It can also be thrown off of orbit by interacting with another celestial object. Some comets eventually fade out as many of the volatile material contained in the main body of the comet evaporate. One of the most remarkable ends is when a comet either falls into the Sun or smashes into another planet or object. These collisions are extremely important in our Solar System, creating everything from the geography of the Moon via impact craters, to many of the oceans of Earth today.

Comets were believed to be bad omens before we understood more about them. It was Aristotle, a famous Greek philosopher and scientist, who came up with the idea that comets were phenomenon of the upper atmosphere of Earth, created when dried and hot debris caught on fire. This explanation was popularly accepted for thousands of years, until the telescope allowed closer observation of comets. Two of the most famous comets are Halley's and the Hale-Bopp Comet. Halley's Comet was discovered by Isaac Newton and Edmund Halley in 1680, and Halley predicted it would return every 76 years- and so far, he's been correct, with Halley returning in 1758 and making two return trips since then. The Hale-Bopp Comet was discovered in 1995 in New Mexico and Arizona by two different men, where it gets its name. It was visible to the naked eye for nearly 18 months. Hale-Bopp Comet is now traveling far into space in an orbit almost perpendicular to the plane of the solar system, and it expected to return to the inner solar system around the year 4530.



**Anonymous** (British, 19<sup>th</sup> century)  
*Various views of Donati's Comet as seen from the Cambridge Observatory and Slater's Observatory, from The Illustrated London News, October 23, 1858, supplement, p. 387*  
Oberlin College Library Special Collections

In 1858, Donati's Comet captivated the European public throughout the time it was visible to the naked eye (August 19 – December 4). As evidenced by the *Illustrated London News's* extensive coverage of the event, comet-watching became a national

pastime across England, and numerous artists recorded its appearance in the sky. The small images at the bottom of the present page, based on telescopic observations, show the *coma*, or gas and dust cloud surrounding the nucleus of the comet.

Donati's Comet was also the first comet to be photographed, from the Royal Observatory in London in 1858(*see below*). Donati's Comet is a periodic comet, and will return to the inner solar system in 3811.



## Eclipses

An eclipse is when the Moon and the Earth form a line with the Sun. There are two kinds of eclipses: lunar and solar. A lunar eclipse happens when the Earth moves between the Sun and the Moon, blocking part of the Sun's light from reaching it. During a lunar eclipse, you can see the Earth's shadow on the Moon. A solar eclipse is when the moon moves between the Earth and the Sun. The Moon blocks the Sun, and causes the sky to slowly darken as the Moon moves in front of the Sun. When they are in a perfect line, it is called a total solar eclipse. During a solar eclipse, the moon casts two shadows towards Earth- one is called the umbra and the other the penumbra. The umbra shrinks as it reaches the Earth while the penumbra lengthens. The total solar eclipse can only be seen from the area on Earth's surface that enters the Moon's umbra, while those that enter the penumbra only see a partial solar eclipse. Most people will only see one total solar eclipse in their entire life. A total solar eclipse is also the only time the corona, or plasma cloud, around the Sun is visible.

There are many myths that exist about eclipses. In China, an eclipse was believed to be an invisible dragon eating the Sun. Many stories of ancient warfare involve eclipses stopping battles or appearing as omens to convince either side that they were destined to win. Indeed, some scholars believe that the famous monument of Stonehenge was built to predict eclipses. One king of France was so startled by a solar eclipse, it is said he died of fright.



### **Ansel Adams**

(American, 1902-1984)

*The Black Sun, Tungsten Hills, Owens Valley, California, from Portfolio V, 1939*

Gelatin silver print; printed 1970

Friends of Art Fund, 1971.29G

## Stars

The study of stars is fundamental to the overall understanding of the universe and the way it functions. Stars are different than planets because they emit rather than reflect light. Stars are essentially balls of hydrogen and helium with enough mass that they can sustain nuclear fusion at their core. The 'Big Bang' or what scientists now think was the beginning of the universe, left the universe with a composition of almost entirely hydrogen (75%) and helium (23%). These elements exist in large, stable clouds of molecular gas. Occasionally, a point of gravitational disturbance occurs, such as a supernova explosion or a galaxy collision. This disturbance causes the cloud of gas to collapse. As the gases collect together, they begin to heat up, while momentum from the particles' movement begins to cause the whole collapsed cloud to spin. The collection of the mass in the center creates a protostar, which becomes hotter and hotter until eventually it creates nuclear fusion in its core. While nuclear fusion is what defines a star as a star, there is a great range in the mass and behavior of stars. The Sun is considered a medium sized star, with the biggest star being almost 150 times the mass of our Sun. The smaller a star, the longer its life span as it takes less energy to perpetuate itself. Large stars, such as the supergiant stars, burn out very quickly. Stars go through a 'main sequence' phase, which is after they have formed as stars and before they begin to run out of fuel. In this stage, the star is actively converting hydrogen to helium through fusion in its core. When hydrogen runs out, the stars begin to break down. Larger stars can burn heavier elements until they run out while small stars will eject their outer layers and become white dwarves. When a particularly large star collapses, it can create a neutron star or black holes, both of which have incredibly large gravitational pulls.



**William T. Wiley** (American, b. 1937)

**DENE**, 1996

Color lithograph

Gift of Laretta M. Dennis, 1997.40.2

The playful inscription in this print describes Deneb, the brightest star in the constellation Cygnus. Deneb is a supergiant—a highly massive, short-lived star undergoing the end stages of stellar evolution. Expanded beyond its original size, it is actually blue-white, not red, due to its high temperature.

## Galaxies

A galaxy is a large collection of stars that appear as a distinct physical entity due to an internal gravitational system. A galaxy is a collection of stars and gas which move through the universe independently of the Milky Way (the galaxy in which the Earth's solar system exists). Galaxies, like stars, can vary hugely in size, from those numbering almost a trillion stars to those with less than a few hundred stars.

Galaxies are usually classified according to the way their visual features. Spiral galaxies, for instance, are disk-shaped with curving arms. Galaxies with odd shapes are usually the result of gravitational disruptions, often from other nearby galaxies. Dark matter, although not fully understood yet, is thought to make up almost 90% of the mass of any given galaxy, while the remainder is from stars, planets, asteroids, and comets. Galaxies usually form around a super massive black hole or collapsed supernova, since these are some of the few cosmic events with enough gravitational aftermath to maintain the pull necessary to capture, shape, and maintain a system of stars.

The Milky Way is considered to be a barred spiral galaxy, meaning it is a spiral galaxy, with a central bar-shaped structure composed of stars. Scientists have estimated that our galaxy is somewhere between 6.5 and 10.1 billion years old. On clear nights in those areas of the world not affected by light pollution, the band of the Milky Way is clearly visible in the night sky.



**James Rosenquist**

(American, b. 1933)

*Astronomical Blackboard*, 1978

Color etching and aquatint

Bequest of John E. Gabriel,

2007.32.4

## Astronomy & World Religions

For thousands of years, people have looked at the objects in the sky and associated them with gods, goddesses, and mythological stories. The Sun, Moon, and certain constellations in particular have had a long history in human civilization.

The Sun has been worshiped since early Assyrian and Babylonian cultures. Some of the most important gods in world religion have come from the Sun. Of these, the Egyptian Ra, Greek Apollo, and Japanese Amaterasu are the best examples of the diaspora of Solar myths. Amaterasu is the Sun goddesses in the Japanese religion Shinto. The emperor of Japan traditionally claims to be her descendant, and it is because of her that Japan is known as “Nippon or Nihon” translated to Land of the Rising Sun. The Egyptian god Ra was thought to be the creator of the world, and was the father of all of the stars, Earth, and the god Osiris. Apollo, in contrast to Amaterasu and Ra, was not directly responsible for the creation of the Sun or world. Rather, he was the patron of the Sun, logic, reason, and the arts. The Sun as a fabulous or artistic topic has long fascinated mythmakers, and we can see the continued artistic fascination in the Allen’s show.

Like the Sun, the Moon has been a constant source of fascination for humankind. As the Allen’s exhibition illustrates, the moon has inspired countless tales and artistic interpretations. In Mayan cosmology the Moon goddess was known as Ix Chel or the “Lady Rainbow.” Ix Chel was depicted as an evil old woman wearing a skirt with crossed bones and held a serpent in her hand. She was the protector of weavers and women in childbirth, and Mayans associated human events with the phases of the Moon, oftentimes avoiding war during lunar eclipses. The Japanese god Tsuki-Yomi was the brother of the Sun goddess and was born from the parts of various siblings. It is said that the Sun and Moon quarreled and the Sun sent her brother away, which is why they now live apart and alternate in the night sky. Even Christianity had a mythical association with the Moon believing it to be a perfect orb placed in the sky by God.

The myths about the rest of the night sky cross every culture and period. The Greeks in particular had many myths to explain the origins of the stars and constellations. One of the most famous is about the constellation Orion. It is said that Orion was one of the best and most skilled hunters. He had so much success with his hunting that he claimed he would kill all of the wild animals on Earth. The earth goddess Gaia grew angry with him and set an enormous scorpion to Orion. The scorpion was too great for Orion and he was killed. Both the scorpion and Orion were placed in the heavens by the gods and became constellations, where the scorpion appears to constantly chase Orion.



**Mayan, Campeche Coast,  
Southern Mexico**

(Late Classic Period, ca. 600 – 900 C.E.)  
*Tripod Polychrome Plate Decorated with Stepped Key Frieze, Bird and Jaguars, 600 – 750 C.E.*

Buff terracotta with multicolored slip  
Friends of Art Fund, 1973.3

Astronomy has always been central to Maya culture, which still uses the Haab, a Pre-Columbian solar calendar of eighteen months. The mythological bird depicted on this funerary plate was associated with the month Muan, a time of heavy rainfall, and with the planet Mercury. The Maya believed this part-macaw, part-owl creature was a messenger to the gods of the underworld, a

place where the sun descended each night in order to reemerge, reborn, at dawn. In Mayan astronomy, the Muan bird has its own constellation, which contains the stars otherwise known as Castor and Pollux in the constellation Gemini of the Western zodiac.



**Aratus of Soli** (Greek, ca. 315 B.C.E. – 245 B.C.E.)

Edited by **Hugo Grotius** (Dutch, 1583 – 1645) with engravings by **Jacques de Gheyn II** (Dutch, 1565 – 1629)

*Hug. Grotii syntagma Arateorum:*

*Opus poeticae et astronomiae*

Leiden, 1600

Oberlin College Library Special Collections, Gift of Rev. E.B. Fairfield

Aratus's ancient Greek poem *Phaenomena* chronicled the

constellations, weather patterns, and how to tell time by studying the sky. In 1600, the Dutch Humanist Hugo Grotius published this edition of Aratus's text with commentaries by the early Roman writers Cicero and Germanicus Caesar and engravings based on a ninth-century illuminated manuscript of the *Phaenomena*. Though scientifically inaccurate, the illustrations became models for celestial cartography. Shown here is the constellation Sirius (Canis Major), companion to the hunter-shaped constellation Orion. The star at the center of the great hound's head, Sirius, is the brightest star in the sky. For the Greeks, its rising at dawn in late July harbingered a season of intense heat.

## **Website Links**

Oberlin College Observatory - <http://www.oberlin.edu/observatory/>

Astronomy Picture of the Day - <http://apod.nasa.gov/apod/>

International Year of Astronomy 2009 - <http://www.astronomy2009.org/>

Year of Science 2009 - <http://www.yearofscience2009.org/home/>

Cosmic Journey: A History of Scientific Cosmology –  
<http://www.aip.org/history/cosmology/>

Amazing Space – <http://amazing-space.stsci.edu/eds/>

Eyes on the Sky, Feet on the Ground: Hands On Astronomy Activities for Kids -  
[http://hea-www.harvard.edu/ECT/the\\_book/index.html](http://hea-www.harvard.edu/ECT/the_book/index.html)

CERES Project: Online Educator Resources - <http://btc.montana.edu/ceres/>

The ~~Nine~~ Eight Planets: A Multimedia Tour of the Solar System -  
<http://www.nineplanets.org/>

Challenger Center for Space Education - <http://www.challenger.org/>

## **Curriculum Ideas**

### **The Moon**

**Language Arts (Middle/High School):** Examine and discuss books, stories, myths, and legends (in any media) that use the Moon as their principle setting or plot device (see Italo Calvino's novel *Cosmicomics*). There are numerous stories about why the Moon formed, and colonies on the moon feature in numerous science-fiction novels (for instance, by Arthur C. Clark [*Earthlight, 2001: A Space Odyssey*]).

Write your own short story either set on the Moon, or explaining a real or imagined reason why the Moon might have begun to orbit the Earth.

### **The Sun**

**Science (Middle/High School):** A unit on solar energy could cover several scientific topics: the production of energy in the Sun via nuclear fusion; the capture and use of solar energy to power machines on earth; or the process of photosynthesis in plants, where they naturally convert solar energy into their own 'power.'

### **Comets**

**Social Studies (Middle/High School):** Throughout history, comets have always been recorded by humans and were often seen as omens of coming changes in society (either for good or ill). One of the most famous examples is Halley's Comet, which is counted dozens of times over hundreds of years in the historic record.

Research each era when Halley's Comet re-occurred, and note how different cultures noted its arrival. Study those cases where its arrival was seen as heralding large scale changes (such as its depiction on the Bayeux Tapestry, documenting its appearance in 1066, prior to the Battle of Hastings).

### **The Solar System**

**Social Studies/Language Arts (All Ages):** Study the original Greek and Roman myths behind the names of each planet. Why were the planets given these names in Classical times, and how did the movement of each planet relate to the tales? When the 'modern' planets were discovered, why did astronomers continue with this naming system? Did these names still a pattern or theme?

### **Stars**

**Visual Art (Elementary):** Hold a "You're a Star!" red carpet event! Chose a famous (celestial) star to research and write about. Then, make a costume that evokes this star, and have the class 'walk the red carpet' as only true stars can!

## **Tools of Astronomy**

**Science (High School):** Hold a series of experiments using lens and mirrors to manipulate the direction in which light is focused. How do different lens curvatures help or hinder magnification? Study the history of telescopes, especially the early developments of *refracting* telescopes (such as that used by Galileo) and the *reflecting* telescope (developed by Isaac Newton).

What were the critical developments for each, and what discoveries did they lead to? What are some of the more famous types of telescope today (ie. the Hubble Space Telescope), and what wavelengths do they collect (Hubble collects visible and ultraviolet spectrums)?

What advances lay in the future of telescopic science?

## **Ohio Academic Content Standards**

*The following is a list of benchmarks and indicators that the study of this exhibition and its materials meets.*

### Earth and Space Science

#### **K-2**

“Observe constant and changing patterns of objects in the day and night sky.”

#### **3-5**

“Explain the characteristics, cycles, and patterns involving Earth and its place in the solar system.”

#### **6-8**

“Describe how the positions and motions of the objects in the universe cause predictable and cyclic events.”

“Explain that the universe is composed of matter, most of which is at incomprehensible distances and held together by gravitational forces. Describe how the universe is studied by the use of equipment such as telescopes, probes, satellites, and spacecraft.”

#### **9-10**

“Explain how evidence from stars and other celestial objects provide information about the processes that cause changes in the composition and scale of the physical universe.”

“Summarize the historical development of scientific theories and ideas, and describe emerging issues in the study of Earth and space sciences.”

### Physical Sciences

#### **K-2**

“Recognize that light, sound, and objects move in different ways.”

#### **3-5**

“Describe the forces that directly affect objects and their motion.”

#### **6-8**

“In simple cases, describe the motion of objects and conceptually describe the effects of forces on an object.”

#### **9-12**

“Trace/Summarize the historical development of scientific theories and ideas within the study of physical sciences.”

## Science and Technology

### **K-2**

“Explain that to construct something requires planning, communication, problem solving and tools.”

### **3-5**

“Describe how technology affects human life.”

### **6-8**

“Give examples of how technological advances, influenced by scientific knowledge, affect the quality of life.”

### **9-10**

“Explain that science and technology are interdependent; each drives the other.”

## **Other Benchmarks**

### Mathematics

Measurement; Geometry and Spatial Sense; Patterns, Functions, and Algebra; Data Analysis and Probability; Mathematical Processes

### Visual Art

Historical, Cultural, and Social Contexts; Creative Expression and Communication; Analyzing and Responding; Valuing the Arts/Aesthetic Reflection; Connections, Relationships and Applications

### Social Studies

History; People in Societies; Geography

### Language Arts

Acquisition of Vocabulary; Informational, Technical, and Persuasive Text; Writing Applications; Research Standard; Communications: Oral and Visual Standard