**Nicolaus Copernicus**

Nicolaus Copernicus was a Polish astronomer who is best known for the astronomical theory that the Sun was near the center of the universe and that the [Earth](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/planets/earth/introduction_to_earth.html) and other planets rotated around the center. He also stated that the Earth spinning on its axis, rotates once daily and makes a full revolution around the [Sun](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/sun/introduction_to_sun.html) in a year. Copernicus did not believe that the Earth and other planets were influenced by or revolved due to the Sun; instead he believed that the Sun was located near the center of the universe. It was this center of the universe which influenced those bodies and caused them to revolve. This theory is called the heliocentric or sun-center theory of the universe.

**Background**

Copernicus grew up in Poland and was given a solid education due to the influence of his uncle who was a bishop. He moved to Italy to further his studies in 1495 at the age of 22 to further his studies. It was there at the University of Bologna that Copernicus became very interested in astronomy. He befriended one off his professors named Domenico Maria de Novara who was very skeptical of the [Ptolemaic view of the universe](http://www.kidsnewsroom.org/elmer/infocentral/space/html/exploration/people/ptolemy.html#theory). Copernicus began to share his skepticism and he began to look for a solution that would resolve the problems with the wide spread theory about the universe. Sometime between 1507 and 1515 he completed a short paper entitled "Commentariolus". Even though it was not published until the 19th century, it was important because it served as the basis for his radically new theory of the universe. Shortly thereafter, in 1517, Copernicus began work on his major work, "On the Revolutions of the Celestial Spheres," which he did not complete until 1530. However, it was not published until 1543, just before Copernicus died.

**The Copernican Heliocentric Theory**

You must have a little background on the accepted [Ptolemaic view of the solar system](http://www.kidsnewsroom.org/elmer/infocentral/space/html/exploration/people/ptolemy.html#theory) in order to understand the difference between it and that which Copernicus theorized. Scientists believed that the Earth was fixed at the center of the universe and surrounded by several concentric rotating spheres which were the planets, sun and moon. On the outermost sphere, picture the inside of a balloon, where the stars which were fixed. This outermost sphere was said to wobble slightly to account for the procession of the equinoxes. There was one question that this system brought up that puzzled scientists: Why did [Mars](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/planets/mars/introduction_to_mars.html), [Jupiter](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/planets/jupiter/introduction_to_jupiter.html), and [Saturn](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/planets/saturn/introduction_to_saturn.html) every so often appear to move across the sky in one direction and then seem to stop and go in the opposite direction, what they called retrograding across the sky? To explain this phenomena Ptolemy proposed that the planets, sun, and moon moved in small circles while traveling in their much larger orbits around the fixed Earth. These small circles were called epicycles, but many scientists did not see this as the answer. The heliocentric theory would explain why the planets seemed to retrograde across the sky.

The Copernican theory explained many of the observations of astronomers. Some of its revolutionary ideas were that the Earth rotates on its axis daily and revolves around the Sun once a year. The heliocentric theory retained many of the characteristics of its predecessors, one key concept it embraced was planetary spheres, the outermost sphere containing the stars. Copernicus knew that his explanation was not completely correct. Among other things, he realized that the rotation of Earth in its orbit would cause a continuous repositioning of the stars in the sky. He resolved this by posing that the distance between the Earth and the outer sphere which contained the stars was so great that any variation in the position of the stars would be almost undetectable. However, in the heliocentric theory the outermost sphere containing the stars was stationary. The heliocentric system did resolve many of the problems with its predecessors; the apparent yearly motions of the stars and Sun, the apparent retrograde motions of Mars, Jupiter and Saturn, and the fact that [Mercury](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/planets/mercury/introduction_to_mercury.html) and [Venus](http://www.kidsnewsroom.org/elmer/infocentral/space/html/universe/solar_system/planets/venus/introduction_to_venus.html) never travel more than a certain distance from the Sun. Copernicus reordered the planets according to the time it took for them to revolve around the center of the universe (near the Sun). Unlike Ptolemy's theory of the universe, the larger the radius of the planet's orbit, the longer it takes to make one revolution.

**Influence**

When the Copernican theory was first published it was not accepted by the scientific community. Even though it was physically sound, the calculations of astronomical positions were not made much simpler, neither were these calculations much more accurate. [Tycho Brahe](http://www.kidsnewsroom.org/elmer/infocentral/space/html/exploration/people/brahe.html) developed a middle position between the two theories which was more widely accepted. Some of the most famous heliocentric theory supporters were [Galileo Galilei](http://www.kidsnewsroom.org/elmer/infocentral/space/html/exploration/people/galileo.html), [Johannes Kepler](http://www.kidsnewsroom.org/elmer/infocentral/space/html/exploration/people/kepler.html), and of course [Sir Isaac Newton](http://www.kidsnewsroom.org/elmer/infocentral/space/html/exploration/people/newton.html) who helped explain the force, gravity, that all bodies exert on each other.

**Galileo's Biography by Megan Wilde**

**Galileo's Early Life**

Galileo was born in Pisa, [Italy](http://galileo.rice.edu/gal/italy.html) on February 15, 1564. His father, [Vincenzo Galilei](http://galileo.rice.edu/fam/vincenzo.html), was a musician. Galileo's mother was Giulia degli Ammannati. Galileo was the first of six (though some people believe seven) children. His family belonged to the nobility but was not rich. In the early 1570's, he and his family moved to [Florence](http://galileo.rice.edu/gal/florence.html).

**The Pendulum**

In 1581, Galileo began studying at the University of Pisa, where his father hoped he would study medicine. While at the University of Pisa, Galileo began his study of the [pendulum](http://galileo.rice.edu/sci/instruments/pendulum.html) while, according to legend, he watched a suspended lamp swing back and forth in the cathedral of Pisa. However, it was not until 1602 that Galileo made his most notable discovery about the pendulum - the period (the time in which a pendulum swings back and forth) does not depend on the arc of the swing (the isochronism). Eventually, this discovery would lead to Galileo's further study of time intervals and the development of his idea for a pendulum clock.

**On Motion**

At the University of Pisa, Galileo learned the physics of the Ancient Greek scientist, Aristotle. However, Galileo questioned the Aristotelian approach to physics. Aristotelians believed that heavier objects fall faster through a medium than lighter ones. Galileo eventually disproved this idea by asserting that all objects, regardless of their density, fall at the same rate in a vacuum. To determine this, Galileo performed various experiments in which he dropped objects from a certain height. In one of his early experiments, he rolled balls down gently sloping inclined plane and then determined their positions after equal time intervals. He wrote down his discoveries about motion in his book, [De Motu](http://galileo.rice.edu/sci/theories/on_motion.html), which means "On Motion."

**Mechanical Devices**

In 1592, Galileo was appointed professor of mathematics at the University of Padua. While teaching there, he frequently visited a place called the Arsenal, where Venetian ships were docked and loaded. Galileo had always been interested in mechanical devices. Naturally, during his visits to the Arsenal, he became fascinated by nautical technologies, such as the [sector](http://galileo.rice.edu/sci/instruments/sector.html) and shipbuilding. In 1593, he was presented with the problem involving the placement of oars in galleys. He treated the oar as a lever and correctly made the water the fulcrum. A year later, he patented a model for a [pump](http://galileo.rice.edu/sci/instruments/pump.html). His pump was a device that raised water by using only one horse.

**Telescope**

Galileo invented many mechanical devices other than the pump, such as the [hydrostatic balance](http://galileo.rice.edu/sci/instruments/balance.html). But perhaps his most famous invention was the [telescope](http://galileo.rice.edu/sci/instruments/telescope.html). Galileo made his first telescope in 1609, modeled after telescopes produced in other parts of Europe that could magnify objects three times. He created a telescope later that same year that could magnify objects twenty times. With this telescope, he was able to look at the [moon](http://galileo.rice.edu/sci/observations/moon.html), discover the four [satellites of Jupiter](http://galileo.rice.edu/sci/observations/jupiter_satellites.html), observe a supernova, verify the phases of Venus, and discover [sunspots](http://galileo.rice.edu/sci/observations/sunspots.html). His discoveries proved the [Copernican system](http://galileo.rice.edu/sci/theories/copernican_system.html) which states that the earth and other planets revolve around the sun. Prior to the Copernican system, it was held that the universe was [geocentric](http://galileo.rice.edu/sci/theories/ptolemaic_system.html), meaning the sun revolved around the earth.

**Galileo’s Trial**

Galileo's belief in the [Copernican System](http://galileo.rice.edu/sci/theories/copernican_system.html) eventually got him into trouble with the Catholic Church. The [Inquisition](http://galileo.rice.edu/chr/inquisition.html) was a permanent institution in the Catholic Church charged with the eradication of heresies. A committee of consultants declared to the Inquisition that the Copernican proposition that the Sun is the center of the universe was a heresy. Because Galileo supported the Copernican system, he was warned by [Cardinal Bellarmine](http://galileo.rice.edu/chr/bellarmine.html), under order of Pope Paul V, that he should not discuss or defend Copernican theories. In 1624, Galileo was assured by [Pope Urban VIII](http://galileo.rice.edu/chr/urban_viii.html) that he could write about Copernican theory as long as he treated it as a mathematical proposition. However, with the printing of Galileo's book, *Dialogue Concerning the Two Chief World Systems*, Galileo was called to Rome in 1633 to face the Inquisition again. Galileo was found guilty of heresy for his Dialogue, and was sent to his home near Florence where he was to be under house arrest for the remainder of his life. In 1638, the Inquisition allowed Galileo to move to his home in Florence, so that he could be closer to his doctors. By that time he was totally blind. In 1642, Galileo died at his home outside Florence.

**Objective 3 Homework Questions:**

1. What was Copernicus’s main contribution to science?
2. How was Copernicus’s view of the universe different from the old view?
3. How did Galileo’s telescope influence his research?
4. Why was Galileo put on trial?
5. What happened to Galileo as a result of his trial?