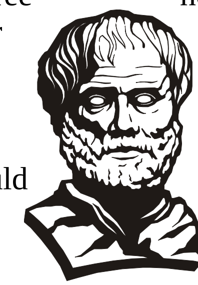
TIME AND SPACE

Aristotle's Conclusion

Aristotle lived in Greece more than three hundred years before the Common Era (or Before Christ). In Aristotle's time, most people believed that many gods ruled the universe. A happy god might allow an abundant harvest, while an angry god would show his fury with storms or earthquakes. Aristotle decided he could understand the world by observing it and using logic and reason. This is why Aristotle is remembered as the Father of Natural Science.


Aristotle

Most people in Aristotle's time believed the earth was flat, but Aristotle concluded that the earth was round. He realized that a lunar eclipse occurred when the earth came between the sun and the moon. He observed that the shape of the earth's shadow was round. If the earth was flat its shadow would have a much different shape. Next, Aristotle considered the position of the North Star. The further north you journeyed, the closer the North Star seemed to move to the middle of the sky. If you traveled south of what we now call the equator, you could not see the star at all. Finally, Aristotle watched ships sailing into port. He noticed that at a distance, he could see the tops of their sails before he saw the rest of the ship. Aristotle deduced that this was because of the curvature of the earth. We know today that Aristotle's conclusions were correct because humans have travel around the earth and we have seen pictures of the earth from space.

Nicholas Copernicus and the Heliocentric Universe

Imagine you discovered something that nobody would believe. Even worse, your discovery might get you into serious trouble. That's what happened in 1514. Nicholas Copernicus was a deeply religious man. He worked for the church as a physician for the poor people of Poland by day, but at night he studied the heavens. Copernicus measured the relative angles of the sun, moon, and planets and concluded that the universe is heliocentric, or that it revolves around the sun. Helios is a word used by the ancient Greeks for the sun. In Copernicus' time almost everyone believed that the earth was the center of the universe and that the sun and other heavenly bodies moved in circles around the earth.


Nicholas Copernicus

Copernicus feared that his ideas did not agree with how some people interpreted the Bible, so he circulated his opinions anonymously. Martin Luther, a leading religious figure of the day, said of Copernicus, "Scripture tells us that Joshua commanded the sun to stand still, and not the earth." A legend about Copernicus tells of a book he wrote about the heliocentric universe. The book was placed in his hands a few days after he lost consciousness from a stroke. Copernicus awoke to see that his work had been published, and then died peacefully. We don't know if that story is true, but it shows how fearful people at that time were of challenging long held beliefs, even if the beliefs are proven wrong.

Galileo's Observations

As a nineteen-year-old in the Italian city of Pisa, Galileo Galilei observed a priest swinging an altar lamp. No matter how wide the swing of the lamp, it seemed the time it took to move from one end to the other was the same. Galileo had discovered what scientists today call isochronism, and his observations led to the development of the pendulum clock.

Like Aristotle and Copernicus, Galileo learned from observing and measuring what he saw. Galileo heard stories of a device that used curved pieces of glass to magnify distant objects. He was unable to find the device we now call a telescope, so he made one for himself. When Galileo observed the heavens, he noticed that several moons orbited Jupiter. This disproved the theory that every heavenly body had to revolve around the earth. In 1616 the church commanded that Galileo never again “defend or hold” the idea of a heliocentric universe. Sixteen years later, Galileo was sentenced to house arrest for life because of what he taught.

Isaac Newton and Gravity


Isaac Newton

Scientists understood that the world was round, but in 1687, and English scientist named Isaac Newton explained why people do not fall off the earth. Newton realized that everything in the universe was attracted to everything else, and that the greater and closer the object, the greater its pull. We call this force gravity, which comes from a Latin word meaning heaviness. Everything and everybody has gravity—even you—but the earth has a mass of 5,972,000,000,000 pounds. The earth is very large, so people and objects are attracted to its gravitational pull. The earth orbits the sun because of the sun’s gravitational pull on the earth.

Longitude and Latitude

The ancient Babylonians originally divided any circle or sphere into 360 degrees. Ptolemy was a Greek thinker who borrowed their ideas as he wrote his book on geography. The furthest point at the right or left side of a circle is 90 degrees from the top of the circle. There are 180 degrees between any two sides of a circle or sphere. The north and south poles are 180 degrees apart from one another, and both are 90 degrees from the equator. The equator is the imaginary line that is as far from the North Pole as it is from the South Pole.

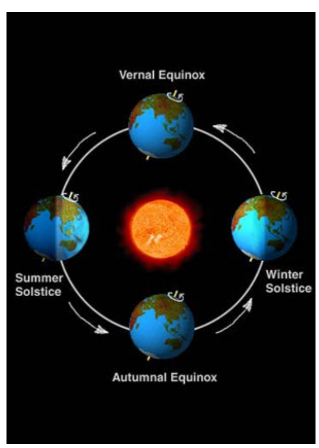
The horizontal lines that circle the globe are called Lines of Latitude. Lines of Latitude are also known as parallels because they parallel, or run in the same direction as the Equator. The lines that run between the North and the South Poles are called Lines of Longitude, or meridians. The line at zero degrees longitude is called the prime meridian. The prime meridian runs through the Royal Observatory in Greenwich, England. Meridians are counted east and west from the prime meridian, which is numbered zero degrees longitude. The International Date Line is located 180 degrees, or as far away as possible, from the prime meridian. When it is noon along the prime meridian, it is midnight along the International Date Line.

Geographers also divide the earth into hemispheres. *Hemi-* is a prefix that means half. Everything north of the equator is in the Northern Hemisphere, while everything south of the equator is in the Southern Hemisphere. The Western Hemisphere is west of the prime meridian, while the Eastern Hemisphere is east of the prime meridian. The hemispheres both end at the International Date Line. The United States is in the Northern and Western Hemispheres. West Palm Beach, Florida is 80 degrees west of the prime meridian and 27 degrees north of the equator. This is commonly expressed as 27^{o}N,80^{o}W.

Seasons

The earth’s axis is an imaginary line that runs through the middle of the earth from the North Pole to the South Pole. The axis of the earth is tilted about 23½ degrees. This tilt of the earth results in our seasons.

In June, the Northern Hemisphere is tilted toward the sun, so the people in the Northern Hemisphere have longer and warmer days. The days are shorter and colder in the Southern Hemisphere in June, because the earth is tilted away from the sun. The days start getting shorter in the Northern Hemisphere and longer in the Southern Hemisphere after June 21. Daytime lasts exactly as long as nighttime on the first day of autumn (September 21) and the first day of spring (March 21). The first day of winter in the Northern Hemisphere, on December 21 is the shortest day of the year in the Northern Hemisphere and the longest day of the year in the Southern Hemisphere.



The days are longer in summer and shorter in winter the further you move from the equator. It’s generally dark on a summer night in Florida by 8:30 p.m., but in Vermont, there will still be some light at 10:00 p.m. The situation is reversed in the winter, where the sun will go down in Vermont by 3:45 p.m. while it remains light in Florida until 5:15 p.m..

Northern Alaska is called the "Land of the Midnight Sun" because it never gets dark during the summer months. That part of the earth is facing the sun all day and all night. Antarctica never sees daylight during those months. The situation is reversed in December and January when northern Alaska never sees the sun while it continues to light the sky at night in Antarctica.

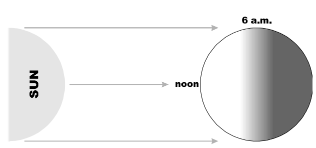
Time

Days and nights occur because the earth is spinning on an axis. Time changes as you move east or west, so the earth is divided into twenty-four time zones, one for each hour of the day. Some time zone boundaries zigzag so that people living in one region or country can have the same time.

The time along the prime meridian in Greenwich, England, is known as Greenwich Mean Time, or GMT. People communicating across two different parts of the globe often use Greenwich Mean Time. The east coast of the United States is five time zones behind GMT, so if it is midnight in Greenwich, it is 7:00 p.m. in Florida.

There are four time zones in the continental United States. They are Eastern, Central, Mountain, and Pacific. You might notice that live television programs often begin at 8:00 Eastern, 7:00 Central, 6:00 Mountain and 5:00 Pacific. Alaska is an hour behind Pacific Time and Hawaii is two hours behind Pacific Time.

Almost every nation uses the same system of measuring time, but China does not have time zones. China extends across five times zones, but the time is the same everywhere in China. If you live in western or eastern China, the sun will not be directly overhead at noon.



Daylight Saving Time

Most western nations advance the clock ahead one-hour during the summer months. We call this period Daylight Saving Time. Benjamin Franklin originally suggested the idea. He wanted to take advantage of the additional daylight time in the summer when many people were sleeping. The United States did not adopt Daylight Saving Time until the 1900s, and today every state but Hawaii and Arizona observe Daylight Saving Time. Hawaii is closer to the equator than the other states, and since the amount of daylight does not vary as much, the state did not feel it was necessary to set back the clock. Summer temperatures in Arizona often reach 100^{o}, so lawmakers there decided it would be better to end the day early so Arizonians could enjoy an extra hour of cooler evening weather.

Daylight Saving Time lasts from the first Sunday in April to the last Sunday in October in the United States, but in 2007 the period will last longer. It will begin the second Sunday in March and end the first week in November.

Measuring Time

It is now possible to buy a watch or clock that synchronizes itself with the United States Naval Observatory. There, more than fifty clocks measure the frequency emitted by atoms of the metallic element cesium. The atomic clocks are accurate to within one second every 1,400,000 years. In fact, our ability to measure time is more accurate than the stability of the earth. A "leap second" is added to the clock most years because ocean tides are causing the earth to turn slightly slower.

Humankind first measured the time of day with sundials, but they were only usable on sunny days. In ancient Rome, lawyers would be scheduled to speak in the Forum ante medium, before the run reaches its highest point, or post medium, after the sun reaches its highest point. Today the abbreviations a.m. and p.m. reflect this practice.

The first mechanical clocks in Europe had no numbers. Most people couldn't read, and the technology to create a clock face was not initially in place. Clocks would count out the hour by ringing a large bell high in a tower. The term o'clock is a contraction for "of the clock."

Our months correspond with the phases of the moon. A full moon occurs every 27 days, but in time we have adjusted the calendar in order make twelve months equal to the solar year.

Years

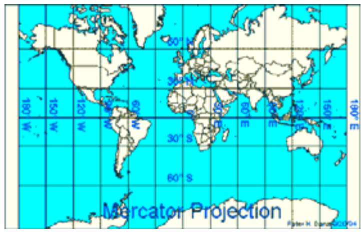
The earth travels around the sun every 365.242199 days, or what we call a "solar year." The ancient Romans devised the Julian calendar that lasted 365.25 days, but the solar year is eleven minutes and fourteen seconds shorter.

By 1582, the Julian calendar was ten days behind the solar calendar. Most western nations began using the Gregorian calendar, named for Pope Gregory XIII. The Gregorian Calendar synchronized the calendar year with the solar year by skipping the next ten days. The day after October 4, 1582 was October 15, 1582. England and its American colonies did not follow the teachings of the pope, so it did not adjust to the Gregorian calendar until 1752. By this time, the Gregorian calendar was twelve days ahead of the Julian calendar.

Most of our calendar years last 365 days, but every four years we add one day to February. February usually has only 28 days, but the month lasts a day longer in what we call "leap years." Years divisible by four are usually leap years. The last four leap years were 2000, 2000, 1996, and 1992. Our next leap year will be 2008. We have to make another adjustment to the calendar because leap years would make the calendar year last 365.25 days, and the solar year is .007801 shorter, so we have to make further changes. Centennial years are years that end in 00. Centennial years are not leap years unless they are divisible by 400. This means that 1700, 1800, and 1900 were not leap years, but 2000 was. The next time someone says that there are 365 days in a year; you'll have a lot of corrections to offer!

> Mercury has the shortest year and the longest day of the planets that revolve around the sun. Mercury spins on its axis every fifty-nine days, but the planet's trip around the sun is only eighty-eight days. On Mercury, a year lasts less than a day and a half.

Map Projections



When you try to flatten a tennis ball, what happens? The sides split, and the shape is changed. The same thing happens when you try to take a world map and flatten it onto a piece of paper. It can't be done without stretching some places. This stretching is called distortion. A globe can show size, shape, distance, and direction accurately, but since paper is not three dimensional, we will have to use map projections. A map projection is a way to show a drawing of the earth on a flat surface. All flat maps have distortion, so we use different map projections to meet different needs.

Gerardus Mercator created a map where parallels and meridians crossed at right angles. The Mercator Projection is excellent for navigation because it shows direction clearly. The Mercator Projection, however, has a great deal of distortion. In order to get the parallels and meridians to cross at right angles, Mercator stretched the areas further away from the poles and squeezed the areas closer to the equator.

An equal area map displays the shapes and sizes of things more accurately than a Mercator Projection. Compare Greenland and Africa on the two projections. Africa is actually fourteen times larger than Greenland, but on a Mercator Projection, they seem to be about the same size.

Many modern mapmakers use complicated mathematical formulas that combine the advantages of the Mercator Projection and an equal area map. The border of the western United States and Canada is the longest straight border in the world. On some map projections the line will be straight, while on others you will notice a slight curve.