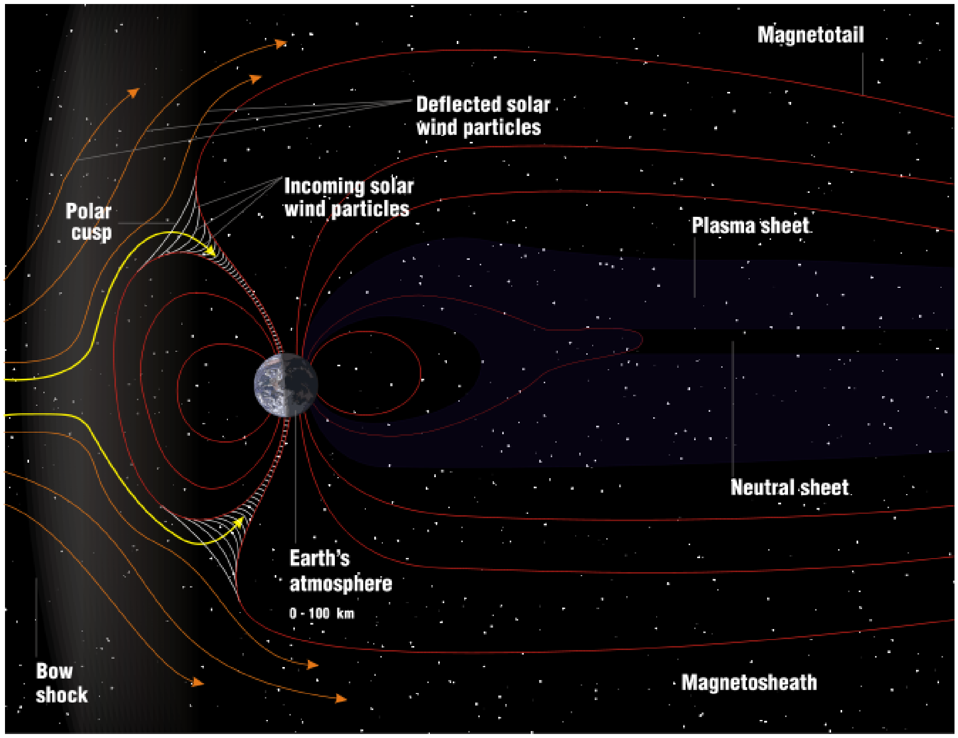
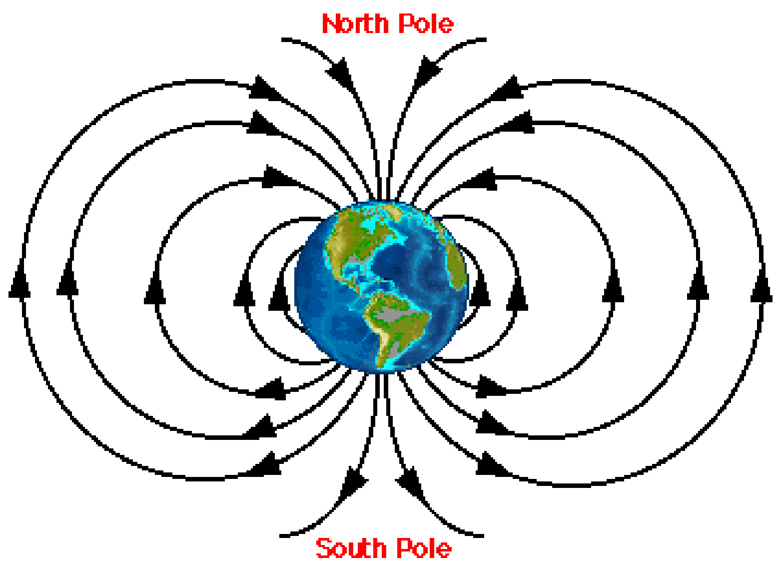
The aurora borealis, or northern lights more commonly known, is a light display formed in the northern polar regions of the globe. (See Picture Above) The aurora found in the southern region of the globe is known as the aurora australis. Auroras are typically located in the polar regions, typically around Antarctica and are best visible at night. The ideal months to witness the northern lights is from December to March, because the sky is the darkest and nights are longest during this time. However, they may be seen year round. The part of the atmosphere they typically reside in is known as the ionosphere. The ionosphere is composed of the upper part of the stratosphere including parts of the mesosphere, thermosphere, and exosphere. The Aurora Borealis received its name from the Roman goddess Aurora and the Greek name for the northern wind Boreas.

The Aurora Borealis can last between 10-15 minutes and emits lights in a variety of colors including: green, yellow, orange, blue, and most rarely red. They can range up to 60-70 miles above Earth and move in long bands rotating and twisting as ribbons. The intensity of auroras varies from night to night as well as from month to month. They tend to be more active at the time extremes of the day such as late at night or early in the morning. Due to the unpredictable nature of the intensity of auroras, research is underway to help better predict when to prepare for them. As of December 17, 2010, the Aurora Webmasters listed on its website the effects of intense auroral displays including: “many problems on the ground, such as intense electric currents along electric power lines (causing blackouts) and oil pipelines (enhancing corrosion), disturbing the ionosphere and disrupting short wave communication, as well as auroral discharge electrons damaging electronics and solar panels of communications and meteorological satellites.” (Aurora Webmasters 2010) This common phenomenon is both stunning and mysterious. Researchers are still studying it today to gain a better understanding of its workings.

The Aurora Borealis, like other auroras, is a physics and astronomical driven phenomenon. The Earth’s upper atmosphere, known as the ionosphere, is susceptible to solar winds. A solar wind is composed of high energy charged particles such as protons and electrons that are discharged from the upper atmosphere of the sun. These emissions of highly charged particles escape the Earth’s gravitation due to their high kinetic energy and are then funneled down to Earth. They then move along the Earth’s magnetic field lines, which push them towards the poles of Earth, and collide with the atoms of the Earth’s atmosphere. As of July 24, 2009, the Physics Forum of Suite 101 listed on its website by the author Paul A. Heckert, the reason why auroras are most visible near the poles is because ”the electrons and other charged particles do not travel in a straight line along the magnetic field lines, they travel in a spiral path around magnetic field lines due to a magnetic force" by the Earth on the particles; therefore, due to their nature of entering the Earth's atmosphere near the north and south magnetic poles, the auroral displays are located predominantly in these regions. (Heckert 2009) They then move along the Earth's magnetic field lines, which push them towards the poles of Earth, and collide with the atoms of the Earth's atmosphere. The highly charged particles become excited and jump to a higher energy level and cause Earth's atoms and molecules to go into an excited state. When the excited electron finally jumps back down to its lower energy level, it releases energy in the form of light. This in turn causes the auroral light displays. The picture below illustrates how solar winds shape the magnetosphere and affect the poles of Earth which in essence illicit the natural light phenomenon of the auroras. (See Picture Below)



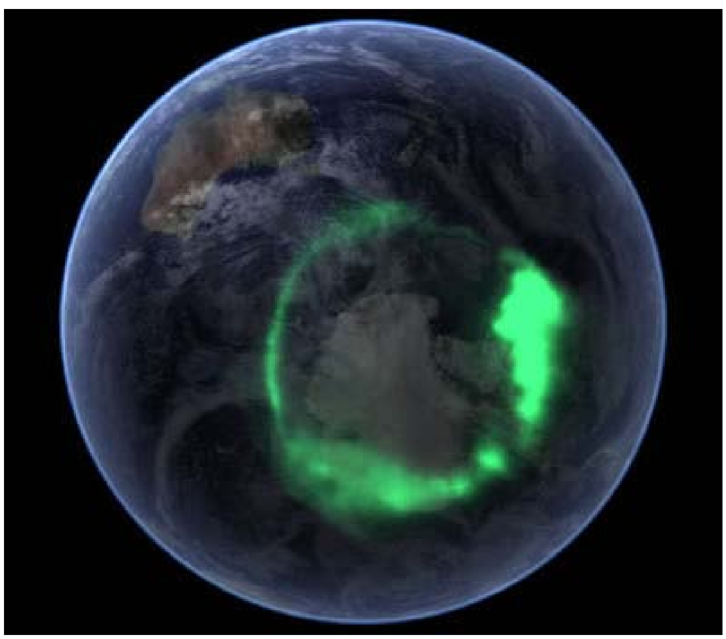
The most important feature that causes the Aurora Borealis as well as the Aurora Australis is solar winds. Solar winds vary in frequency and intensity because of their cycles. Solar wind cycles and solar sun spot activity is believed to last over an 11 year cycle of time. Solar winds are caused by storms on the surface of the sun and are composed of highly charged particles. These streams of highly charged particles are believed to carry millions of megawatts of electrical power. The charged particles then stream to what is known as the ionosphere or upper atmosphere. According to the National Research Council in their book <u>The Atmospheric Sciences</u>, "when the magnetic field within a compression region on the leading edge of a high-speed stream is directed southward, the solar wind is particularly effective in stimulating geomagnetic activity." (National Research Council 1998) This geomagnetic activity includes auroral displays and geomagnetic storms. Both are caused by solar flares and the coronal mass ejections (CMEs) from the sun. A geomagnetic storm is a disturbance in the Earth's magnetosphere and the magnetosphere is a volume of space that surrounds the Earth. According to the National Research Council, "the most severe geomagnetic storms usually are associated with interplanetary disturbances driven by fast CMEs and thus are most common near the maximum of solar activity." (National Research Council 1998) It typically takes solar winds about 3 days to travel the distance from the sun to the Earth. As solar winds flow around the Earth's upper atmosphere, ionosphere, the highly charged particles are funneled towards the poles. The reason behind this is due to the shape of Earth's magnetic field lines. The Earth can be thought of as a sort of bar magnet that contains two poles and a magnetic field. As we learned in UPII, the Earth's magnetic field lines flow from South to North. Therefore, as solar winds hit the ionosphere, they are trapped in the Earth's magnetic field lines and are channeled to the poles. The magnetosphere extends around the Earth and balances the effects caused by solar winds. Below is a picture of what the Earth's magnetic field lines look like. (See Picture Below) Besides solar winds, the ionosphere is "subjected to enormous winds borne aloft by tiday and atmospheric gravity waves generated in the dense atmosphere of the Earth" which in essence creates "weather that matches the severity of solar-induced effects." (National Research Council 1998)



The auroral lights displayed are in direct correlation with the chemical composition of the particles emitted from the solar winds. Due to the content of Earth's atmosphere being composed of mainly nitrogen and oxygen, the auroral colors emitted from these common constituents tend to appear the most in the Aurora Borealis and Aurora Australis. Oxygen molecules tend to cause the green glow while nitrogen molecules cause a signature blue glow. The more rarely seen red glow is caused by oxygen atoms. Due to the longer amount of time it takes to emit red light in comparison to green light, the higher number of collisions cause the rarity in which we seldom see red auroral lights. Red auroral emissions tend to take around 2 minutes to form whereas green emissions take around 2-3 seconds to form. Collisions of the particles tend to become more frequent as the particles move lower in the atmosphere. The most common auroral color is green due to the high number of collisions at lower altitudes; however, as altitude increases, red auroral lights can be seen more frequently because they are allowed time to appear. Red auroras are typically above 150 miles in altitude whereas green auroras are up to 150 miles in altitude, blue auroras are up to 60 miles in altitude, and purple/ violet auroras are above 60 miles in altitude. Another factor that influences the colors emitted in auroras is the density of the atmosphere. As atmospheric gas becomes denser, particle collisions happen more frequently and when atmospheric gas becomes less dense, particle collisions happen less. Auroras are shaped by Earth's magnetic field lines and tend to stretch across the sky in bands and folds. The patterns in which auroras form are influenced by the lines of magnetic force. Patterns can include long drawn-out glows, slow pulses, and rippling currents of ribbon-like streams. The patterns can also be influenced by the type of energized particles that collide with the atmosphere.

The Aurora Borealis as well as the Aurora Australis are generally found in what is known as the auroral ovals, which are around the magnetic poles. According to Tony Phillips of geology.com, "spring is aurora season." (Phillips 2011) Due to there being two equinoxes, that means that fall is aurora season as well. Auroras occur during the two seasons of spring and fall almost twice as much as winter and summer. (Phillips

2011) Scientists do not know why the auroras are prevalent during this time nor do they know why sub-storms arise. Sub-storms are "auroras that erupt with little warning and with surprising intensity." (Phillips 2011) To gain a better understanding as to why sub-storms arise, scientists from NASA have deployed 5 spacecraft known as THEMIS ("Time History of Events and Macroscale Interactions during Substorms"). These satellites are specially made to help study the unpredictable auroras. Due to the unpredictable nature of auroras and their strong electric current and energy, auroras have been known to cause many damaging effects. The THEMIS satellite launched in space in February of 2007, has already "observed a geomagnetic storm with a total energy of 500 thousand billion Joules." (Phillips 2011) (Below is a picture taken by NASA's IMAGE satellite. (See picture below)



The only difference between the Aurora Borealis and the Aurora Australis is they are located at separate magnetic poles and have different names. The Aurora Borealis is located in the northern hemisphere and near the north pole whereas the Aurora Australis is located in the southern hemisphere and near the south pole. Most auroras tend to be alike and occur at the same time, sometimes even same colors and patterns. This concept makes sense since the solar winds flow along the same magnetic field lines at both poles. Among the best places to watch the Aurora Borealis is in upper northern hemisphere. Canada, the Northwest Territories, and Alaska all experience the Northern Lights on a regular basis. However, the Aurora Borealis has been known to go as far south as Texas and Louisiana on some occasions depending how powerful solar activity is during that time. The Aurora Borealis is seen more frequently than the Aurora Australis because the southern lights are concentrated more around Antarctica and the southern Indian Ocean where it is not as inhabited. Researchers have found that auroras peak in cyclic fashion just as solar activity does. Auroras peak roughly every 11 years in direct correlation with solar wind activity. Clear, dark, and long nights are typically the best times to view the auroras. (See Picture Below)

Many people have claimed they have heard auroras while watching them. This claim is most likely false because of the high altitude of the auroras. The lowest aurora is around 60 miles. Due to the upper atmosphere being very thin, it does not carry sound waves. It would take a long period of time for the aurora to carry sound to the ground. It would most likely not have an audible sound.

Besides the Aurora Borealis and Aurora Australis here on Earth, other planets have been known to have auroras as well. Other planets that have been known to have auroras are Saturn and Jupiter. Just like Earth, these planets have a magnetic field as well. Auroral ovals have been known to appear near the equator on some planets like Neptune and Uranus. This is due to the magnetic field of the planet not being aligned with the rotational axis of the planet. The majority of planets in the solar system have auroras. Some are more irregular and displaced than ours here on Earth.

Auroras have been around for centuries and many have theorized as to how auroras are formed. Benjamin Franklin at one point suggested auroras were formed by a concentration of electric charges in the poles. One theory known as the "leaky bucket theory" suggested that the auroras were an overflow of the radiation belt. Another theory slightly closer to the actual cause of auroras was the belief in auroral electrons being emitted from the sun in beams. Whatever the theory, many have been intrigued by this natural phenomenon and tried several times to explain its cause.

At this point in time, scientists are still in the process of researching and finding out more information about auroras. They are unpredictable to an extent because we do not know when exactly solar winds will hit the Earth. We know that the auroras are caused by solar winds and the sun's (CMEs) as well as about the 27 day cycle of the sun;

however, at this point in time, we are unable to predict more than 2 hours in advance. Our satellites give us around a 1-2 hour warning before auroras are emitted.

In conclusion, the main factors influencing the Aurora Borealis as well as the Aurora Australlis displays are solar activity, Earth's magnetic field, and electrical current system. Auroras are directly linked with how active sun emissions or (CMEs) are emitted. The greater the solar activity, the more frequently auroras appear. The Earth's magnetic field captures and directs all highly charged particles emitted from the sun and channels them towards the poles. The Earth acts in the same sense as a magnet with two dipoles. The magnetic field lines of Earth run from the south to the north. These magnetic field lines help shape the magnetosphere, space around the Earth that deflects solar winds. There is no difference between the aurora borealis and the aurora australis besides the fact that the borealis is in the northern hemisphere and the australis is in the southern hemisphere. Both auroras have similar colors and patterns and appear usually around the same time. Aurora lights and patterns are determined by the particles chemical composition as well as the composition of the atmosphere. Auroras can be composed of oxygen and nitrogen molecules and atoms. Auroras elicit a variety of colors and patterns but are not predictable. The most rare aurora color is red due to its high retention time in the atmosphere and the most frequently seen color is green due to its low retention time. Scientists still do not know everything about auroras and cannot predict their occurrence; however, satellites have been launched to help gain a better understanding of how they work. Although sometimes detrimental, auroras are beautiful and natural displays of light that are driven by astronomy, meteorology, chemistry, and most importantly physics.