Teacher's Guide

The Aurora

Introduction

Aurora are produced in the north and south magnetic polar regions when energetic particles from the Sun, or from other locations in the Earth's magnetic field, collide with atoms of oxygen, nitrogen or hydrogen in the atmosphere. A source of mystery for countless millennia, we now understand how they are produced, but can still admire them for their beauty. Scientists have studied them for over 100 years, and there are certain details about how aurora form and change with time that are the subject of new investigations from the ground, and from space.

Objective

Students will read an article to be informed about auroral activity, describe information given, and apply their understanding to create an auroral display.

Procedure

1) Discuss the student's prior knowledge about aurora.

2) Allow sufficient time for the students to read "The Aurora: New Light on an Old Subject".

3) Students complete questions number 1 through 6. Encourage the students to refer to the article as needed. Discuss the student responses.

4) Students can color the map according to their interpretation of the aurora.

For images of the aurora, and more information on the appear ance of the aurora, arrange for the class to use the computer center. Visit the resource Internet pages on Aurora listed in the back of this workbook.

Materials

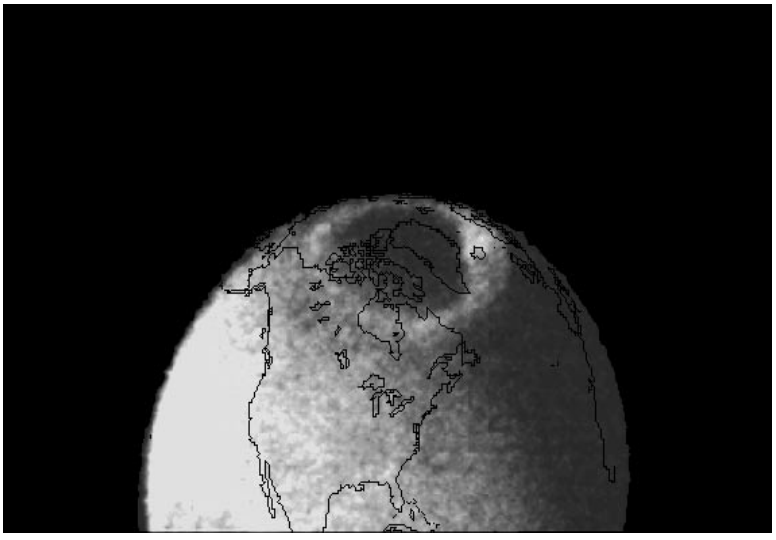
— "The Aurora: New Light on an Old Subject"

—Student Page

—Crayons, colored pencils or markers.

Conclusion

Students will learn about the aurora phenomenon and how scientists have studied it over the last few centuries. They will learn how older ideas have been replaced by newer theories.



The Aurora: New Light on an Old Subject

Dr. Sten Odenwald (Raytheon ITSS and NASA Goddard Space Flight Center)

For thousands of years, humans have admired the spectacle of the 'Northern Lights' also known as the Aurora Borealis. The multi-colored curtains of light that, from time to time, play across the skies like phantasmogoric serpents, have been seen by Scandanavian Vikings, Eskimos, and even on exceptional occasions, by inhabitants of the Mediterranean and Japan. Today, astronauts can see auroras from the vantage point of space where it appears as an oval-shaped glowing donut over 5000 kilometers in diameter, centered on the north magnetic pole. During the last few decades, scientific investigation of this natural phenomenon have uncovered many new insights to how auroral displays are produced, and that many other planets such as Jupiter and Saturn also share such a phenomenon. But first, some history!

In the mid-19th century, Anders Jonas Angstro noted that there was a similarity between auroral displays and certain kinds of electrical discharges that could be studied under laboratory conditions. This was the first recognition that some kind of electrical discharge was responsible for producing auroras. This was in distinction to earlier popular ideas that auroras were reflections of light from ice crystals high up in the atmosphere, or that they were related to terrestrial lightning. It wasn't until around 1925 that spectroscopic investigations finally identified one of the atoms causing the distinctive greenish light: Oxygen. This particular light is only produced at a single wavelength near 5577 Angstroms, about mid-wa through the familiar visible spectrum. It is a feature caused b oxygen atoms at very low gas densities being excited b specific amounts of energy.

Around the turn of the century, physicists and astronomers had identified certain prominent atomic emission lines in such objects as distant, interstellar gas clouds and even the solar surface. Such elements as ‘nebulium', 'coronium' and 'geocoronium'. Following decades of spectral analysis, these emission lines were finally tracked down, all except for one. The element 'helium' was discovered in the solar spectru before it was finally found on earth, however the remaining mysterious lines turned out not to be from exotic ne elements, but from ordinary iron atoms. The coronium lines were found in the coronal regions of the sun high above the solar surface. Originally it was thought that they were produced by an even lighter element than hydrogen which makes up the bulk of the solar material. Instead, the emission lines attributed to coronium were found to come from iron atoms that had been stripped of 13 of their electrons!

Auroras are now known to be electrical phenomena triggered by high speed electrons that enter the upper atmosphere in powerful currents, following the magnetic field of the earth into the polar regions. These electrons collide with atoms of oxygen and nitrogen to stimulate them to emit specific wavelengths of light. The process works very much like a neon sign, in which a current of electrons passes through a lo density neon gas inside the tube to stimulate the atoms to emit light.

Auroras can never touch the ground, contrary to the many reports handed down by folklore. The emission of the light requires very low density gas conditions so that the atoms do not become 'collisionally excited' into other states. Too many collisions in a high-density environment will eliminate the specific electronic transition needed to produce the specific auroral lines. The density of the atmosphere near the lower range of the auroral limit near 70 kilometers is nearly the same as what is found inside a neon bulb. At the upper range of the auroral display at 1000 kilometers, the atmosphere is even more rarified.

In April, 1741 Olof Hiorter discovered from studies of the earth's magnetism that,whenever a prominent auroral displa occurred, the magnetic field of the earth in the vicinity of the aurora would be disturbed. By 1770, J.C. Wilcke discovered that prominent auroral rays tended to align with the direction of the earth's magnetic field. A prominent solar flare on September 1, 1859 was observed by Richard Carrington and at the same time, several miles away at a local magnetic observatory outside of London, a major disturbance in the earth's magnetic field was recorded. These separate clues revealed that aurora are not just pretty lights in the sky, but are indicators of a process which often begins on the sun as a solar storm. These storms emit particles which sometimes collide with the earth and produce currents that flow into the magnetic polar regions. Aurora result from these flows of particles, and these flows also modify the earth's magnetic field to produce magnetic 'storms'.

Because aurora are indicators of severe magnetic activity, they are often correlated with many problems that can arise with electrical equipment. Aurora produce their own forms of radio radiation that can interfere with long distance communication. The rapidly changing magnetic fields near the ground can induce electrical currents in power lines that result in power black-outs. On March 13, 1989 a major solar stor produced a dazzling auroral display that was observed as far south as Florida and Japan. It also caused a power blackout for 9 hours that affected 6 million people in Quebec. Even natural gas pipelines are affected. As auroral electrical currents flow along these pipelines, they produce enhanced corrosion which can have catastophic consequences. Although the Alaskan pipeline was specifically designed with proper insulation to reduce this corrosion, the Siberian natural gas pipeline was built much earlier without this safeguard. In 1990, a portion of the pipeline ruptured and flooded a small valley with the vapors of the liquid natural gas. When two passenger trains entered the valley, the conductors smelled the gas and seconds later the entire valley exploded sending over 500 people to their deaths.

One possible way of reducing the risk for such catastrophes is to devise a way to successfully forecast when such major auroral 'storms' will happen. NASA satellites such as SOHO, ACE, TRACE and others in planning are parked about 1.5 million kilometers towards the sun so that this front guard can sense an approaching storm and provide up to an hour's notice of a major storm approaching from the sun. Other satellites monitor the solar surface to watch for flares which transmit their influences at nearly the speed of light and arrive at the earth within 10 minutes. Scientists have begun to elevate 'Space Weather Forecasting' to a high-precision art form even though there is an inevitable aspect of random chance to the way that the sun produces these storms. In the future, we may have better ways of protecting ourselves from the disruptive aspects of auroral displays so that we can, once again, return to admiring their beauty with a restored piece of mind.

Name _____ Date_____

"The Aurora: New Light on an Old Subject"

1. **What is the main idea of the reading selection?**

2. **What conclusions can you draw from the article?**

3. **What new information did you learn?**

4. **What did the author have to know about the reading selection?**

5. **In your own words, summarize the trouble to electrical installations that can be caused by aurora in the polar regions.**

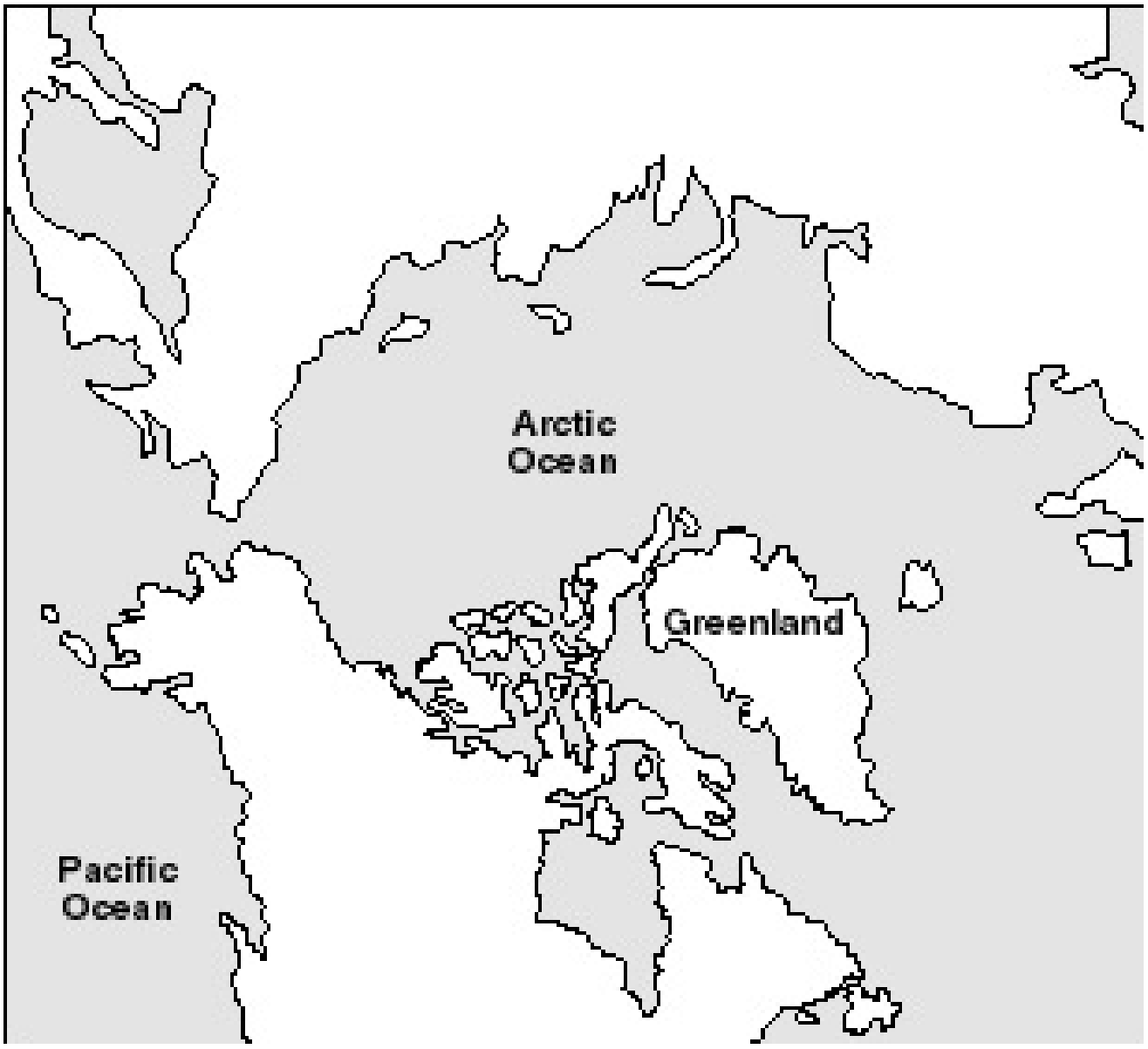
6. **The science of studying the sun and the aurora is a complex process where some ideas may change while other ideas remain supported by new data. Identify ideas that have changed and why the change happened.**

7. **How might an astronaut describe viewing the aurora as seen from above the Earth's surface?**

8. **Color the map as you would expect it to appear using what you have learned from the article.**

Name _____

Date_____



Selected Responses

"The Aurora: New Light on an Old Subject"

1. What is the main idea of the reading selection?

" The main idea of the reading selection is to inform you what the Northern Lights are, where they are found, what they are made of, and the new technologies and discoveries being made about them."

"The main idea of the reading selection is the Aurora: New light on an old subject, what the auroras are, where they are located, and what causes them."

"The main idea is to inform people about the Aurora Borealis."

2. What conclusions can you draw from the article?

"The conclusions that I can draw from the article is that things are definitely going on in the lights and sun, and that scientists are trying to work it out."

"The conclusions that I can draw from the article are that the Aurora (Northern Lights) has been made from nitrogen and oxygen colliding in the sky. There are lots of ways to figure out science over the years with better equipment."

"I can say that the Aurora is very complex, and we have advanced in our knowledge of the auroras."

"Some conclusions that I drew from this article is that the auroras were caused by ice crystals high in the atmosphere. Finally, they found out that atoms caused the green lights, and also that they are caused by solar storms."

"The auroras are indicators of a process which often begins on the sun as a solar storm. Another conclusion is that we have advanced a lot in the study of space."

3. What new information did you learn?

"I have learned that auroras can never touch the ground, and that the auroras produce their own forms of radio radiation. This can interfere with long distance communication."

"I learned that the aurora was thought to be many different things and over the years and that it has kept changing."

"I learned about all of the scientists that helped to discover the Aurora. I also learned that one possible way of reducing the risks for catastrophes is to devise a way to successfully forecast when such major auroral storms will happen."

"I learned Auroras can never touch the ground and that Auroras indicate severe magnetic activity."

"I learned about all of the scientists that helped to discover the Aurora. I also learned that one possible way of reducing the risks for catastrophes is to devise a way to successfully forecast when such major auroral storms will happen."

Selected Responses

4. What did the author have to know about the reading selection?

The author had to know a lot about the aurora to be able to write the reading selection.

The author had to know his information and where to get the information to support his topic.

5. In your own words, summarize the trouble to electrical installations that can be caused by the aurora in the polar regions?

The trouble to electrical installations caused by the auroras in the polar regions is that they can cause currents to travel up and down the pipelines, into gas lines and they can cause blackouts and explosions.

The aurora produces their own forms of radiation that can interfere with long distance communication.The magnetic fields can cause currents in the power lines and cause blackouts.

6. The science of studying the sun and the aurora constantly changes. From the article, cite an example of where scientists have hypothesized or speculated an idea that was later proven correct or incorrect. How was this accomplished? Be sure to include examples from the text to support your answer.

One idea that has changed is that before we weren't able to find outways of disruptive aspects, but we might be able to in the future. Also,another idea that has changed is that the Alaskan pipeline was specifically designed with the proper insulation to reduce the effects of a solar storms, but it didn't work in Siberia.The pipeline exploded.

One idea that has changed was that they originally thought they were produced by an even lighter element than hydrogen, which makes up the bulk of solar material, but instead the emission lines attributed to coronium were found to come from iron atoms that had been stripped of 13 of their electrons. This idea was changed because of new information.

Before we weren't able to protect ourselves from the disruptive aspects, but now we might be able to in the future. Also another idea that has changed is that the Alaskan pipeline was specifically designed with proper insulation to reduce the effects of solar storms, the Siberian pipeline was not; and it broke.

7. How might an astronaut describe viewing the aurora as seen from above the Earth?

Astronauts would describe the Aurora as an oval-shaped glowing donut.

An astronaut may describe the aurora as an oval-shaped glowing donut over 5000 kilometers in diameter centered on the north magnetic pole.

8. Color the map as you would expect it to appear using what you have learned from the article.

Students may have trouble coloring the correct location for the Aurora. The map is presented from a differ ent perspective than the students are accustomed.