

## Seeing The Big Picture

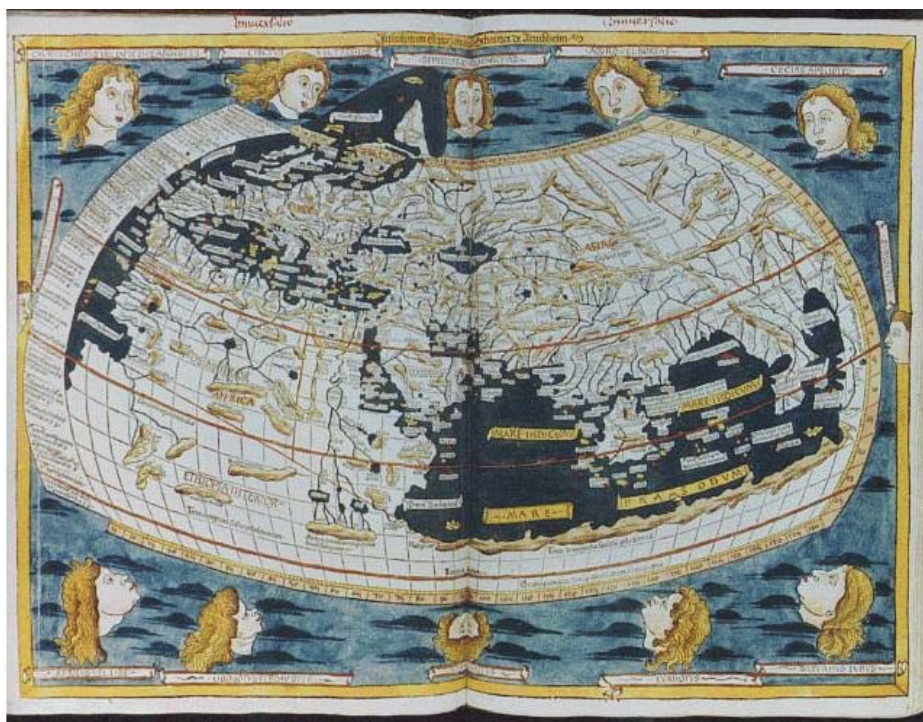
### Outcomes:

1. Describe how our explanations of how Earth has changed overtime are based on the collection of evidence and finding relationships between various observations in imaginative ways. (109-2)
2. Describe how our understanding of the forces that shaped our Earth have changed overtime as new evidence was collected. (110-5)
3. Identify the Theory of Continental Drift as one early explanatin for how our Earth changed over time. (110-1)
4. Identify the Theory of Plate Tectonics as an example of a major shift in our world view. (110-3)

### Introduction

The evidence of the earliest group of humans on our planet dates back 200 000 years. These people were located in the vicinity of Omo Kibish, Ethiopia in eastern Africa. Forty thousand years ago, or 160 000 years later, >modern= humans spread out of Africa to

inhabit the rest of the Earth. It wasn't until relatively recently, less than 600 years ago, that explorers left Europe and set sail to discover the continents of North and South America. Over this span of human history the way in which we humans have pictured our planet has changed significantly.



World view prior to the Columbus 1492 voyage. *In Germanus, 1482*

(Source: [http://www.newberry.org/K12maps/module\\_01/k-2.html](http://www.newberry.org/K12maps/module_01/k-2.html))



World view after the discovery of the Americas. *Mercator, 1587*

(Source: <http://www.libs.uga.edu/darchive/hargrett/maps/1587m4.jpg>)

With the discovery of the Americas the picture of the world changed and so did the thinking of its people. Those who thought of the Earth as being flat were now forced to rethink their old ideas. Early explorers produced maps and from these maps a new picture of our planet emerged.

### The Emergence of a New Theory

Try to imagine yourself traveling back, over one hundred years in time, to northern Europe.

You are a teenager who enjoys skating and hiking. You finish school and choose to study meteorology, the science of weather. When you are in your mid twenties you are invited on an expedition to explore Greenland during which time you have an opportunity to observe maps of the Atlantic Ocean. You notice that the shorelines on the eastern part of North and South America seem to match up with Western Europe and Africa. You wonder why this is

and question if there is some way in which these two far away continents could have once been joined together as one.

You search for other evidence to support your idea. Remember, the World Wide Web is not available yet so your only alternative for research is to look in books! During your research you discover that fossils of similar species of plants and animals, that are incapable of significant movement, have been discovered on both sides of the Atlantic Ocean. You notice that some fossils of creatures that once lived in the ocean are being found in sedimentary rocks on mountain tops and that minerals that only form in warm climates were being found in Polar Regions. All of this evidence supports the idea that land masses on our planet have shifted over time. However, one question remains unanswered: What is making them move?

Later in life you are selected to fight for your country in World War I and although you are wounded twice you survive to write down your ideas and publish a book so that others can read about your theory. Most of your friends, including educated members of your own family, still think that your ideas are incorrect. At the age of fifty you have an opportunity to return to Greenland on another expedition and tragically you are lost in a blizzard.

Your imagination has placed you in the shoes of the man who proposed the Theory of Continental Drift, Alfred Wegener. He proposed this theory in 1912 but up until his untimely death in 1930 it still had not been accepted as true because he could not explain how the continents had moved. The explanation of how the continents moved was not provided until 1960, when a scientist named Harry Hess was exploring the Atlantic Ocean. Using sonar Hess was able to map the ocean floor and identify a mountain chain running the length of the Atlantic Ocean. When they drilled into the crust of this area they discovered that the rock got older as they moved away from the ridge. Magnetometer surveys revealed that magnetic reversals occurred in layers parallel to the ridge. These frozen records in the rock also provided evidence to support seafloor spreading and this proved that the continents had moved from their original position because the continents would have moved as the crust moved. It is now thought that convection currents provide the mechanism that causes the plates to spread apart and create new crust.

Over the years, as new observations were made and new evidence was collected, Wegener's Theory of Continental Drift has been refined into our current Theory of Plate Tectonics. The Theory of Plate Tectonics involves large crustal plates that move over the Earth's mantle. In some areas, such as in the mid-Atlantic, the plates are moving apart. In other areas they are pushing together and sliding past one another. Wegener's ideas, supported by the evidence collected by Harry Hess, J. Tuzo Wilson, and others, have given us a global perspective of why the surface of the Earth is shaped the way it is.

## Local Effects of Plate Tectonics

Did you know that where you live now was once next door to a different ocean? Long before the Atlantic Ocean formed there was another ocean called Iapetus already there. The Atlantic Ocean was named after the Greek god Atlas. Since the father of Atlas was Iapetus, this was the name given to that old ocean that existed before the Atlantic. Remains of this ancient ocean can be seen in the Central Zone of Newfoundland (see Figure 1).

It is no accident that this island of Newfoundland is such a wonderful place to find marine fossils! The Western Zone represents the eastern edge of the old North American continent and the Eastern Zone represents the western edge of Africa. Using fossil and mineral evidence, scientists have shown that the western edge of Africa was once attached to the Avalon Peninsula. The Iapetus Ocean lay between what is the present day Central Zone. About 500 million years ago, tectonic forces squeezed the Eastern Zone towards the Western Zone pushing up our present day Appalachian Mountains on the west coast of the island and giving rise to the Central Zone.



Figure 1: Geological subdivisions of Newfoundland.

(Source: [http://www.heritage.nf.ca/environment/nfld\\_story.html](http://www.heritage.nf.ca/environment/nfld_story.html))

## The Importance of Plate Tectonics

Scientists have discovered that our continents are moving at a speed of about 3cm a year. You may wonder why we should be concerned about plate tectonics if the plates are moving so slowly. The small movements that occur in the

crustal plates are associated with earthquake and volcanic activity. For example, on December 26, 2004 an underwater earthquake caused a Tsunami to form which was responsible for the deaths of over 300 000 people in countries around the Indian Ocean. This is equivalent to the number of people who have died due to volcanic activity on our planet since A.D. 1500.

While some plate tectonic forces may be responsible for devastating effects others may be beneficial. For example, tectonic forces form cracks in the Earth's crust that allow hot fluids from the mantle to seep into the crust and form deposits of precious minerals such as copper and gold. These forces are also responsible for bending the crust and forming shallow seas where salt deposits can form or deeper depressions where oil can be formed. While earthquake and volcanic activity are relatively sudden events, the processes that form mineral and oil deposits may take millions of years. Many oil and mineral deposits related to these tectonic forces have been discovered in Newfoundland and Labrador.

### **Plate Tectonics and the Nature of Science**

The history of the development of the Theory of Plate Tectonics provides an excellent example of the Nature of Science. Stop for a minute and consider the following questions: What is a scientist? What do you picture a scientist to be like? What do scientists do on a daily basis? Where do scientists work? What are the characteristics of a scientist?

Does your picture of a scientist portray them as people who wear lab coats as they work in laboratories? Do you think scientists look at the facts that they are presented with and then make an objective decision? Do you think scientists are people who can easily separate their views and opinions from the facts and decisions they have to make? If you said yes to any of these questions then you are not alone. Many people think of scientists as people (mostly male) who work in a laboratory setting, who can put

their personal feelings and beliefs aside, and who are not influenced by outside pressures or petty concerns, when they are making decisions related to their work.

Nothing could be further from what happens in reality! Scientists are people just like you, your parents, your teachers, etc, who work in a variety of settings, not just laboratories. And because they are people (both male and female) they make mistakes, they have egos, they ignore evidence that contradicts their viewpoints and beliefs, they are competitive, and they often take their work very personally.

As you have read above, when Wegener first proposed his ideas on how the continents were related to one another, very few scientists believed him. Even when he provided them with very detailed examples from other researchers, his ideas were ignored. You might ask how this could be so... how could the scientists of his day ignore what is plainly obvious to us today? That is a very difficult question to answer. Maybe the senior scientists were jealous of this young upstart. It could have resulted from different interpretation of the data Wegener supplied. It might have had something to do with the fact that it is very difficult to change your opinion about something you have believed in all your life. For whatever reason, many scientists of Wegener's day refused to give any credence to his ideas. In fact, it has been said that, only when the older generation of scientists retire and die off, can a new theory be truly accepted by the scientific community.

Science, and scientific activities, does operate under a set of expectations. To help control personal bias, or even cheating, from affecting scientific decisions, scientists do expect that when others provide them with conclusions from experiments, that the data provided is clearly recorded and that the experiments can be repeated to obtain the same data. Science operates from the standpoint that the physical world can be understood through careful, systematic study. Just as in Wegener's time, while scientific ideas are subject to change as new observations are made, normally the new ideas take into account the previous ideas and theories. It is very rare that

a scientific theory would be rejected completely. Rather, theories are modified to take into account any new, accepted information. In this way, scientific research is a cumulative process of asking questions, making observations, and, using both the intellect and imagination, in trying to make sense out of the observations. If you would like to learn more about the Nature of Science, refer to the Project 2061 link in the References section.

### Conclusion:

As humans have evolved on our planet, the way that we frame our thinking has evolved. We are very fortunate that there always seem to be some people that have the ability to see things differently than others. Some individuals pose questions that challenge the things we currently believe. Alfred Wegener was once a young person with an imagination and curiosity about the things that he encountered during his life. These characteristics may have helped him to form his theory. This theory of continental drift evolved into our recent Theory of Plate Tectonics that now shapes the way that we look at the processes that mould our planet. Eventually, knowing where these forces are active may help us to save lives by predicting catastrophic events such as earthquakes and tsunamis. It may also improve our ability to discover new deposits of valuable mineral resources. Many Earth scientists feel that we have just scratched at the surface of the scientific discoveries that will help us understand how our planet, and others throughout the universe, has formed. Most of the mysteries of our planet have yet to be solved. Are you a curious person with an active imagination?

### Questions:

1. An examination of the map of 1482 reveals significant differences in the way that people viewed the Earth at that time. When compared with the map of 1482, what evidence would Wegener see in the Mercator's map of 1587 that would support his Theory of Continental Drift?

2. What was the missing piece of the puzzle that Wegener needed to support his theory?
3. Does a new discovery always change the way we “see the big picture”? Why/why not?
4. Newfoundland is approximately 4000 km from Africa. If the Earth's crust is moving at a rate of 3 cm per year how long ago would we have been joined together? Do you think that this is possible? Explain your answer.
5. New scientific discoveries seem to spark ideas that lead to other discoveries. The recent technological revolution has created audio and video devices with greater memory capacity in smaller and smaller packages. What technological advances provided evidence to support the Theory of Plate Tectonics?
6. What is a “convection current”? How do convection currents cause crustal plates to move?
7. What are the three pieces of evidence that supports Wegener's Theory of Continental Drift?

### References

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## Research Ideas

Can you find fossils that link the Avalon Peninsula to Northern Africa?

What geological feature links western Newfoundland to the rest of the old North American continent?

What rock types would you expect to make up most of central Newfoundland?

## Activity 1:

**Purpose:** To examine the convection currents that are the driving force behind plate tectonics.

**Materials:** 1 L beaker and 1 teaspoon of rice in 700 mL of water

**Procedure:** Students will observe the motion of rice as the water is slowly boiled. Ask them to compare their observations to the motion of magma in the Earth's mantle. Students should recognize that these hot spots are analogous to plate boundaries.



Figure 2: Convection currents in boiling water

## Activity 2:

For a simulation of plate tectonic students should explore:  
<http://www.pbs.org/wgbh/aso/tryit/tectonics/>

Google Earth can be used explore the boundaries of the crustal plates. Students may be asked to try and find relationships between the plate boundaries and a particular geological feature such as a mountain range, a deep ocean trench, or locations of earthquakes and volcanoes?