THE SCIENTIFIC METHOD

INTRODUCTION

The process by which science progresses over time is called the scientific method. It is this set of procedures that sets scientific inquiry apart from other studies. It is the goal of this type of inquiry to understand the world around us, and to be able to make predictions about those parts we do not understand. Ideally, the knowledge gained in this fashion is reliable, consistent, and not arbitrary. In order to use this method you must make a basic assumption that the universe is essentially an orderly place; that the rules governing matter and energy in one spot apply in all others. There are exceptions to this, but is seems that most disappear as we apply this method to learn more about them.

The scientific method starts with observations of a phenomenon, and then attempts to explain the observations with a **hypothesis** that can be tested. **Experiments** may lead to dismissal or modification of the hypothesis. Once a hypothesis stands up, it must be used to explain other phenomena. A critical part of the process is that other scientists review the hypothesis and check it with their own experiments. If a hypothesis produces repetitive results and allows prediction of other phenomena it will gradually gain acceptance within the scientific community and may eventually become a **theory**. No hypothesis or theory, no matter how well accepted, is immune to modification or outright dismissal. Theories can never be proved, only disproved. A critical part of the scientific method is that the experiment is supreme; no theory will stand if experiments show it to be incorrect. Because testing is so fundamental process, both hypotheses and theories must be verifiable by experiment.

1. Collect observations about a phenomenon.

2. Construct one or more hypotheses to explain the observations.

3. Test the hypothesis with experiments.

4. Modify the hypothesis as needed and retest.

5. When the hypothesis is reliable the work must be published for peer review

By way of example, we can look at the work of Alfred Wegner, a German meteorologist and physicist, whose fascination with one aspect of geology led him to develop a hypothesis that eventually revolutionized the way we look at geology. He wrote four books, each book documented more evidence for his hypothesis that all of earth's continents were once one large landmass that he called Pangaea (Greek for "All Earth").

Wegener's observations included:

- The fit of the continents (consider South America and Africa for example),

- Separated mountain ranges of the same, structure, rock type, and age (the Appalachians and the Caledonians in northern Europe),
- Widespread ancient glacial events (one event that included Africa, South America, Antarctica, Australia, and India),
- And widespread fossils (several examples found on now-separated continents).

Wegner's hypothesis:
That the continents we have today started as one single landmass that has since split up and moved around to the familiar locations

Testing the hypothesis:
Wegner continued to add evidence to support his idea with his work and that of others. To this end he wrote four volumes, published in 1915, 1920, 1922, and 1929. In his view, he had tested and proven the hypothesis.

Unfortunately for Professor Wegner, his hypothesis was not accepted until other lines of evidence were found in the 1960's. Wegner had no adequate mechanism to explain the movements of the continents and died in 1930 with his ideas poorly received. The later evidence proved that the sea floor was spreading. When Wegner's continental drift hypothesis was combined with sea-floor spreading, the modern (now) theory of plate tectonics was born. This theory has been extensively tested and has become fundamental to all aspects of modern geologic study.

OBJECTIVES

1. To become familiar with the scientific method and to be able to identify the steps with a practical exercise.
2. To understand how the process includes peer review.
3. To gain an appreciation for the definitions of, and relationships between hypothesis and theory.

LAB EXERCISE
This lab will be in conjunction with the Structure Lab because it is related to Plate Tectonics and those processes drive most of the structures we see.

In this exercise you presented with some earthquake data collected from an area where two oceanic plates have collided, forming the Island of Sumatra in the Indian Ocean. The data are presented in a map and in cross section. Each circle is an earthquake and you can see there are a lot of them. The different colors represent earthquake depths.

Study the data and answer the following questions:

1. What part of the Scientific Method process is represented by the locations of all the earthquakes? _________________
2. Develop a hypothesis to explain the locations of the earthquakes (include how location varies with depth).

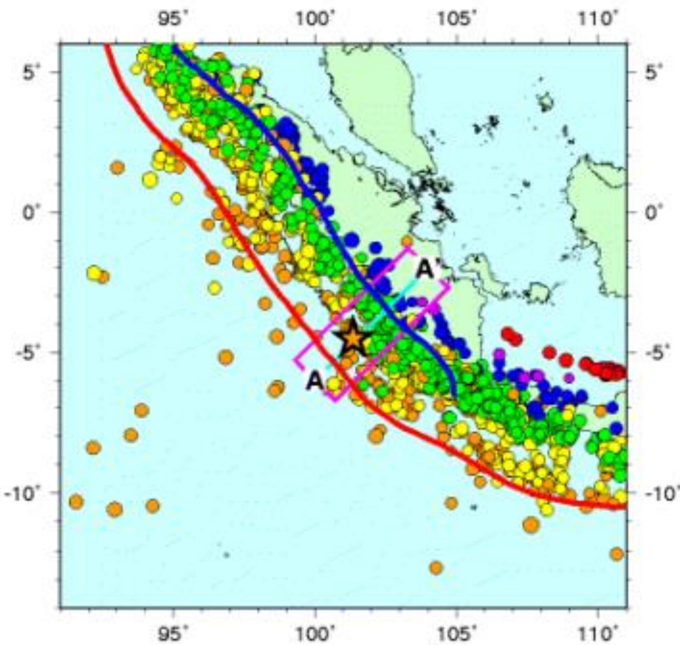
3. What would you do to test your hypothesis?____

4. Where would you expect the strongest earthquakes be on the map? ___________________________________
5. Give two reasons why this is the case.

_____________________________________ _______________________________________

6. What would you expect to see on the surface along the blue line (hint, look on the cross section and note the shallow earthquakes about where the blue line is)? ____

Seismicity Cross Section



To the left a historic seismicity map from Sumatra. (Red line = subduction zone) The star shows the 8.4 earthquake of 14 September 2007. To the right a cross section A-A'.

Both images from USGS.