Theories are powerful tools (National Science Teachers Association, *The Teaching of Evolution Position Statement*):

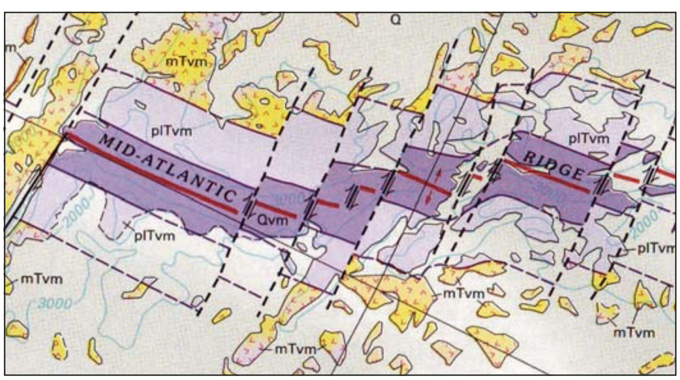
> Scientists seek to develop theories that
> - are firmly grounded in and based upon evidence;
> - are logically consistent with other well-established principles;
> - explain more than rival theories; and
> - have the potential to lead to new knowledge.

Scientific theories are falsifiable and can be reevaluated or expanded based on new evidence. This is particularly important in concepts that involve past events, which cannot be tested. Take, for example, the Big Bang Theory or the Theory of Biological Evolution as it pertains to the past; both are theories that explain all of the facts so far gathered from the past, but cannot be verified as absolute truth, since we cannot go back to test them. More and more data will be gathered on each to either support or disprove them. The key force for change in a theory is, of course, the scientific method.

A scientific law, said Karl Popper, the famous 20th century philosopher, is one that can be proved wrong, like "the sun always rises in the east." According to Popper, a law of science can never be proved; it can only be used to make a prediction that can be tested, with the possibility of being proved wrong. For example, as the renowned biologist J.B.S. Haldane replied when asked what might disprove evolution, "Fossil rabbits in the pre-Cambrian." So far that has not happened, and in fact the positive evidence for the "theory" of evolution is extensive, made up of hundreds of thousands of mutually corroborating observations. These come from areas such as geology, paleontology, comparative anatomy, physiology, biochemistry, ethnology, biogeography, embryology, and molecular genetics. Like evolution, most accepted scientific theories have withstood the test of time and falsifiability to become the backbone of further scientific investigations.

Science Through the Recent Ages

The term *science* is relatively modern. Nearly all civilizations, however, have evidence of methods, concepts, or techniques that were scientific in nature. Science has its historical roots in two primary sources: the technical tradition, in which practical experiences and skills were passed down and developed from one generation to another; and the spiritual tradition, in which human aspirations and ideas were passed on and augmented (Mason, 1962). Observations of the natural world and their application to daily activities assuredly helped the human race survive from the earliest times. In western society, it was not until the Middle Ages, however, that the two converged into a more pragmatic method that produced results with both technical and philosophical implications.



The Mid-Atlantic Ridge (N is to upper left) on the 2005 Geologic Map of North America. Location near 50N, 30W.

An excellent example of the development of science and the scientific method is the demise of the geocentric view of the solar system. Although it strongly appears to the naked eye that the sun and moon go around Earth (geocentric), even ancient astral observers noted that stars moved in a different yearly pattern, and certain planets or "wanderers" had even stranger movements in the night sky. In the 16th and 17th centuries, observers began to make more detailed observations of the movements of the stars and planets, made increasingly complex with the aide of the newly invented telescope. Galileo improved the telescope enough to observe the phases of Venus as seen from Earth. With the application of mathematics to their precise measurements, it became obvious to astronomers like Copernicus, Kepler, and Galileo that the planets and Earth must revolve around the sun (heliocentric). It is necessary, however, to backtrack here a little and make clear that, as early as the third century B.C., the Greek astronomer Aristarchus proposed that Earth orbited the sun. Earth's spherical nature was not only well known by about 300 B.C., but good measurements of Earth's circumference had already been made by that time. Unfortunately, throughout history, knowledge from one culture has not necessarily been passed on to other cultures or generations.

New discoveries and technological advancements led to what is known as the Scientific Revolution, a period of time between Copernicus and Sir Isaac Newton during which a core transformation in "natural philosophy" (science) began in cosmology and astronomy and then shifted to physics. Most profoundly, some historians have argued, these changes in thinking brought important transformations in what came to be held as "real" and how Europeans justified their claims to knowledge.

> The learned view of things in 16th-century thought was that the world was composed of Four Qualities (Aristotle's Earth, Water, Air, and Fire). By contrast, less than two centuries later Newton's learned contemporaries believed that the world was made of atoms or corpuscles (small material bodies). By Newton's day most of learned Europe believed the Earth moved, that there was no such thing as demonic possession, that claims to knowledge … should be based on the authority of our individual experience, that is, on argument and sensory evidence. The motto of the Royal Society of London was: Nullius in Verba, roughly, Accept Nothing on the Basis of Words (or someone else's authority). (Hatch, 1991, p. 1)

One of the first to put this idea in print was Rene Descartes. Although the exact dates of the Scientific Revolution may be