It has been nearly a century and a half since Charles Darwin and Alfred Russel Wallace (1858) introduced the world to what is considered by many to be the most exciting discovery in science; the evolution of life forms by means of natural selection.

Since its introduction and its subsequent detailed treatment by Darwin in the “Origin of Species” (1859), evolutionary theory has experienced an evolution of its own. Darwin developed his theory on the origin of species during a period in which science had no knowledge of chromosomes, DNA or genes and Gregor Mendel’s seminal work on inheritance had not yet become known to even a minority of the scientific community. However, as it so frequently the case with gifted minds, Darwin was able to employ deduction, inference and extrapolation to fill in the gaps in contemporary Victorian science.

With the rediscovery of Mendel’s work in 1900 and the subsequent identification of chromosomes and the deciphering of the structure of DNA, modern science was now armed with knowledge and methodologies that Darwin could have only imagined. Scientists were then able to apply these new discoveries to classical Darwinian evolutionary theory resulting in an increase of the explanatory power and predictive ability of the theory; neo-Darwinian evolutionary theory was born.

The study of the development and modification of evolutionary theory is quite literally, a textbook example of how the process of science is conducted, tested, modified and applied. It would be difficult to find a more exquisite example of the process and nature of modern science than in the history of evolutionary theory. It is for this reason that evolutionary theory is the common theme around which the content and nature of science is and should be presented in science texts.

THE CHALLENGE TO EVOLUTIONARY THEORY AND SCIENCE EDUCATION

Like all scientific theories, evolutionary theory is dynamic and can be modified as new information becomes available. This is how science is done. Although scientists continue to discuss and even disagree on some of the details of evolution, there is consensus within the scientific community on the validity and robustness of the theory. However, such consensus does not exist in the general population. A minority of the public either does not understand the basic components of evolutionary theory or refuses to accept them as valid science.

A recent but certainly not original attack against the teaching of evolution in public schools (Michigan House Bills 4946 & 5005) has been the assertion that evolution is an “unproven (sic)” theory and is therefore a scientific theory in crisis. Anti-evolutionists use this argument to suggest that evolutionary theory should not be taught because it represents an unfounded and inferior or soft science. However, recognizing that this argument lacks any credible evidence, many anti-evolutionists are willing to allow evolution to be taught as long as what they term “competing or alternative theories” are introduced as well. As there are no competing scientific theories to evolution, they offer such alternatives as “creation science”, “intelligent design” or the “design hypothesis”. However, these alternative “theories” do not meet any recognized definition of science as they lack empirical evidence and do not explain what is observed in nature with reference to natural law e.g., physics, chemistry, geology, biology, etc. They also offer no predictive ability, an essential component of scientific theory.

When anti-evolutionists suggest that evolution is “unproven (sic)” or it is a “theory in crisis”, defenders of evolution usually respond by burying the anti-evolutionist in a mountain of scientific facts, examples and quotes. This approach is rarely successful as no amount of data, articles or books will manage to convince such skeptics. Evolution skeptics could easily bring themselves up to speed by availing themselves of the readily accessible wealth of scientific and educational information available on the subject. You simply cannot teach evolutionary theory during a conversation or debate.

A more productive approach with anti-evolutionists would be to
help them determine if evolutionary theory meets the definition of science and if it meets the tests for being a robust scientific theory. Such analysis should then be followed by an examination of the “alternative theories” to see if they meet the same criteria for science and theory robustness.

DO EVOLUTION AND THE “COMPETING THEORIES” MEET THE STANDARDS OF SCIENCE?

It is important to understand that there are many valuable forms of human inquiry such as science, philosophy, sociology and theology. Science is ill equipped to answer many ultimate-type questions such as the question of life after death. Science’s inability to address this type of question does not by default prove or disprove the statement. Instead, this type of question must be given to the philosophers or the theologians to debate as it cannot be addressed by science.

Recognition of the value of these various forms of human inquiry makes the anti-evolutionist’s attack on evolution education very puzzling. Why would we study faith-based ideologies in the science classroom when we don’t follow Voltaire with crustacean biology in philosophy class? Consequently, the question that must be asked is “what constitutes science or scientific inquiry?”

As any science teacher will confirm, there are as many definitions of science as there are introductory science textbooks. However, regardless of diction and syntax, modern definitions of science share the following conceptual components.

1. **Science is guided by natural law and explains what is observed with reference to these laws** e.g., the laws of physics, geology, chemistry, biology, etc.

   For example, rainbows and thunder could be explained from a scientific perspective by employing factual knowledge from the field of physics whereas the deposition and arrangement of geologic strata could be explained using the laws of physics and geology. The proposed “competing theories” to evolution, such as creation “science” or intelligent design, require supernatural intervention to account for the evolution of life and therefore do not meet the criteria for science.

2. **Science must be testable against the natural world**

   The hypothesis that invertebrates evolved prior to the vertebrates can be tested by examining the first appearance of each group in the geologic strata. The components of the creation theories are rarely testable against the empirical world. Although a young earth (<10,000 yrs.) can be disproved quantitatively and the number of ribs present in human males and females can be determined to be the same, the assertion that God created the vertebrates cannot be tested and therefore falls outside the realm of science.

3. **The conclusions of science are tentative pending additional information**

   Biologists once thought that cells walls were static, rigid structures. The fluid-mosaic model of cell structure has changed this view. However, this new knowledge has not caused the abandonment of cell theory. Unlike science, faith-based ideologies are considered absolute and rarely change e.g., the long delayed acceptance of heliocentrism over geocentrism.

4. **Conclusions in science are potentially falsifiable**

   As scientific hypotheses and theories must be testable, it follows that they are potentially falsifiable.

   For example, science accepts that invertebrates evolved prior to the vertebrates. This conclusion is potentially falsifiable as finding turtles in the fossil record prior to the trilobites would refute or falsify this conclusion. Since faith-based “alternative theories” are not testable, they are not potentially falsifiable and therefore fall outside the purview of scientific investigation and therefore science.

5. **Science asks a question and then seeks answers**

   Science seeks to understand the natural world by asking questions about its organization and mechanisms. The answers to these questions are sought through the formation of testable hypotheses. In science, experimentation is conducted in order to find answers to questions and to reach conclusions. Faith-based ideologies are the
antithesis of this process as conclusions are stated first, then evidence is sought to support the conclusions.

**How Robust is Evolutionary Theory?**

Much of the evolution debate is grounded in a misunderstanding of the language of science. All too often we hear anti-evolutionists (and sometimes teachers) say that “...after all, evolution is only a theory”. Such a statement demonstrates a profound misunderstanding of the concept of scientific theory and confuses it with the colloquial or vernacular use of the term that implies an educated guess or a hunch.

In science, a theory denotes “…a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences and tested hypotheses” (National Academy of Sciences, 1998). Furthermore, a scientific theory has strong predictive ability and unifies previously unrelated areas of knowledge.

In statistics, we compare the power of a various statistical tests by determining their robustness or their ability to determine the actual relationships between events. The same conceptual tests can be applied to scientific theories such as evolutionary theory as follows:

1. **How many independent lines of evidence support the theory?**
   Evolutionary theory is validated by evidence obtained from many independent fields of scientific inquiry and not just from the biological sciences. Evidence supporting evolutionary theory is found in the fields of geology, physics, chemistry, cosmology, paleontology, archaeology, sociology and the many fields of biology such as genetics, molecular biology, comparative anatomy, embryology, etc. The lines of evidence from each of these fields are said to be independent since they are not necessarily dependent upon data gathered and conclusions drawn from the other fields in order to reach their own conclusions and formulate their own theories.

   The more independent lines of evidence there are supporting a theory, the more robust (reliable) a theory is considered. There is no more robust theory in all of science than the theory of evolution.

2. **How well does the theory unify previously unrelated areas of knowledge?**
   Nineteenth century scientists were unable to explain the distinct distribution of members of the camel family (camels, llama, alpaca) between Europe and the Americas. Their family relationship was recognized but no mechanism of dispersal or diversification could be determined. Darwin provided the mechanism of diversification via evolutionary theory and when Alfred Wegner introduced his theory of plate tectonics, the mechanism of dispersal was then understood. Areas of knowledge previously thought to be unrelated were now connected.

   In the absence of the unifying power of evolutionary theory, much of biology becomes a collection of disassociated and relatively mundane facts. Under the unifying umbrella of evolutionary theory, the history of life on earth becomes the most spectacular story every told! The robustness of a theory increases as the areas of knowledge associated by the theory also increase. Evolutionary theory establishes relationships between many areas of otherwise unrelated areas of knowledge into a single, powerful predictive descriptor of the processes of nature.

3. **What is the predictive potential of the theory?**
   A scientific theory must have predictive potential or the ability to predict outcomes of events based upon the principles of the theory. For example, based upon evolutionary theory, scientists can predict that vertebrates will not be found in younger geologic strata than the invertebrates. Biologists can also predict the adaptive value of certain traits under stated environmental conditions as well as determine the behavior and consequence of pathogens introduced into new populations. Evolutionary theory also allows the prediction of the outcome of the overuse of antibiotics in humans. As the accuracy of a theory’s predictive ability increases, so does its robustness.

4. **How evident are the causal relationships within the theory?**
   Scientific theories must identify the causation of the events that the theory seeks to explain. A theory’s robustness increases as
the causal relationships within the theory are identified and their operation described.

Our best explanation of gravitational force to date is the theory of relativity. Although well established, we still have much to learn and contribute to this theory in order to more clearly establish causal relationships. However, in evolutionary theory, many causal relationships are well understood. At the very general level, we understand that new species evolve through the causal process of natural selection. At a more detailed level, we now understand the causal effects of homeotic genes and their influence upon developing embryos and how they can influence the evolution of new species.

**Does Evolution Meet the Standards of Science and is it a Robust Theory?**

As discussed earlier, it is nearly impossible to provide an anti-evolutionist with enough science in a conversation or debate to enable them to understand this rather complex area of study and to subsequently accept evolutionary theory. However, if the discussion, debate or proposed legislation (Michigan House Bills 4946 and 5005) suggests that evolutionary theory is actually soft science and is “unproven (sic)” then the response is quite easy and succinct.

As discussed above, evolutionary theory meets all of the requirements of science. Proposed alternative theories such as creation “science” and intelligent design (design hypothesis) do not meet any definition of science. The federal courts have made this quite clear on multiple occasions e.g., McLean v. Arkansas Board of Education, 1982; Edwards v. Aguillard, 1987.

With respect to the assertion that evolution is unproven (sic) and is a theory is crisis, nothing could be further from the truth. Evolutionary theory is unequivocally, one of the most robust theories every established in science. As Craig Nelson of Indiana University once said to me, “We are more certain about evolutionary theory than we are about the fact that the earth revolves around the sun”. This is not to say that heliocentrism is in doubt, but that there are more independent lines of evidence substantiating evolutionary theory than there are supporting the evidence of the earth’s rotation around the sun.

If a person were to say that they rejected evolutionary theory because it is bad science, their statement would be an indictment of modern science. This is because the independent lines of evidence supporting evolutionary theory originate in some of the basic foundational theory of chemistry, physics, geology, paleontology, etc. To say that evolutionary theory is soft or bad science is a direct challenge to the validity of most fields of modern science.

Evolutionary theory is an integral part of modern science and should be taught in a manner commensurate with this importance. Scientists have determined that evolutionary theory is the best and only scientific explanation of the history of life on earth. Therefore, teachers should present the evolutionary theory of the history of life on earth unaccompanied by faith-based ideologies masquerading as science. Doing otherwise would not be make the presentation “fair or equal” but would result in the offering of false alternatives to our students, which is a violation of academic honesty and our professional responsibilities as trustees of our student’s academic development.

**References**


In adopting the position statement of the National Science Teachers Association (NSTA http://www.nsta.org/159&psid=10) (1997) regarding the teaching of evolution, The Michigan Science Teachers Association (MSTA) supports the position that evolution is a major unifying concept of science and should be included as
Proposed Legislation Requires "Intelligent Design"

On July 2 House Bill 4946 was introduced in the Michigan House of Representatives and referred to the Education Committee. This bill would amend Michigan's school code to require the state board of education to modify its science standards to include the idea of "intelligent design of a Creator" wherever evolution is mentioned.

HB 4946 was introduced by a member of the Education Committee, Rep. Kenneth Bradstreet, and has 24 co-sponsors, 8 of whom also sit on that 19-member committee. The relevant portion of HB 4946 reads as follows:

(10) As soon as practicable after the effective date of this subsection, the state board shall revise the recommended model core academic curriculum content standards under subsection (2) as follows:

(a) In the science standards, all references to "evolution" and "how species change through time" shall be modified to indicate that this is an unproven theory by adding the phrase "All students will explain the competing theories of evolution and natural selection based on random mutation and the theory that life is the result of the purposeful, intelligent design of a Creator."

(b) In the science standards for middle and high school, all references to "evolution" and "natural selection" shall be modified to indicate that these are unproven theories by adding the phrase "Describe how life may be the result of the purposeful, intelligent design of a Creator."

(c) In the science standards for middle and high school, all references to "evolution" and "natural selection" shall be modified to indicate that these are unproven theories by adding the phrase "Explain the competing theories of evolution and natural selection based on random mutation and the theory that life is the result of the purposeful, intelligent design of a Creator."

July 25, 2003

Another "Design Hypothesis" Bill

On July 17 House Bill 5005 was introduced in the Michigan House of Representatives and referred to the Education Committee. HB 5005 endorses "teaching the design hypothesis as an explanation for the origin and diversity of life."

House Bill 4705, introduced in 2001, contained the same provisions and some of the same sponsors as HB 5005. The 2001-2 Education Committee took no action on HB 4705. The full text of HB 5005 follows:

HOUSE BILL No. 5005


A bill to amend 1976 PA 451, entitled "The revised school code," (MCL 380.1 to 380.1852) by adding section 1164.

THE PEOPLE OF THE STATE OF MICHIGAN ENACT:

Sec. 1164. (1) The teaching in a public school science class of the methodological naturalism hypothesis as an explanation for the origin and diversity of life shall not preclude also teaching the design hypothesis as an explanation for the origin and diversity of life. A public school official shall not censor or prohibit the teaching of the design hypothesis.

(2) As used in this section:

(a) "Design hypothesis" means the theory that life and its diversity result from a combination of chance, necessity, and design.

(b) "Methodological naturalism hypothesis" means the theory that nature is all there is and that all phenomena, including living systems, result only from chance and necessity.

July 28, 2003

part of K-College science frameworks and curricula. The MSTA recognizes that evolution has not been emphasized in science curricula in a manner commensurate to its importance because of official policies, intimidation of science teachers, the general public’s misunderstanding of evolutionary theory and a century of controversy. Furthermore, teachers are being pressured to introduce creationism, creation “science”, and other nonscientific views, which are intended to weaken or eliminate the teaching of evolution.

In accordance of the Michigan State Board of Education’s March 10, 1982 resolution regarding the “Teaching of Religion and Creationism in Michigan Public Schools”, the MSTA agrees with the position that the “…State Board of Education oppose the teaching, in public educational institutions, of any course in religion which is outside of the realm of a secular program of education and be it further resolved that the State Board of Education recommend that any school district currently teaching creationism or any course in religion in an attempt to indoctrinate toward any particular belief or disbelief cease and desist such teaching.”

In recognition of the Michigan State Board of Education’s resolution on the teaching of evolution and the MSTA adoption of the NSTA position statement on teaching evolution, the Michigan Science Teachers Association advocates that HB 4946 & HB 5005 be removed from any further consideration by the House of Representatives.