Evolution: The Darwinian Revolutions

BIOEE 2070 / HIST 2870 / STS 2871

DAY & DATE: **Wednesday 27 June 2012**
READINGS:
- **Darwin/*Origin of Species*, chapters 1-4**
- **MacNeill/*Evolution: The Darwinian Revolutions* chapters 1-4**
- **Ruse/*Darwin and Design: Does Evolution Have a Purpose?* chapters 1 & 2**

Lecture 6:00-7:50: **Natural Selection and Scientific Reasoning**
Section 8:00-9:00: **Discussion of natural selection, scientific method, and philosophy of science**

Announcements:

• Essay topic #1 is now available.

Pick up a handout or check out the course website for a copy. It is due on Monday 9 July at the beginning of class.

• Several of the course textbooks and readings are available for free online:

***On the Origin of Species…*(first edition) available at:**
http://darwin-online.org.uk/content/frameset?itemID=F373&viewtype=side&pageseq=1

***The Autobiography of Charles Darwin*, available at:**
http://darwin-online.org.uk/content/frameset?itemID=F1497&viewtype=side&pageseq=1

MacNeill/Evolution: The Darwinian Revolutions, available at the course website:
http://evolution.freehostia.com/

Cosmides & Tooby/"Evolutionary psychology: A primer," available at:
http://www.psych.ucsb.edu/research/cep/primer.html

• There is a course website, located at:

http://evolution.freehostia.com/

All of the course materials, including handouts, lecture notes, etc. will be available at this website.

Plato anxd Aristotle's Theories of Design in Nature

During our first class, we discussed the concept of purpose and its relationship to the theory of evolution by natural selection. In particular, we discussed how the concept of purpose is not included in scientific explanations of such processes as gravity. We also discussed how purpose is also not part of the evolutionary explanation for the characteristics of living organisms.

Scientists have adopted a point of view first proposed by Democritus of Abdera in the fifth century B.C. Using primarily observations and simple logic, Democritus concluded that all matter is composed of tiny, indivisible particles called atoms, that the Milky Way galaxy is composed of a cloud of very distant stars, and that purpose has no part in the origin and evolution of nature. He is best known for two statements that summarize these ideas:

"Nothing exists except atoms and the void."

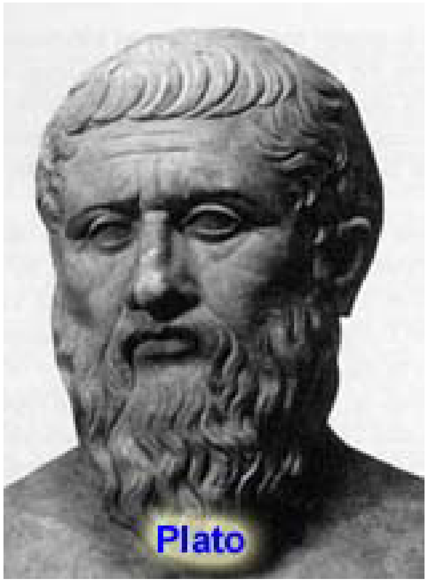
And

"All things are the fruit of chance and necessity."

However, Democritus' ideas were not widely accepted, even among the ancient Greeks. His astonishing and original insights were overshadowed by the work of two other Greek philosophers, who formulated metaphysical theories of reality in which the concept of purpose plays a central role.

Plato

The idea that some intentional agent, especially a deity, participates in the design we see in nature can be traced back to Plato, a Greek philosopher and follower of Socrates. Plato also lived during the fifth century B.C., but unlike Democritus, who lived on a remote island, Plato lived and worked in the capital city of Athens. In Plato's dialog, the "Timaeus", Plato asserts that the "demiurge" (*i.e.* creator) fashioned the things in the universe, and particularly living things. Originally all things were in a state of chaos. Then, the demiurge imposed design and purpose on the chaos, producing the universe we observe.



- **According to Plato, "all things are the fruit of reason and necessity".**

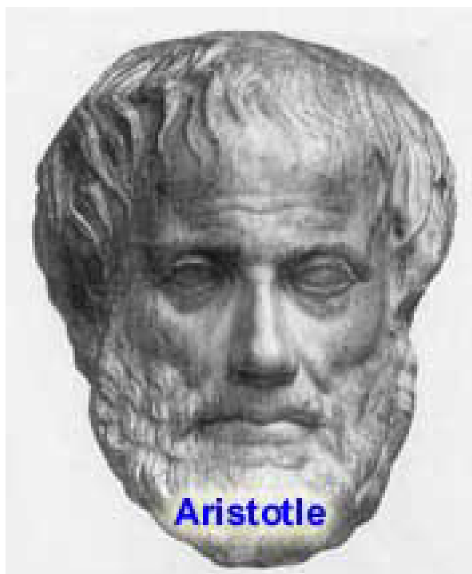
- **Reason "cajoles" cooperation between the things in the universe and the forces of necessity, producing the rational order we see in the universe around us.**

Here is an example of Plato's reasoning vis-a-vis the design of the human body, and especially the head:

- **According to Plato, the only truly valuable part of the human body is the head, the seat of the intellect. However, if the demiurge had only created us with heads, we would roll around on the ground and become lodged in crevasses, and be unable to get out. Therefore, the rest of the body was created to carry the head around, and protect it from danger and injury.**

Aristotle

Aristotle, who was a student of Plato, formulated a more practical theory of the origin of things in the universe. He believed that there were four different, but related, causes for all things:



- **Material causes: because of their structure and physical properties, things fit together to produce other things, such as silver being the "cause" of a silver cup**

- **Efficient causes: the immediate cause of something, such as a mother being the "cause" of her child**

- **Formal causes: some things are "caused" because they are members of a particular form or category of things, such as a horse being "caused" by being a member of the species of horses**

- **Final causes: things are caused by bring about a particular end state, as in things designed for a purpose**

Using Plato's terminology, material and efficient causes are by "necessity", whereas formal and final causes are by "reason". Aristotle essentially followed Plato's basic ideas, but without introducing the concept of a "demiurge" (*i.e.* a deity).

Plato and Aristotle's views were eventually integrated into the doctrines of medieval Christianity. This was possible because their works were preserved by Irish monks and transmitted by Muslim scholars in northern Africa, Spain, and the southern Mediterranean.

Science and Religion

Most people have a "feeling" that nature is designed in some deep way. Most religions agree: the concept of God goes hand-in-hand with the concept of design in nature. This is even true for most religions that lack a deity.

However, the members of the National Academy of Sciences do not agree. The National Academy published a pamphlet entitled "Science and Creationism," followed by a book entitled *Teaching about Evolution and the Nature of Science*, in which the heliocentric theory of the solar system was used as an example of how to teach science. What the NAS overlooked is that all of the astronomers whose works were cited in the book — Copernicus, Kepler, Galileo, and Newton — were all "young Earth" creationists, a fact that was immediately pointed out by creationists.

The "Feeling of Design"

The "feeling of design" is central to all regions. In addition, religions generally provide their believers with a "feeling of hope" in addition to a "feeling of design in nature".

> **Houston Smith, a historian of religion, has said that "Hope is our prime resource." He believes that hope is essential to psychological and physiological health. Furthermore, Smith believes that Darwinian evolutionary theory "dashes all such hopes" and that Darwinian evolution is the antithesis of the best that religions have to offer.**

How do *you* feel about this (and how do scientists feel about it)?

• Pass out, complete, collect, and tally the modified Gallup poll on beliefs about evolution

The results of the survey on the origins of life and humanity have been tallied. I will put them on the board:

How do these results compare with the results of other similar polls?

Evolution Poll Results (% of sample)	Gallup Poll General Public	Gallup Poll College Graduates	Gallup Poll American Scientists	Evolution Course 2001 – 2011	Evolution Course 2001 – 2011
Young Earth Creationist	44	24	5	5	5
God-Guided Evolution	46	59	40	41	26
Intelligent Design					15
Naturalistic Evolution	10	17	55	54	54
Totals	100	100	100	100	100

Do American scientists believe in God?

James H. Leuba conducted a poll of American scientists in 1914, asking whether they believed, disbelieved, or were agnostics about this statement:

> **"I believe in a God in intellectual and affective communication with mankind, *i.e.* a God to whom one may pray in expectation of receiving an answer." By "answer" I do not mean the subjective, psychological effect of prayer.**

James H. Leuba poll of American scientists (1914):

- **percentage of American scientists who personally believed in God = 42 %**
- **percentage of American scientists who personally disbelieved in God = 41 %**
- **percentage of American scientists who personally were agnostics = 17 %**

Leuba repeated his poll of American scientists in 1933, following the Scopes "monkey" trial (which happened in Dayton, Tennessee in 1925).

James H. Leuba poll of American scientists (1933):

- **percentage of American scientists who personally believed in God = 15 %**
- **percentage of American scientists who personally disbelieved in God = 68 %**
- **percentage of American scientists who personally were agnostics = 17 %**

Edward J. Larson conducted a similar poll in 1998, using members of the National Academy of Sciences, the most prestigious scientific organization in the United States.

Edward J. Larson poll of the National Academy of Sciences (1998):

- **percentage of NAS members who personally believed in God = 7 %**
- **percentage of NAS members who personally disbelieved in God = 73 %**
- **percentage of NAS members who personally were agnostics = 20 %**

Do American scientists believe in life after death?

James H. Leuba also conducted a poll of American scientists in 1914, asking whether they believed, disbelieved, or were agnostics about this statement:

> **"I believe in immortality for all people…[or in] conditional immortality."**

James H. Leuba poll of American scientists (1914):

- **percentage of scientists who personally believed in life after death = 51 %**
- **percentage of scientists who personally disbelieved in life after death = 21 %**
- **percentage of scientists who personally were agnostics = 28 %**

James H. Leuba poll of American scientists (1933):

- **percentage of scientists who personally believed in life after death = 18 %**
- **percentage of scientists who personally disbelieved in life after death = 53 %**
- **percentage of scientists who personally were agnostics = 29 %**

Again, Larson conducted a similar poll in 1998, using members of the National Academy of Sciences

Edward J. Larson poll of the National Academy of Sciences (1998):

- **percentage of NAS members who personally believed in life after death = 8 %**
- **percentage of NAS members who personally disbelieved in life after death = 73 %**
- **percentage of NAS members who personally were agnostics = 19 %**

Conclusion: American scientists as a group have become significantly less religious during the 20th century, and the most prestigious scientists are nearly all atheists or agnostics.

What is the political context?

> **"There are many outstanding members of this academy ...some of whom are biologists...who are very religious."**
> **– Bruce Alberts, President of the National Academy of Sciences**

You have seen the results of Leuba and Larson's polls, and observed the trends those polls illustrate. Why does Alberts say this?

Most scientists in the National Academy of Sciences are partially funded by the National Science Foundation, which receives the bulk of its funding from American taxpayers.

The National Science Foundation never uses (nor allows the use of) the term "evolution" in grant applications, because its administrators fear that the American public (who are overwhelmingly religious and believe in some kind of supernatural modification of the history of life on Earth) would cut off funding for science that was tied to evolutionary theory.

However, as Larson has pointed out, although Alberts claims that there are "many" religious scientists,

> **"The evidence suggests otherwise."**
> **- Edward J. Larson**

Why has this happened? Is there something about scientific reasoning that causes scientists to become atheists or agnostics?

Scientific Method

Biology, like chemistry and physics, is an empirical science: it is based on observations of the real world. There are non-empirical sciences, such as mathematics and symbolic logic, which are formulated without direct observation of the real world. The theories of the empirical sciences, such as biology, are developed using a procedure called the scientific method.

Many people think that the scientific method is similar to magic, or is so difficult to understand and apply that only trained scientists can use it. Nothing could be further from the truth. The scientific method is basically just "common sense" consistently applied. In general, the scientific method consists of six or seven steps, beginning with observations of the real, natural world.

Step One: You observe the world around you, focusing on a particular object or process you find interesting:

- **For example, if you have never eaten an apple before, and you encounter a green apple growing on an apple tree, you might be tempted to sample it. You do, and the apple tastes sour.**

Step Two: You ask yourself a question about what you have observed:
You are curious as to whether all apples are sour, so you ask yourself the question, "Are all green apples sour?" You try another one, and it's sour too:

- **Another one - it's sour as well. Hmmm...**

Step Three: You formulate a hypothesis: that is, a tentative guess based on the pattern that you have observed so far:

- **Based on the foregoing observations, a reasonable hypothesis about green apples would be:**

"Green apples are sour"

Inductive Reasoning

There is a term used to describe the kind of reasoning that scientists use to formulate hypotheses: it is called inductive reasoning (or "induction"). Essentially, inductive reasoning is formulating a generalization based on a series of individual cases (*i.e.* arguing from the particular to the general).

Inductive reasoning is how virtually all human knowledge and understanding begins. Notice two things about any conclusions you might formulate using inductive reasoning:

- The validity of your generalization is only as good as the number of similar observations that you have used to formulate your generalization.

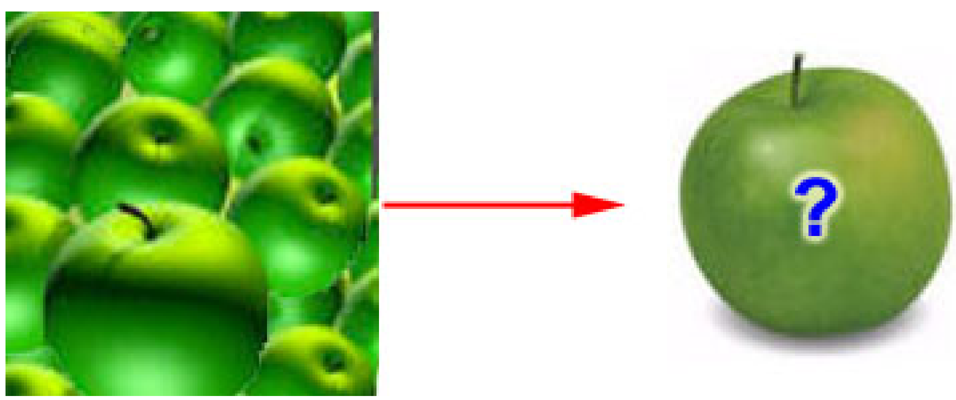
- Regardless of how many observations you may have made, you cannot be *absolutely* certain that the generalization that you have formulated is universally applicable. This is because you can only observe a small subset of all possible cases of whatever it is you are interested in. After all, no matter how many apples you bite, you might not (yet) have tasted a Granny Smith (a green apple that tastes sweet!)

Up to now, your reasoning processes have not really been any different than what everyone has always done. Even the ancient Greeks used inductive reasoning; what makes the scientific method different is what you do next.

Step Four: You formulate a prediction: that is, a guess about what will happen if you perform another observation in the light of your generalization.

- Your generalization was "Green apples are sour." Therefore, a logical prediction you might make is:

"This is a green apple; therefore, it is sour."



Deductive Reasoning

There is also a term used to describe the kind of reasoning that scientists use to formulate predictions based on hypotheses: it is called deductive reasoning (or "deduction"). Essentially, deductive reasoning is formulating a prediction about a specific case based on a generalization (*i.e.* arguing from the general to the particular). Deductive reasoning is how many of us make judgements about the objects and processes we see around us.

Two caveates about any predictions you might formulate using deductive reasoning:

- The validity of your prediction is only as good as your generalization. If your generalization is based on a small number of individual observations (especially only one), then it is unlikely to be very useful in making predictions that will be supported by further observation.

- **Regardless of how you have formulated your generalization (*i.e.* your hypothesis), if you do not then test it using one of the methods described below, you haven't really done any science. In fact, you haven't really done anything useful...yet.**

Step Five: You test your prediction; that is, make further observations that could either confirm or deny the validity of your hypothesis. There are two somewhat different ways to do this:

- **Make some more observations, similar to the ones that led you to formulate your hypothesis in the first place; this is called discovery science. In the case of your green apple hypothesis, this would consist of simply tasting another green apple (or two).**

- **Perform an experiment. This means performing two kinds of observations: an experimental test, where you manipulate the variable that you are testing, and a control test, where you do not manipulate the same variable. In the case of our green apples, there is no experimental or control test. However, in many tests of biological hypotheses, control tests are used to determine if the variable being manipulated actually affects the outcome.**

Note that whichever way you test your prediction (by further observations or by experiment), you are once again using inductive reasoning. This means that all of the conditions listed above still apply:

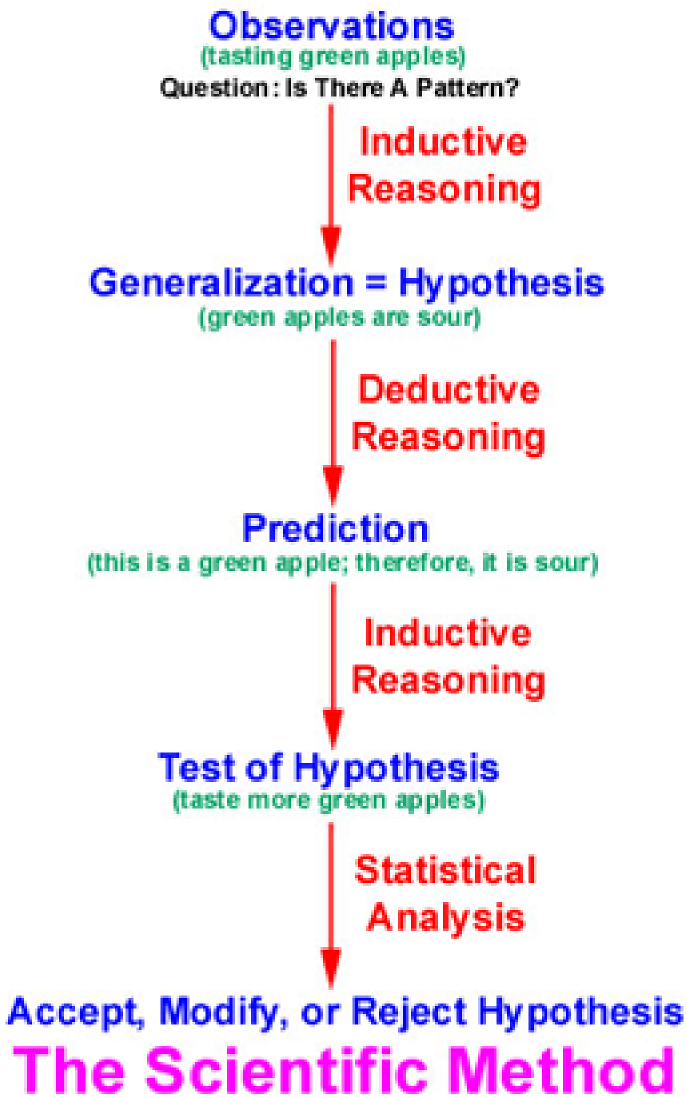
- **The validity of your conclusions is only as good as the number of similar observations that you have used to test your hypothesis.**

- **Regardless of how many observations you may have made, you cannot be absolutely certain that the hypothesis that you have tested and confirmed is universally applicable.**

- **Step Six: You compare your test results with the prediction that you made using your hypothesis. If the results are pretty close to the ones predicted, then you have confirmed your hypothesis. However, if the results are significantly different from the ones you predicted, you take the next (and in many ways the most important) step:**

Step Seven: You modify (or completely reformulate) your hypothesis and repeat all of the steps above.

- **So, you try another green apple, and this time (it's a Granny Smith) you discover it's sweet! What do you do? You modify your hypothesis: "*Most* green apples are sour, *except for Granny Smith apples*." And then you keep on testing...**



Theories and Laws

In science, a hypothesis that has been repeatedly tested and has not yet been shown to be invalid (*i.e.* all of it's predictions have worked out so far) is referred to as a theory. Notice that many non-scientists use the word "theory" to mean what a scientist means when s/he uses the word "hypothesis;" that is, a tentative guess about the way the world works, which has not yet been thoroughly tested.

When a scientist uses the word "theory," s/he is generally referring to what a non-scientist would call a scientific law. This difference in usage flows from the tendency of scientists to consider that virtually no scientific principle is ever completely confirmed; it's only as good as the experiments that have been done so far to test it. This means that what scientists refer to as "theories" generally have a great deal of evidence backing them up, more than alternative explanations.

In other words, scientific theories (such as the theory of evolution) are what most non-scientists would refer to as "scientific laws."

"Truth" in Science

One of the most important implications of the foregoing is that nothing is really "true" in science, using the commonly accepted definition of "truth:" that is, always and absolutely "true." All scientific theories are open to revision, and even a cursory look at the history of science indicates that theories that were once considered "true" are now either highly modified or have been thrown out altogether.

What is Science?

Science is our best current guess at how the universe works, until we find out otherwise.