

Evolution: The Darwinian Revolutions

BIOEE 2070 / HIST 2870 / STS 2871

DAY & DATE: Wednesday 18 July 2012

READINGS:

- Behe/ "Intelligent Design as an Alternative Explanation for the Existence of Biomolecular Machines" (provided in course packet)
- Dembski/"What Every Theologian Should Know About Creation, Evolution, and Design" (provided in course packet)
- Provine/"On Human Free Will" (provided in course packet)
- Ruse/*Darwin and Design: Does Evolution Have a Purpose?* chapters 11 & 12
- Wegner/*The Illusion of Conscious Will*. Chapter 3, pages 63 to 98 (provided in course packet)

Lecture 6:00-7:50: The Modern Evolutionary Synthesis and its Implications

Section 8:00-9:00: Discussion of the implications of evolution for human free will and purpose in nature

• **Essay #2 is due next Monday 23 July 2012:**

Please submit it as a Word .doc attached to an email, and paste a copy into the body of the email (just in case).

• **Research paper proposals are also due next Monday 23 July 2012:**

If you have decided to submit a research paper instead of essays #2 and #3, you must submit an outline and list of proposed references, again as a Word .doc attached to an email, and paste a copy into the body of the email.

• **Some of the readings for this section of the course are available at the course website:**

Behe, M. (1998) Intelligent design as an alternative explanation for the existence of biomolecular machines (unpublished manuscript)

Dembski, W. (2005) What Every Theologian Should Know About Creation, Evolution, and Design. *OrthodoxyToday.org* (<http://www.orthodoxytoday.org/articles/DembskiDesign.php>)

Dobzhansky, T. (1973) Nothing in biology makes sense except in the light of evolution. *American Biology Teacher*, March 1973, volume 35 pages 125 to 129

Kaviar, B. (2003) A history of the eugenics movement at Cornell. 2003 Tallman Prize winner. (unpublished manuscript)

MacNeill, A. (2011) *Evolution: The Darwinian Revolutions*, The Modern Scholar.

Mayr, E. (1982) *The Growth of Biological Thought: Diversity, Evolution, and Inheritance*, chapters 12 and 13

Provine, W. (1971) *The Origins of Theoretical Population Genetics*, chapter 5

Look for them in the "Course Packets" section of the course website at

<http://evolution.freehostia.com/course-packet/>

The password for the course packets is:

evolutioncp

Implications of the “Modern Evolutionary Synthesis”

The history of evolutionary theory has always been a history of controversy. As we have seen so far in this course, there have actually been three controversies:

- A controversy between evolutionary theory and widely held cultural beliefs, especially Christianity; Darwin made reconciliation between these two beliefs impossible, so long as religion (and especially Christianity) is not taken as largely metaphorical;
- A controversy between evolutionary biologists over the mechanisms and pace of evolutionary change; and
- A controversy between people who believe that evolution has a purpose and those who don't.

By the date of Darwin's death in 1882, evolution had been accepted by most scientists. Darwin's assertion that descent with modification was the source of animal and plant diversity was widely accepted in England, France, Germany, Russia, and the United States. It was not widely accepted by the general public (and still isn't, as indicated by the poll results presented in the second lecture).

However, Darwin's theory of natural selection was not widely accepted, even within the scientific community. Indeed, by 1900, many scientists believed that natural selection was defunct as the mechanism of evolution. It had been replaced by several non-Darwinian theories based on other proposed mechanisms. A description of this period is contained in Peter Bowler's book, *The Eclipse of Darwinism*, published in 1983.

The rise of Mendelian genetics, beginning in 1900 with the rediscovery of Mendel's experiments with garden peas, convinced many scientists that mutations were the real "engine" of evolution. This is essentially "discontinuous evolution," whereas Darwin's theory of evolution by natural selection is "continuous evolution."

- In 1894, William Bateson published [*Materials for the Study of Variation: Treated with Special Regard to Discontinuity in the Origin of Species*](#), in which he cataloged an astonishing array of phenotypic variations in domesticated and wild animals and plants, and proposed that such sudden “mutations” (*not* natural selection) were the basis for evolutionary change. He also coined the word “genetics”, using it to describe the process of inheritance as described by Mendel.
- Hugo DeVries, one of the "rediscoverers" of Mendel's theory of genetics, published [*Species and Varieties: Their Origin by Mutation*](#) in 1905. In it, he proposed that "macromutations" (that is, mutations that caused gross changes in the phenotypes of organisms) were the real "engine" of evolution. This view persisted for several decades, especially among Mendelian geneticists.

Beginning in 1905, some geneticists began studying variation in crop plants, such as corn and wheat. Unlike Mendelian variation, in which certain traits show either dominance or recessiveness (*i.e.* only two discontinuous character states), most traits were found to be the result of many genes coding for (and therefore modifying) the same traits. This produced a kind of “continuous variation,” which Darwin himself had asserted was necessary to provide the “raw material” for natural selection.

In the 1930s and 40s, the "evolutionary synthesis" occurred, in which Darwinian theory and the more recent investigations into continuous variation were combined with Mendelian genetics. Through the work of R. A. Fisher, J.B.S. Haldane, Sewall Wright, and Theodosius Dobzhansky, the theory of evolution was modified to show that changes in Mendelian gene frequencies could be explained in terms of natural selection. G. G. Simpson showed that the fossil record generally supported this view, and G. Ledyard Stebbins showed that the same principles applied to the evolution of plants.

Darwin's original question of the "origin of species" was also addressed as part of the "synthesis." Dobzhansky asserted that Darwin's principle of "reproductive incompatibility" was the basis for the splitting of an existing species into two or more new species. Ernst Mayr elaborated on this theme, proposing a model for speciation based on geographical isolation, especially in small populations at the periphery of larger panmictic populations. This concept, called allopatric speciation, became the dominant model for speciation and diversification at all taxonomic levels.

In 1959, the centennial of *The Origin of Species* and the 150th anniversary of the birth of Charles Darwin, the "modern synthesis" of Darwinian evolution and Mendelian genetics was celebrated in universities around the world. Among such celebrations was one at the University of Chicago, where many of the principle figures in the synthesis presented papers and socialized with the growing community of professional evolutionary biologists. Julian Huxley's book, *Evolution: The Modern Synthesis* (published in 1942), set the stage for this celebration, describing what he called "20th Century Darwinism." In it, Huxley argued that natural selection was the most important cause of evolutionary change, a position widely shared by most evolutionary biologists.



Tenets of the "Modern Evolutionary Synthesis"

From 1959 to 1964, most biologists (following Ernst Mayr's lead) agreed that evolutionary theory had been "unified" and that it had reached its penultimate form. Among the tenets of the "unified" theory of evolutionary biology at that time were the following:

- That evolution is best defined as "changes in allele frequencies in populations over time";
- That there is an essentially direct correspondence between genes and the traits for which they code;

- That genetic recombination is more important than mutation as a source of variation;
- That natural selection is the primary mechanism of evolution at all levels;
- That genetic drift is also an important mechanism in evolution, explaining changes (such as the “founder effect”) that happen in small populations;
- That the evolution of gross phenotypic characteristics (such as eyes, wings, etc.) is a good model of evolution at the molecular level;
- That the “biological species concept” provides an unambiguous and useful definition of all species;
- That speciation is virtually always the result of geographic isolation (i.e. allopatry);
- That macroevolution (i.e. the origin and evolution of higher taxa) proceeds via essentially the same mechanisms as microevolution (i.e. genetic drift, natural selection, and sexual selection); and
- That microevolution and macroevolution were both necessarily gradual (i.e. not saltatory).

What We Know Now About the “Modern Evolutionary Synthesis”

With a perspective of half a century, we now know that most of these tenets were either grossly inaccurate or just plain wrong. More recent research has shown:

- That much of evolution is selectively neutral, especially at the level of nucleotide sequences in DNA;
- That the genome of most organisms is chaotic, with bits and pieces of gene sequences being added, removed, and rearranged in nearly random patterns, often by “parasitic DNA”;
- That genes and traits are only weakly associated (i.e. the “one gene-one enzyme” theory does not apply to most of the genome, and when it does it does so in peculiar and unpredictable ways);
- That much of the genome of most organisms, especially eukaryotes such as ourselves, is stuffed with redundant sequences, modular gene segments, and regulatory regions which do not code for polypeptides at all, but some of which are nevertheless essential to phenotypic expression; and
- That phenotypic and protein evolution is largely decoupled from the evolution of much of the DNA sequence in most organisms, especially eukaryotes.
- That mutation is immensely important, not only as a source of evolutionary novelty but also as a source of overall genetic change, especially in short-lived organisms such as bacteria;
- That random genetic drift is not an important mechanism in evolution (and may not even exist);

- That macroevolution proceeds by fundamentally different mechanisms than microevolution, and that these macroevolutionary mechanisms are still largely unknown;
- That the biological species concept is largely inadequate to characterize species at many levels, and that adherence to it has inhibited research into the mechanisms of speciation; and
- That the mechanisms of speciation, like those of macroevolution, are still largely unknown.

As our knowledge of the whole genomes of several species (including humans, chimpanzees, dogs, round worms, and several bacteria) has shown, the vast majority of the underlying genetic code of living organisms does nothing like what the originators of the "modern synthesis" thought the genome was doing. It is essentially a "boiling chaos" of non-coding genetic information, which mutates at an astonishingly high rate, with effects that we have not yet begun to understand.

Natural Selection is an Effect, Not a Cause

This does not undermine the importance of natural selection in evolution, at least not insofar as it is believed to be the basis for adaptations. However, following John Endler's lead (in his landmark book, *Natural Selection in the Wild*, published in 1986), evolutionary biologists now no longer consider natural selection itself to be a "cause" of anything. It is, rather, an *effect*, caused by other processes, including:

- genetic variation (resulting from mutation and genetic recombination in all their multifarious forms),
- genetic inheritance (resulting from the expression of the genetic code, in all of its bewildering complexity),
- population expansion and contraction (resulting from the general tendency of organisms to produce more offspring than is necessary to replace themselves), and
- differential (i.e. unequal, non-random) survival and reproduction.

It is these four underlying conditions, working together, that produces the changes in genotype and phenotype that we call "natural selection."

The Importance of the "Engines of Variation"

Overall, the evolution of the theory of evolution has swung back and forth like a huge pendulum, in approximately fifty-year cycles:

- 1859 to 1909: Darwinian evolution by natural selection, replaced by evolution by macromutation (variation via unknown mechanisms → variation via macromutation)
- 1909 to 1959: evolution by macromutation, replaced by neo-darwinian gene-level microevolution (variation via macromutation → variation via micromutation)
- 1959 to 2011: neo-darwinian gene-level microevolution, replaced by multi-level selection and macroevolution via evolutionary developmental mechanisms (variation via micromutation →

variation via multiple genetic, epigenetic, and developmental mechanisms)

- 2011 to 2059: ???

In every case, the underlying focus has always been on the “engines of variation” and how they affect what George Gaylord Simpson called the “tempo and mode of evolution.” We will spend the last two weeks of this course exploring some of the “branches” of evolutionary theory that have evolved over the past fifty years, and attempt to predict where they will take us in the future.

Implications of the Theory of Evolution

As we discussed in our very first class, evolutionary biology is an *empirical* science. That means that **all of the principles of evolutionary biology are supported either directly or indirectly by observational (i.e. “empirical”) evidence.** The empirical scientific method is a powerful tool, a sword that cuts through confusion and misunderstanding. But, like any good sword, it is a dangerous weapon with two very sharp cutting edges.

Some evolutionary biologists have argued that there are philosophical implications of our discoveries and current understanding of evolutionary biology, implications that cut deeply into our most cherished beliefs. The following is an annotated list of such potential implications, along with attributions to the evolutionary biologist(s) who make such claims. In reading and discussing this list, we should always keep in mind two important caveats:

- That regardless of the content of any given implication, we should always add the qualifying phrase “as far as we can tell from the available empirical evidence,” and
- It may be *impossible* to obtain empirical evidence to either validate or falsify any or all of the implications listed.

If the latter is the case, we should be very careful to distinguish between philosophical implications that flow directly and logically from the available evidence, and those that require an empirically unsupportable “leap” of logic.

With these caveats in mind, here are some of the major implications of evolutionary theory that have been cited by philosophers, scientists, and theologians:

If evolutionary theory is a valid depiction of nature, then...

- The gods may not be dead, but they are *irrelevant*.
- Gods that work entirely through the laws of nature or that simply create the universe and then let it run without further interference are *untouched* by evolutionary theory.
- Such gods are utterly *pointless*.
- There is *no* life after death.
- There are no *natural* foundations for any theory of ethics.

- There is also no *ultimate* meaning in life, either individually or collectively.
- There is no *pre-existing* purpose in nature.
- Intentionality (i.e. "purpose") *does* exist; it evolves by means of natural selection.
- Human free will, as traditionally defined, does *not* exist.
- The feeling of free will is an *illusion*, and may itself be a product of natural selection.

Charles Darwin believed in all of these implications of the theory of evolution. However, Darwin believed that the loss of ultimate meaning in life and the idea of human free will carried little "sting." And, as shown by his exemplary life and fearless death, such a loss need have no effect on a person's ethics or meaning in life. Let's consider these implications in more detail:

The gods may not be dead, but they are *irrelevant*.

According to Richard Dawkins, Daniel Dennett, Greg Graffen, Sam Harris, Christopher Hitchens, Ernst Mayr, P. Z. Myers, William Provine, Michael Schermer, Victor Stenger, and a growing list of others (including me), Paley's argument from design is dead. A god (or gods) who is/are capable of creating a universe in which evolution by natural selection can produce living organisms (who go on to create all known purposeful artifacts and processes) has/have created a universe in which **design and purpose *emerge as products of evolution by natural selection***, rather than causing or guiding it. This kind of purpose is most emphatically *not* the kind of purpose to which Paley was referring, and cannot be used to "prove" the existence (or non-existence) of god(s) without falling victim to fatal logical circularity.

Gods that work entirely through the laws of nature or that simply create the universe and then let it run without further interference are *untouched* by evolutionary theory.

Deism (or its equivalent in "front-loaded intelligent design") is logically indistinguishable from atheism, insofar as the god(s) of deism do not communicate with us nor do they intervene in nature once they have created it. Therefore, their existence (or lack thereof) is utterly beyond our ability to prove or disprove using empirical methods. Even if they are assumed to exist (or once existed), their active participation in nature was limited to the first infinitesimal fraction of a trillionth of a second of the existence of the universe over 13 billion years ago, or perhaps to the creation of life on Earth 3.8 billion years ago. In either case, they no longer care about us at all, do not participate in our lives in an detectible way, and do not/cannot either communicate with us nor alter reality to either help or harm us.

Purely logical arguments for the existence (or non-existence) of god(s) are what predated Paley and natural theology; indeed, the bankruptcy of such arguments is what prodded Paley and the other natural theologians to formulate their theology in the first place. Virtually all philosophers and scientists for the past two centuries who have not begun with a prior commitment to theism have concluded that theistic explanations for the existence and attributes of nature are without empirical or logical foundation, and therefore *irrelevant* to science.

Such gods are utterly pointless.

This is because god(s) who are sufficiently powerful (i.e. are omnipotent) to create a set of natural laws that govern all events in the universe without further interference, and who know the outcome of all such events (i.e. are omniscient and omnipresent) and use such knowledge to create such a universe are logically neither personal nor will (nor even can) intervene in human affairs to bring about good ends or avert bad ones (i.e. they are not omnibenevolent).

This is why Richard Dawkins said that Darwin made it possible to be a “philosophically fulfilled atheist” and William Provine has asserted that evolutionary theory is the greatest "engine of atheism" ever devised. And while not all evolutionary biologists are not necessarily atheists, the vast majority (over 95%) are either atheists or agnostics.

There is *no* life after death.

Everyone who has died has stayed dead, and everyone who has come back to report on it has done so while still alive, including those who have had “near-death experiences.”



William Provine has repeatedly asserted that the theory of evolution necessarily implies that when you're dead, "you're dead, dead, dead!" (a quote he heard from a member of the Ithaca Unitarian Church). Professor Provine himself has suffered from a potentially fatal brain tumor, and has accepted his own mortality and that of those closest to him. He asserts that "the loss of gods is better for our rational minds and our emotional health."

Furthermore, from the standpoint of the natural sciences, the idea that there is some kind of "life after death" is logically absurd. Where would such a life take place, and how would we know about it? There are huge, intractable problems with the whole idea: What age would one be in the place where one exists after death? Why that age and not some other? What would one do there? and on and on...

There are no natural foundations for any theory of ethics.

Throughout history many people have argued that there are “natural” justifications for ethics, including evolutionary ones. However, all such arguments have been shown to be “naturalistic fallacies.”

As G. E. Moore conclusively showed,



“Is” does not entail “ought,” nor vice-versa.

While “is” statements (i.e. descriptions) can be *conditions* of “ought” statements (i.e. prescriptions), such prescriptions themselves cannot be logically derived from descriptions. They constitute two fundamentally different logical categories.

There is no *ultimate* meaning in life, either individually or collectively.

Although ultimate meaning in life cannot be empirically shown to exist, the proximate meanings that we find in life - our families, our friends, the rewards of life in our communities, our work, and all of the things that make day-to-day life livable - are more than enough to fill our lives with happiness and joy. Indeed, believing fervently in some "ultimate" meaning in life sometimes causes some people to ignore such sources of immediate happiness and enjoyment, and to live a life set apart from (and essentially denying the importance of) such proximate values.

There is no *pre-existing* purpose in nature.

As we discussed in our very first lecture, the empirical sciences explain all natural phenomena using only material and efficient causes. Aristotle’s “formal” and “final” causes, which constitute what we usually think of as “abstract rules” and “purposes” are not necessary for scientific explanations, and are therefore (like the gods discussed earlier) completely irrelevant to our understanding of how life and living organisms have come to be what they are.

Furthermore, although we can all immediately recognize a wide range of purposeful objects and processes in the world around us, it is a far from trivial exercise to define exactly what characteristics we can use to unambiguously identify such things as purposeful. This becomes critically important in evolutionary biology, as evolutionary adaptations are assumed to have “functions” that have most or all of the characteristics that we associate with purposefulness.

Intentionality (i.e. "purpose") *does* exist; it evolves by means of natural selection.



As Ernst Mayr pointed out in his landmark paper on this subject (Mayr, 1974; “Teleological and teleonomic: A new analysis”, which is available in your **Course Packet**), it is legitimate to assume that evolutionary adaptations have “functions”, as their purposefulness is contained in the underlying genetic and environmental “programs” that bring about such adaptations. However, the origin and evolution of such programs are not purposeful as far as we can tell.

Human free will, as traditionally defined, does *not* exist.

Although we can and do make choices, the choices we make are, as first posited by Democritus, “the fruit of chance and necessity” – they are either random or are determined by a combination of our genetic and evolutionary heritage and our personal histories. William Provine has asserted that evolutionary biology has eliminated the possibility of human free will. He is joined in this assertion by nearly all economists, psychologists, and sociologists, who assert that the idea of human free will (like the god(s) of deism) are irrelevant to our understanding of human behavior. Most of them would therefore take the additional (but metaphysical) step and assert that, since the concept of free will is irrelevant in understanding and predicting human behavior, it therefore does not exist.

The demise of free will is by far the most difficult implication of evolutionary theory for most people to accept. Even most atheists, including such prominent philosophers of evolutionary theory as Daniel Dennett, cannot accept the idea that human free will does not exist. According to a recent study of prominent evolutionary biologists (conducted by Greg Graffin and Will Provine), the vast majority of evolutionary biologists are atheists or agnostics, but the majority of them still believe that humans have free will.

Provine has also asserted that the concept of free will is one of the very worst ideas ever invented by humans, as it justifies and provides additional fuel for the basic human desires for blame and revenge.

- If free will does not exist (*i.e.* if all of our thoughts and actions are determined), then we cannot blame people for their actions, nor extract revenge
- This does *not*, however, mean we must therefore let them hurt us or other people)

Furthermore, the concept of "free will" is itself logically unintelligible. It cannot be defined in a way that avoids logical circularity or which does not contradict what we understand about nature and evolution.

The feeling of free will is an *illusion*, and may itself be a product of natural selection.

We often feel as if our actions are "free" and motivated by something we could call our "will." As Daniel Wegner points out in one of the readings for this lecture (available in the Course Packet), this illusion is generated in our nervous systems. Like all "feelings," it is fundamentally a neurochemical phenomenon that exists because it increased the reproductive success of our ancestors (relative to people who had no such "feelings").

- I believe that the ability to generate such an illusion makes it possible for us to use our own actions as a guide for future behavior, and that therefore the neurological mechanisms that produce the illusion of free will constitute an evolutionary adaptation that has evolved by natural selection.

Free Will and Determinism

The concept of **universal determinism** (i.e. that everything everywhere is determined by some omniscient, omnipotent, omnipresent entity or force) is both unprovable and irrelevant, especially with respect to the concept of "free will." According to the theory of evolution, human actions and motivations are entirely *locally* determined by a combination of heredity and environment and the interactions between them. However, and contrary to the beliefs of some scientists, one cannot reduce all human actions to chemistry and physics:

- For example, no one in this class has her or his parent's DNA. By the time you are the age of typical college student, every vestige of the original DNA that you received from your parent has been copied and recopied so often that the original molecules have been diluted to the point of non-existence. However, the *information* carried and transmitted by those molecules remains, is passed on, and is in many ways virtually immortal.
- This means that to entirely "reduce" genetic information to pure chemistry and physics, one must go back to the origin of genetic information over 3 billion years ago. This is quite literally impossible.
- However, it is possible to reduce the cause of human actions to a combination of genetic information and environmental influences, without inferring any other causes (such as supernatural influences or forces). Therefore, to assert that such supernatural influences or forces exist is pointless and irrelevant.
- According to this view of reality, what we think of as "free will" (i.e. the *illusion* of free will) is an emergent property of our evolved nature, which exists because in the past it made it more likely that our ancestors would survive and reproduce.
- In essence, our perception of the decisions that we have made "freely" in the past allows us to formulate a "theory of self" that we can then refer to as we make further choices in the future.

- This ability has the effect of producing greater predictability and regularity in our own behavior, and allows us to conform our behavior to what we perceive to be our best interests, given our ecological and social contexts.

According to Provine, philosophers escape from the problem of the indefinability of the concept of "free will" by erecting logically circular definitions of free will. They do this primarily to preserve some justification for revenge.

- Philosopher Ted Honderich defines "free will" in such a way as to preserve our "retributive desires" (*i.e.* our desire for revenge).

Consequences of the End of the Idea of Human Free Will

If Charles Darwin, Will Provine, and Daniel Wegner are right, we do not live on a planet on which organic beings have free will. Furthermore, Provine believes that the recognition of the absence of free will can be a great boon for the increase in kindness and understanding in society.

- He emphasizes that he is *not* saying that we should not stop people from doing things of which we do not approve.
- We *can* stop people from performing actions of which we do not approve without resorting to revenge.
- By not making monsters out of people who do "bad things" we make it possible to understand them and their motivations and to work to end the cycle of revenge.

At some level, all human behaviors (both bad and good) have this same "involuntary" quality as those described by Wegner – they are fully determined by our genetics and our personal histories. Hence, the concepts of both blame and praise are nonsensical, except insofar as they alter our behavior in the future...and when they do so, they are *determining* that behavior.

According to Provine, rather than expecting people to use their free will to act morally, we must recognize that children (and other members of society) can and must be programmed to act morally. Acting morally is *not* innate in humans, despite the assertions of some primatologists to the contrary. This also has implications for science and scientists:

- People (*i.e.* scientists) can be "programmed" (*i.e.* taught) to accept their hypotheses based on empirical evidence, rather than on their beliefs or desires.

Finally, if you accept the foregoing, it is also possible to see that science and religion can *agree*:

- Both counsel (for different reasons) that we should forgive sins, both those perpetrated against us and those we perpetrate against others.
- Both assert that revenge is *not* a justifiable human response, regardless of our desire that it be so.