Evolution: The Darwinian Revolutions

BIOEE 2070 / HIST 2870 / STS 2871

DAY & DATE: **Monday 30 July 2012**

READINGS:

- **Cosmides & Tooby/"Evolutionary psychology: A primer" Available at:** **http://www.psych.ucsb.edu/research/cep/primer.html**
- **MacNeill/"The capacity for religious experience is an evolutionary Adaptation for warfare."** ***Evolution and Cognition*****, vol. 10, no. 1, pp. 43-60 (provided in the course packet). See also:** **http://evolutionlist.blogspot.com/2006/04/capacity-for-religious-experience-is.html**
- **MacNeill/"Vertical Polygamy" Unpublished manuscript, 22 pp. (provided in the course packet). See also:** **http://evolutionlist.blogspot.com/2006/04/polygamy-de-facto-and-de-jure.html**
- **Ruse/*Darwin and Design: Does Evolution Have a Purpose?* chapter 15**

Lecture 6:00-7:50: **Sociobiology and Evolutionary Psychology**
Section 8:00-9:00: **Individual selection versus group selection**

Announcements:

• Essay #3 or your Research Paper is due this Wednesday 1 August 2012!
You *must* turn it in to your TA, preferably via email, but in any case,

ABSOLUTELY *NO* PAPERS WILL BE ACCEPTED AFTER WEDNESDAY 1 AUGUST AT 6:00 PM!

Sociobiology and Evolutionary Psychology

So far, we have been discussing the theory of evolution as applied to the physical characteristics of living organisms. But, what about behavior? Can the theory of evolution be applied to what animals do, as well as to what they look like and constructed?

Darwin thought so. In Chapter 7 ("Instincts") of the *Origin of Species*, he wrote:

- **"It will be universally admitted that instincts are as important as corporeal structure for the welfare of each species, under its present conditions of life. Under changed conditions of life, it is at least possible that slight modifications of instinct might be profitable to a species; and if it can be shown that instincts do vary ever so little, then I can see no difficulty in natural selection preserving and continually accumulating variations of instinct to any extent that may be profitable." (*Origin of Species, 1st Edition* (1859) pg. 209/Wilson, pp. 583-584)**

But could this idea be applied to human behavior? As we have already seen, Darwin didn't address the evolution of humans in the *Origin of Species*. However, he did address what most people would consider to be one of the hallmarks of human behavior: the tendency of humans to perform altruistic acts (that is, acts which appear to benefit someone besides the person performing them).

The evolution of altruism presented Darwin with a serious problem: how can natural selection produce a behavior that is apparently injurious to the individual performing it? For example, in honeybees, the workers will sting any animal that threatens their hive. They do this even though their stingers are usually so deeply implanted in the skin of the interloper that it tears out of the abdomen of the stinging worker herself, killing her. How can what appears to be suicide in honeybees evolve by natural selection, especially when one realizes that worker bees are also sterile (*i.e.* do not reproduce)? As Darwin posed the question:

- **"[I] will confine myself to one special difficulty, which at first appeared to me insuperable, and actually fatal to my whole theory. I allude to the neuters or sterile females in insect-communities: for these neuters often differ widely in instinct and in structure from both the males and fertile females, and yet, from being sterile, they cannot propagate their kind." (*Origin of Species, 1st Edition* (1859) pp. 235-236/Wilson, pg. 600)**

As usual, Darwin had an answer:

- **"This difficulty, though appearing insuperable, is lessened, or, as I believe, disappears, when it is remembered that selection may be applied to the family, as well as to the individual, and may thus gain the desired end. Thus, a well-flavoured vegetable is cooked, and the individual is destroyed; but the horticulturist sows seeds of the same stock, and confidently expects to get nearly the same variety; breeders of cattle wish the flesh and fat to be well marbled together; the animal has been slaughtered, but the breeder goes with confidence to the same family….Thus I believe it has been with social insects: a slight modification of structure, or instinct, correlated with the sterile condition of certain members of the community, has been advantageous to the community: consequently the fertile males and females of the same community flourished, and transmitted to their fertile offspring a tendency to produce sterile members having the same modification. And I believe that this process has been repeated, until that prodigious amount of difference between the fertile and sterile females of the same species has been produced, which we see in many social insects." (*Origin of Species, 1st Edition* (1859) pp. 237-238/Wilson, pg. 601)**

Far from being "fatal" to his theory, the existence of highly specialized sterile castes of social insects actually solved a problem for Darwin that would have been fatal to his theory had he not thought of it:

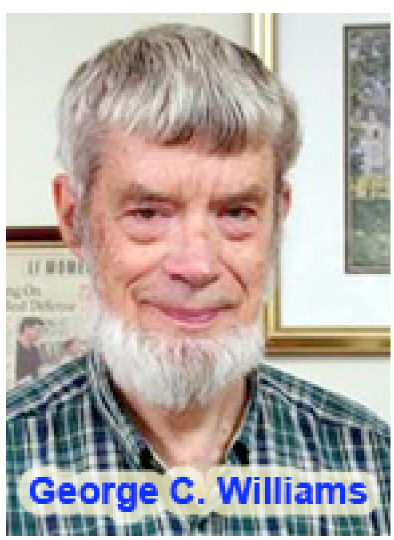
- "As ants work by inherited instincts and by inherited tools or weapons, and not by acquired knowledge and manufactured instruments, a perfect division of labour could be effected with them only by the workers being sterile; for had they been fertile, they would have intercrossed, and their instincts and structure would have become blended. And nature has, as I believe, effected this admirable division of labour in the communities of ants, by the means of natural selection. But I am bound to confess, that, with all my faith in this principle, I should never have anticipated that natural selection could have been efficient in so high a degree, had not the case of these neuter insects convinced me of the fact." (*Origin of Species, 1st Edition* (1859) pg. 242/Wilson, pp. 603-604)

Altruism and Group Selection

Darwin's suggestion – that natural selection seems to operate at the level of the "family", or more generally the "group" rather than the individual – prevailed for more than a century. Indeed, during the first part of the 20th century, the idea that social animals constituted a kind of "superorganism" was commonly believed.

This idea, which is based on the idea that individuals may perform behaviors that are injurious to themselves, but which can evolve because they benefit the group of which they are a member, culminated in the publication in 1965 of *Animal Dispersion in Relation to Social Behavior*, by V. C. Wynne-Edwards. In it, Wynne-Edwards argued that animals have various behavioral mechanisms, such as territoriality, dominance, courtship, etc., that have the effect of limiting their reproduction. According to Wynne-Edwards, these behaviors all evolved because they limited the population sizes of animal groups, which limited their destructive effects on their environment, and were therefore selected at the level of groups, rather than individuals.

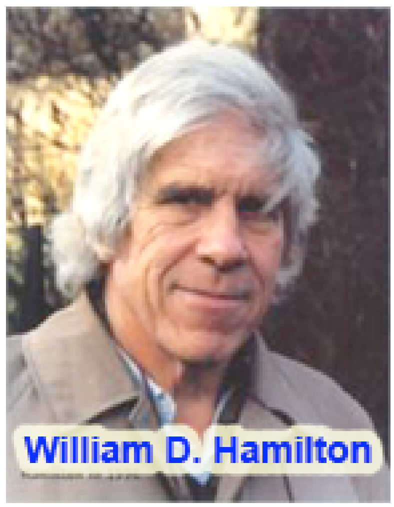
Wynne-Edwards' proposed mechanism of group selection generated intense controversy among evolutionary biologists, for whom selection at the level of individuals was the guiding principle of Darwinian evolution. In 1966, G. C. Williams published *Adaptation and Natural Selection: A Critique of Some Current Evolutionary Thought*, in which he demolished Wynne-Edwards' theory. Central to Williams' refutation was the following thought experiment:



- **Consider a group of animals living in a circumscribed environment (a flock of robins in the park, for example). Each member of the group foregoes maximizing her/his reproduction (*i.e.* has fewer offspring), with the result that the group lives in balance with its ecosystem. Now, consider what happens if only one of those individuals "cheats": that is, has as many offspring as possible. If that behavior is heritable, the group will quickly be overwhelmed with "cheaters", despite the advantages of restraint. Therefore, no matter how seemingly advantageous, altruism of this type will always be susceptible to replacement by reproductive maximizers.**

Kin Selection and Reciprocal Altruism

Although Williams' critique of Wynne-Edwards carried the day, it exacerbated the problem of the evolution of social behavior, particularly apparently altruistic behavior. The solution to this problem was finally provided by W. D. Hamilton, who in 1964 published "The genetical theory of social behavior" in the *Journal of Theoretical Biology*. In this landmark paper, Hamilton proposed the concept of kin selection, whereby the capacity for apparently altruistic behaviors can evolve because they benefit closely genetically related kin.



- **Hamilton pointed out that eusociality (a form of intense social behavior, characterized by the presence of sterile castes) has evolved multiple times in one group of insects: the Hymenoptera, in which the mechanism of sex determination causes females to be more closely related to their sisters than to their own offspring. This means that Hymenoptera have a predisposition to evolving eusociality, because females that assist their sisters in reproducing have a higher reproductive success *at the level of their shared genes* than females who have their own, solitary offspring.**

This idea – that natural selection operates at the level of genes rather than individuals – could explain the evolution of altruism and provide the basis for a new explanation of the evolution of social behavior. However, it did not address apparently altruistic acts between non-related individuals. That these occur is not disputed:

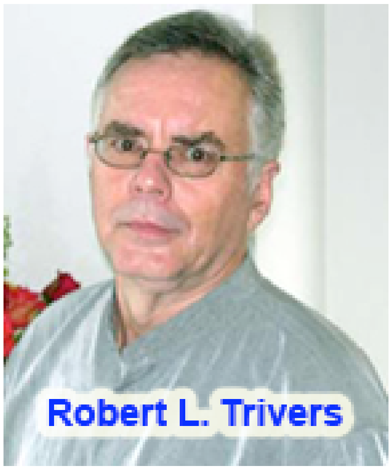
- **For example, there are many species of "cleaner fish", which make their living by picking the parasites off the skins (and occasionally even the insides of the mouths) of other, larger, unrelated fish.**

- **Another very common and seemingly altruistic behavior is the giving of alarm calls when a predator is spotted by a member of a group, such as a mixed flock of birds. Such alarm calls**

alert the other members of the group (regardless of species), while at the same time exposing the individual giving the alarm call to the predator.
- Many ungulate mammals (such as antelope and deer) perform a behavior called "stotting" when the detect a predator: they "bounce" up into the air while exposing a bright white tail and hindquarters. This alerts other members of the group (including other species) to the presence of the predator, while making the "stotter" more visible to the predator.

There are many other examples of such mutualistic symbioses between members of very different species. It is clear to see that the members of such symbioses benefit from them. What is not clear is how they could have gotten started in the first place, as there is always the temptation for either partner to "defect" and either eat the other partner (in the case of the cleaner fish), avoid the predator without giving an alarm call or stotting, or otherwise not acting altruistically.

A solution to this problem was proposed by Robert L. Trivers, who in 1971 published a paper entitled "The evolution of reciprocal altruism", in which he proposed a theory of reciprocal altruism, according to which apparently altruistic acts between unrelated individuals could evolve so long as they were consistently reciprocated. Trivers used mathematical game theory to show that mutualistic symbioses could evolve by natural selection so long as several conditions were met:



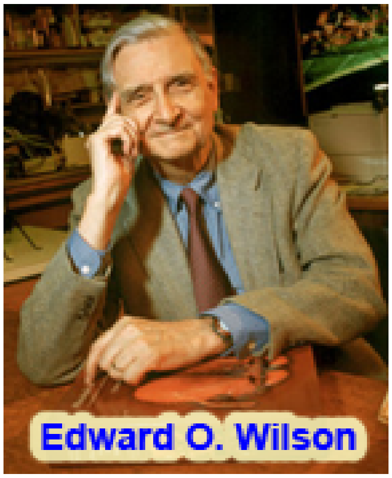
- Interactions between players in an evolving game were repeated, with no definite end to the game
- The units of exchange in each "play" of the game were relatively small and approximately equal in value
- The "players" reciprocated altruistic acts on the part of each other by reciprocal acts of their own
- The "players" in such a game could identify each other and remember each others' actions
- "Defectors" (*i.e.* non-cooperators) could be punished for defection

According to Trivers' theory, what ultimately determined whether altruism could evolve was neither trust nor love, nor even positive emotions of any kind, but rather *duration*: the longer two individuals interact, the more likely altruism is to evolve between them as the result of reciprocation. Trivers' theory was later amplified by the work of Robert Axelrod and W. D. Hamilton, who showed that the most effective strategy for evolving reciprocal altruism was a

strategy called "tit-for-tat": that is, to cooperate with the other player on the first iteration of the game, and then do exactly what the other player does in response from then on.

Sociobiology, The New Synthesis

Following the insights of Hamilton, Trivers, and their colleagues, a general theory of the evolution of social behavior was developed, culminating in 1975 in the publication of *Sociobiology: The New Synthesis*, by Edward O. Wilson. In this encyclopedic book, Wilson did for social behavior what Darwin did for evolution by natural selection: he grounded the new theory in a testable mechanism (actually, two mechanisms — kin selection and reciprocal altruism) and supported the theory with immense amounts of detail about the natural history of social behavior among a myriad of animals.



Unlike Darwin, however, Wilson did not shy away from discussing the implications of sociobiology for humans. Instead, he showcased those implications in the very first chapter of the book. In chapter 1 of *Sociobiology: The New Synthesis*, "The Morality of the Gene", Wilson wrote:

- **"Camus said that the only serious philosophical question is suicide. That is wrong even in the strict sense intended. The biologist, who is concerned with questions of physiology and evolutionary history, realizes that self-knowledge is constrained and shaped by the emotional control centers in the hypothalamus and limbic system of the brain. These centers flood our consciousness with all the emotions — hate, love, quilt, fear, and others — that are consulted by ethical philosophers who wish to intuit the standards of good and evil. What, we are then compelled to ask, made the hypothalamus and limbic system? *They evolved by natural selection*." (Wilson (1975) pg. 3)**

- **“The hypothalamic-limbic complex of a highly social species, such as man, "knows," or more precisely it has been programmed to perform as if it knows, that its underlying genes will be proliferated maximally only if it orchestrates behavioral responses that bring into play an efficient mixture of personal survival, reproduction, and altruism. Consequently, the centers of the complex tax the conscious mind with ambivalences whenever the organisms encounter stressful situations. Love joins hate, aggression, fear; expansiveness, withdrawal; and so on; in blends designed not to promote the happiness and survival of the individual, but to favor the maximum transmission of the controlling genes." (Wilson (1975) pg. 4)**

Sociobiology was even more controversial than Darwin's original theory of evolution by natural selection. In particular, it clashed with the dominant theories of human psychology and sociology, especially in the United States. Debates raged between Wilson's supporters, who believed that that evolutionary theory could be applied to social behavior at all levels, and Wilson's opponents, who believed that the theory was socially regressive and even dangerous.

Most intense of all the reaction of most social scientists, partly because Wilson explicitly proposed that such sciences as anthropology, economics, psychology, and sociology would eventually be subsumed under the heading of sociobiology as those disciplines became "biologicized." No one wants to think the field that one has dedicated one's life to will, in the fullness of time, be "cannibalized" (Wilson's term) by evolutionary theory. Many of them viewed sociobiology as just Spencerian "social darwinism" with a new face and a new vocabulary.

However, there were early converts to Wilson's program. Several anthropologists, psychologists, and even a few sociologists began to apply the principles of sociobiology to human behavior, proposing hypotheses and testing them empirically. Out of this work there has arisen several "biologicized" fields, including evolutionary psychology. Unlike Spencerian social darwinism, evolutionary psychology is based on the classical hypothetico-deductive method of empirical science, in which hypotheses are generated, predictions formulated and tested (usually using statistical analysis), and the results used to either validate or modify evolving theory.

Evolutionary Psychology: The Integrated Science of Human Behavior

Here is the introduction to "Evolutionary Psychology: A Primer", by Leda Cosmides & John Tooby, "Evolutionary Psychology: A Primer", two founders of evolutionary psychology (The complete text can be found at: http://www.psych.ucsb.edu/research/cep/primer.html):

- "The goal of research in evolutionary psychology is to discover and understand the design of the human mind. Evolutionary psychology is an *approach* to psychology, in which knowledge and principles from evolutionary biology are put to use in research on the structure of the human mind. It is not an area of study, like vision, reasoning, or social behavior. It is a *way of thinking* about psychology that can be applied to any topic within it…In this view, the mind is a set of information-processing machines that were designed by natural selection to solve adaptive problems faced by our hunter-gatherer ancestors."

Instincts and Human Behavior

In the final pages of the *Origin of Species*, Darwin made a bold prediction: "In the distant future I see open fields for far more important researches. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation."

Thirty years later (in 1890), William James tried to do just that in, *Principles of Psychology*, one of the founding works of experimental psychology. In *Principles*, James talked a lot about "instincts," a term he used to refer to what we would now call behaviors produced by specialized neural circuits that are common to every member of a species and are the product of that species' evolutionary history.

It is common to think that other animals are ruled by "instinct" whereas humans lost their instincts and are ruled by "reason", and that this is why we are so much more flexibly intelligent than other animals. James took the opposite view. He argued that human behavior is more flexibly intelligent than that of other animals because we have *more* instincts than they do, not fewer.

We tend to be blind to the existence of these instincts, however, precisely because they work so well -- because they process information so effortlessly and automatically. As a result, we do not realize that "normal" behavior needs to be explained at all.

- **Our natural competences -- our abilities to see, to speak, to find someone beautiful, to reciprocate a favor, to fear disease, to fall in love, to initiate an attack, to experience moral outrage, to navigate a landscape, and myriad others -- are possible only because there is a vast and heterogenous array of complex computational machinery supporting and regulating these activities.**

An evolutionary approach allows one to recognize what natural competences exist, it indicates that the mind is a heterogeneous collection of these competences and, most importantly, it provides positive theories of their designs.

- **An evolutionary focus is valuable for psychologists, who are studying a biological system of fantastic complexity, because it can make the intricate outlines of the mind's design stand out in sharp relief. Theories of adaptive problems can guide the search for the cognitive programs that solve them; knowing what cognitive programs exist can, in turn, guide the search for their neural basis.**

The Standard Social Science Model

A common view among philosophers and scientists has been that the human mind resembles a blank slate, often called a "tabula rasa," virtually free of content until written on by the hand of experience. Over the years, the metaphor used to describe the structure of the human mind has been consistently updated, from blank slate to switchboard to general-purpose computer, but the central tenet has remained the same.

According to this view, all of the specific content of the human mind derives from the "outside" — from the environment and the social world — and the evolved architecture of the mind consists of a small number of general purpose mechanisms that are content-independent: "learning," "induction," "intelligence," "imitation," "rationality," "the capacity for culture," or simply "culture."

- **The same mechanisms are thought to govern how one acquires a language, how one learns to recognize emotional expressions, how one thinks about incest, or how one acquires ideas and attitudes about friends and reciprocity -- everything but perception. This is because the mechanisms that govern reasoning, learning, and memory are assumed to operate uniformly,**

according to unchanging principles, regardless of the content they are operating on or the larger category or domain involved. Therefore, the contents of human minds are social constructions and the social sciences are autonomous and disconnected from any evolutionary foundation.

Three decades of progress and convergence in cognitive psychology, evolutionary biology, and neuroscience have shown that this view of the human mind is radically defective. Evolutionary psychology provides an alternative framework that is beginning to replace it. On this view, all normal human minds reliably develop a standard collection of reasoning and regulatory circuits (often called "modules") that are functionally specialized and, frequently, domain-specific. These circuits organize the way we interpret our experiences, inject certain recurrent concepts and motivations into our mental life, and provide universal frames of meaning that allow us to understand the actions and intentions of others. Beneath the level of surface variability, all humans share certain views and assumptions about the nature of the world and human action by virtue of these human universal reasoning circuits.

Five Basic Principles of Evolutionary Psychology

Psychology is that branch of biology that studies (1) brains, (2) how brains process information, and (3) how the brain's information-processing programs generate behavior. Once one realizes that psychology is a branch of biology, inferential tools developed in biology — its theories, principles, and observations — can be used to understand psychology.

Here are five basic principles, all drawn from biology, that evolutionary psychologists apply in their attempts to understand the design of the human mind:

Principle 1. The brain is a physical system that functions as a biological computer. Its neural circuits are adapted via natural selection to generate behavior that is appropriate to ecological circumstances. The brain is a physical system whose operation is governed solely by the laws of chemistry and physics. Therefore, all of our thoughts and hopes and dreams and feelings are produced by chemical reactions going on in our brains. The neural circuits of the brain are adapted to generate behaviors in response to information from the environment.

Principle 2. Our neural circuits were adapted by natural selection to solve problems that our ancestors faced during our species' evolutionary history. The reason we have one set of circuits rather than another is that the circuits that we have were better at solving problems that our ancestors faced during our species' evolutionary history than alternative circuits were. The brain is a naturally constructed computational system whose function is to solve adaptive information-processing problems (such as face recognition, threat interpretation, language acquisition, or navigation). Over evolutionary time, its circuits were cumulatively added because they "reasoned" or "processed information" in a way that enhanced the adaptive regulation of behavior and physiology.

Brains (and the minds that are hosted by them) are adapted to ecological situations that cropped up again and again during evolutionary history. In particular, they are adaptations to circumstances that affected the *reproduction* of individual organisms — however indirect the causal chain may be, and however small the effect on number of offspring produced. This is because differential reproduction (and not survival *per se*) is the engine that drives natural selection.

- **Consider the fate of a neural circuit (and its associated behavior) that had the effect of enhancing the reproductive rate of the individuals that had it, but shortened their average lifespan in so doing (one that causes a mother to risk death to save her children, for example). If this effect persisted over many generations, then its frequency in the population would increase, regardless of the effects on the lifespan of individuals.**

- **By contrast, consider a neural circuit whose average effect was to decrease the reproductive rate of the organisms that had it. Eventually, it would disappear from the population. Most adaptive problems have to do with how an organism makes its living: what it eats, what eats it, who it mates with, who it socializes with, how it communicates, and so on. The *only* kind of problems to which natural selection can adapt neural circuits are adaptive problems.**

Obviously, we are able to solve problems that our hunter-gatherer ancestors never faced — we can learn math, drive cars, use computers. Our ability to solve other kinds of problems is a side-effect or by-product of circuits that were designed to solve adaptive problems.

- **For example, when our ancestors became bipedal -- when they started walking on two legs instead of four -- they had to develop a very good sense of balance. We have very intricate mechanisms in our inner ear that allow us to achieve our excellent sense of balance. The fact that we can balance well on two legs while moving means that we can do other things besides walk -- it means we can skateboard or ride the waves on a surfboard. However, the fact that we can surf and skateboard are mere by-products of adaptations designed for balancing while walking on two legs.**

Principle 3. Consciousness is just the tip of the iceberg; most of what goes on in our minds is hidden from us. As a result, our conscious experience can mislead us into thinking that our circuitry is simpler that it really is. Most problems that we experience as easy to solve are very difficult to solve -- they require very complicated neural circuitry. We are not, and cannot become, consciously aware of most of our brain's ongoing activities. The vast majority of our behavior — things like breathing, balancing while we walk, blinking our eyes to keep them moist, and so forth — is initiated and regulated by our autonomic (*i.e.* "unconscious" and involuntary) nervous systems. The only behaviors (including motivations and "thoughts") we become aware of are a few high level conclusions passed on by thousands and thousands of specialized mechanisms that are gathering sensory information from the world, analyzing and evaluating that information, checking for inconsistencies, filling in the blanks, and producing adaptive responses.

- **Our conscious experience of an activity as "easy" or "natural" can lead us to grossly underestimate the complexity of the circuits that make it possible. Doing what comes "naturally", effortlessly, or automatically is rarely simple from an engineering point of view. To find someone beautiful, to fall in love, to feel jealous -- all can seem as simple and automatic and effortless as opening our eyes and seeing, so simple that it seems like there is nothing much to explain. But these activities feel effortless only because there is a vast array of complex neural circuitry supporting and regulating them.**

Principle 4. Different neural circuits are specialized for solving different adaptive problems. A basic engineering principle is that the same machine is rarely capable of solving two different problems equally well. We have both screw drivers and saws because each solves a particular problem better than the other. Just imagine trying to cut planks of wood with a screw driver or to turn screws with a saw.

• Our minds consist of a large number of circuits that are *functionally specialized*. For example, we have some neural circuits that are adapted for vision — all they do is help us see. Other neural circuits are adapted for hearing — all they do is detect changes in air pressure, and extract information from it. They do not participate in vision, vomiting, vanity, vengeance, or anything else. Still other neural circuits are adapted for sexual attraction — *i.e.,* they govern what we find sexually arousing, what we regard as beautiful, who we'd like to date, have sex with, and so on.

An essential corollary of this concept is that the brain must be composed of a large collection of circuits, with different circuits specialized for solving different problems. We can think of each of these specialized circuits as a mini-computer running a sub-routine program that is dedicated to solving one problem. Such dedicated mini-computers and sub-routines are often called *modules*. We can view the brain as a collection of dedicated mini-computers and sub-routines — a "confederacy of modules." More precisely, we can view the brain as a collection of dedicated mini-computers and sub-routines whose operations are *functionally integrated* to produce behavior.

Until recently, it was thought that most cognitive functions — learning, reasoning, decision-making, etc. — were thought to be accomplished by circuits that are very general purpose. Prime candidates were "rational" algorithms that implement formal methods for inductive and deductive reasoning. "General intelligence" — a hypothetical faculty composed of simple reasoning circuits that are few in number, content-independent, and general purpose — was thought to be the engine that generates solutions to reasoning problems.

An evolutionary perspective suggests otherwise. Biological computers are calibrated to the environments in which they evolved, and they embody information about the recurring properties of these ancestral worlds. Evolved problem-solvers are equipped with crib sheets: they come to a problem already "knowing" a lot about it.

- **For example, a newborn's brain has response systems that "expect" faces to be present in the environment: babies less than 10 minutes old turn their eyes and head in response to face-like patterns, but not to scrambled versions of the same pattern with identical spatial frequencies.**
- **Toddlers have a well-developed "mind-reading" system, which uses eye direction and movement to infer what other people want, know, and believe. (When this system is impaired, as in autism, the child cannot infer what others believe.)**
- **Without these privileged hypotheses -- about faces, objects, physical causality, other minds, word meanings, and so on -- a developing child could learn very little about its environment. For example, a child with autism who has a normal IQ and intact perceptual systems is, nevertheless, unable to make simple inferences about mental states. Children with Williams syndrome are profoundly retarded and have difficulty learning even very simple spatial tasks, yet they are good at inferring other people's mental states. Some of their reasoning mechanisms are damaged, but their mind-reading system is intact.**

***Homo sapiens* are thought of as the "rational animal", a species whose instincts, made unnecessary by culture, were erased by evolution. But the reasoning circuits and learning circuits discussed above have the following five properties:**

- **they are complexly structured for solving a specific type of adaptive problem**
- **they reliably develop in all normal human beings**

- **they develop without any conscious effort and in the absence of any formal instruction**
- **they are applied without any conscious awareness of their underlying logic**
- **they are distinct from more general abilities to process information or behave intelligently.**

Principle 5. Our modern skulls house a stone-age mind. Natural selection, the process that produced and adapted our brain, takes a long time to produce a circuit of any complexity. Even relatively simple changes can take hundreds of generations. The environment in which humans — and, therefore, human *minds* — evolved was very different from our modern environment.

- **Our ancestors spent well over 99% of our species' evolutionary history living in hunter-gatherer societies. That means that our forebearers lived in small, nomadic bands of a few dozen individuals who got all of their food each day by gathering plants or by hunting animals. Each of our ancestors was, in effect, on a camping trip that lasted an entire lifetime, and this way of life endured for most of the last 10 million years. Generation after generation, for at least 10 million years, natural selection slowly sculpted the human brain, favoring circuitry that was good at solving the day-to-day problems of our hunter-gatherer ancestors — problems like finding mates, hunting animals, gathering plant foods, negotiating with friends, defending ourselves against aggression, raising children, choosing a good habitat, and so on. Those whose circuits were better designed for solving these problems left more children, and we are descended from them.**

- **The world that seems so familiar to us, a world with roads, schools, grocery stores, factories, farms, and nation-states, has lasted for only an eyeblink of time when compared to our entire evolutionary history. The computer age is only a little older than the typical college student, and the industrial revolution is a mere 200 years old. Agriculture first appeared on earth only 10,000 years ago, and it wasn't until about 5,000 years ago that as many as half of the human population engaged in farming rather than hunting and gathering. Natural selection is a slow process, and there just haven't been enough generations for it to design circuits that are well-adapted to our post-industrial life.**

The key to understanding how the modern mind works is to realize that its circuits were not adapted to solve the day-to-day problems of modern Americans — they were adapted to solve the day-to-day problems of our hunter-gatherer ancestors. These stone age priorities produced a brain far better at solving some problems than others.

- **For example, it is easier for us to deal with small, hunter-gatherer-band sized groups of people than with crowds of thousands; it is easier for us to learn to fear snakes than electric sockets, even though electric sockets pose a larger threat than snakes do in most American communities. In many cases, our brains are *better* at solving the kinds of problems our ancestors faced on the African savannahs than they are at solving the more familiar tasks we face in a college classroom or a modern city. In saying that our modern skulls house a stone age mind, we do not mean to imply that our minds are unsophisticated. Quite the contrary: they are very sophisticated computers, whose circuits are elegantly designed to solve the kinds of problems our ancestors routinely faced.**

For this reason, evolutionary psychology is relentlessly past-oriented. Cognitive mechanisms that exist because they solved problems efficiently in the past will not necessarily generate adaptive behavior in the present. Indeed, evolutionary psychologists reject the notion that one has "explained" a behavior pattern by showing that it promotes fitness under modern conditions.

These five principles are tools for thinking about psychology, which can be applied to any topic: sex and sexuality, how and why people cooperate, whether people are rational, how babies see the world, conformity, aggression, hearing, vision, sleeping, eating, hypnosis, schizophrenia and on and on. The framework they provide links areas of study, and saves one from drowning in particularity. Whenever you try to understand some aspect of human behavior, they encourage you to ask the following fundamental questions:

- **Where in the brain are the relevant circuits and how, physically, do they work?**
- **What kind of information is being processed by these circuits?**
- **What information-processing programs do these circuits embody?**
- **What were these circuits adapted to (in a hunter-gatherer context)?**

Two Testable Predictions From Evolutionary Psychology

Now that we have discussed the basics of evolutionary psychology, let's consider two examples that may help to illustrate the outlook that evolutionary psychologists take to analyzing human behavior. One of these examples is what most people would agree is "good" — that is, socially desirable. The other is not; it is simply the result of natural selection, which is neither "good" nor "bad."

Incest Avoidance

It is a generally accepted principle in human psychology that humans will avoid incest whenever possible. That is, they will avoid marrying or having sex with close relatives, usually defined as parents, offspring, siblings, and close cousins. In classical (*i.e.* Freudian) psychology, this avoidance is explained by reference to the "oedipus complex" whereby male children are theorized to be sexually attracted to their mothers and therefore view themselves as rivals with their fathers for their mother's attention. This conflict is supposedly resolved by the development of the "superego," which is the set of socially defined rules by which adults generally govern their behavior.

However, the explanation for incest avoidance that is advanced by evolutionary psychologists is quite different. It is based on a few simple evolutionary principles:

- **Close genetic relatives are, for reasons of mendelian genetics, much more likely to share recessive lethal alleles**
- **Matings between close genetic relatives therefore have a much higher probability of producing either maladapted or dead offspring (*i.e.* have relatively low reproductive success)**

- **Therefore, individuals who *for whatever reason* avoid having sex with their close genetic relatives will have higher reproductive success, and therefore the mechanism by which they avoided such matings will be positively selected (*i.e.* will increase in frequency in the population).**

An immediate question comes to mind: what is the mechanism by which this incest avoidance is accomplished? In other animals, it appears to be regulated by a combination of chemical and visual signals. However, in humans the mechanism is surprisingly simple: you simply do not develop any sexual attraction to anyone with whom you lived in constant close proximity during early childhood.

- **This effect, known as the kibbutz effect (also called the Westermarck effect, after its discoverer, Edvard Westermarck), was first noticed among children raised communally in Israeli kibbutzim. In these "communalist" societies, children are raised communally by the group, rather than by their parents. This means that genetically unrelated girls and boys are raised together during early childhood. Although the organizers of the kibbutzim expected (and wanted) otherwise, children who were raised together in this way virtually never marry each other. When interviewed, they reported that they felt almost no sexual attraction to the people with whom they were raised, regardless of their degree of genetic relatedness. In other words, a neurological (and probably also hormonal) mechanism (*i.e.* the inhibition of sexual attraction for people you are raised with as a child) has been positively selected in humans because it results in increased reproductive success.**

Stepfather Infanticide

At first glance, it would seem that infanticide (i.e. the killing of one's infant offspring) would always be selected against. However, observations of both humans and non-human mammals indicates that infanticide is not uncommon. In particular, male African lions and male hanuman langurs (a species of monkey that lives in India) are notorious for sometimes killing the babies of the females with whom they live. This behavior seems maladaptive; wouldn't the males who commit infanticide be selected against? However, upon closer examination, an evolutionary explanation becomes obvious:

- **The females of both African lions and hanuman langurs live in closely related kin groups (*i.e.* lion "prides" or langur "troops"). When male offspring are born, they are raised by these female groups until they reach puberty, and then they are driven from the pride/troop. Upon reaching adulthood, males re-enter a pride/troop, often killing or driving away the previous dominant adult male(s). They then kill all of the infants fathered by the male(s) they have killed or driven off. This forces the females into estrus (*i.e.* they come back into "heat" and are**

able to mate again). This means that all of the infants fathered and provisioned by the new male will be his, thereby increasing his reproductive success.

Human infanticide is usually explained as the result of social conditions, such as poverty and social stress, which is supposed to cause parents to become temporarily violent and "accidentally" injure or kill their offspring. However, this hypothesis does not predict that there will be any differences between male and female rates of infanticide, nor that there will be any effect of genetic relatedness.

However, demographic research conducted on human infanticide in Canada and the United States indicates that the overwhelming majority of infant injuries and deaths are caused by stepfathers. This is precisely the pattern that one would predict if the tendency toward infanticide were influenced by whatever neurological/hormonal processes were producing infanticide in African lions and hanuman langurs.

Where Do We Go From Here?

It seems likely that the theories of evolutionary psychology will continue to elucidate the evolutionary reasons for much of our behavior. What are the implications of this for our view of ourselves? That will be the topic of our final lecture in this course.