

Lecture 2. Uses of Evolutionary Biology (cont.), Evolution versus Creationism

EEB 2245, C. Simon, 9 March 2017

Most Serious Threats 2017, 2016, 2015, 2013, 2011, 2010, 2009, 2008, 2006, 2004

Highest percentages for each year are marked in bold; years are ordered as above.

- **1) Climate Change** (global warming, sea level rise, severe weather, greenhouse gasses)
- [25%, 23%, 15%, 20%, 17%, 20%, 27%, 20%, 12%, 10%]
- **2) Pollution/loss of resources** (air, water, drought, solid waste, nitrification, nuclear accidents, nuclear waste, industrialization, overconsumption, loss of fossil fuels)
- [24%, 25%, 39%, 24%, 39%, 26%, 31%, 30%, 22%, 23%]
- **3) Cultural conflict:** (Intolerance, ignorance, racism, religious fundamentalism, repression of women, homophobia; Politics- corruption, greed, unequal distribution of wealth, globalization, corporate corruption, poverty, hunger, War/terrorism)
- [20%, 18%, 17%, 23%, 25%, 26%, 15%, 20%, 33%, 27%]
- **4) Loss of biodiversity** (extinction, habitat conversion, deforestation, poaching, urbanization/invasive species, invasive genes, over-fishing, famine, bee decline).
- [16%, 21%, 09%, 23%, 08%, 12%, 07%, 18%, 12%, 16%]
- **5) Emerging diseases** (AIDS and other new viruses, Cancer from cigarettes/ozone depletion, obesity, lack of access to medical care, antibiotic resistant staph & other deadly bacteria, medical law suits, lack of sanitation, H5N1 bird flu, and their spread due to globalization, epidemics)
- [06%, 09%, 00%, 03%, 07%, 04%, 04%, 12%, 12%]
- **6) Overpopulation-** This influences many of the other categories.
- [04%, 07%, 14%, 11%, 09%, 09%, 16%, 08%, 09%, 11%]
- **7) Natural Disasters or other.**
- [4%]

Uses of Evolutionary Biology to address threats (cont.)

Threat: Loss of Biodiversity

Phylogenetic Solutions related to Wildlife & Fisheries

- Understanding population structure helps predict probability of extinction
- Hybridization can cause extinction
- Genetic identification of stocks aids management
- Understanding natural selection:
- Artificial selection by human fishing rules that require fishermen to take only large fish.
- Question: What do you predict will be the effect on age/body size of first reproduction?

Threat: Loss of Biodiversity

Evolutionary Solutions for
Endangered Species Conservation

Case Study: Phylogenetic analyses based on molecular genetic data and the detection of illegal hunting and sale of wildlife

Detecting Sale of Protected-Whale Meat

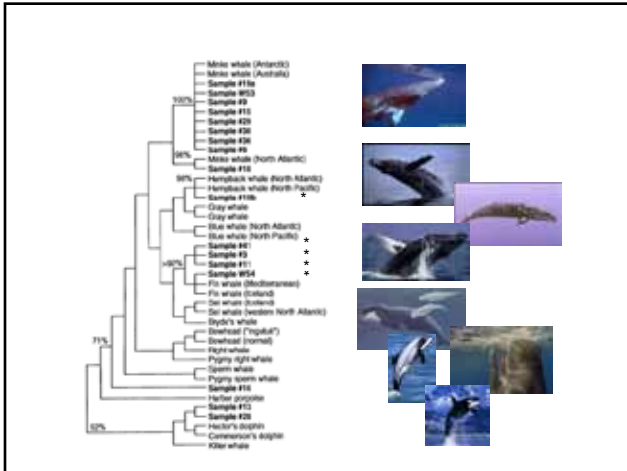
- Global moratorium on commercial harvest of endangered cetaceans- International Whaling Commission, 1985
- Whaling of non-endangered species still allowed in eastern Asia and Scandinavia
- Small cetaceans like porpoises or dolphins are legal to harvest but some whale species are protected

Detecting Sale of Protected-Whale Meat

- In the early 1990' s Baker and Palumbi began purchasing "whale products" from Asian markets for mtDNA analysis
- By comparing unknown samples against a reference database of cetacean mtDNA sequences, they were able to identify species and sometimes geographic source of each sample

Detecting Sale of Protected-Whale Meat

- By 1999, 954 samples of "whale meat" had been purchased in Japan and Korea
- 773 were from whales, 9% were from protected whale species (including blue, humpback, fin and Bryde' s whales)
- Samples that were not from whales included dolphins, porpoises, sheep and horses
- Led to demands that whales be genetically typed to monitor distribution



Threat: Loss of Biodiversity

Genetically Engineered Organisms

- Risk assessment issues have shifted
- From concern over transgenic organisms
- To long-term effects of hybridization w/ wild relatives
- E.g., introgression of herbicide resistance genes, into wild relatives of crops
- Creating problem weeds
- Engineered traits could contaminate wild relatives (storehouses of genetic diversity).

Threat: Loss of Biodiversity

Case Study: Risk of Transgene Spread from *Brassica napus* to *Brassica campestris*

- hybridization and introgression of herbicide (glufosinate) tolerant genes from oilseed rape (*B. napus*; mustard family) to its wild relative *B. campestris*
- just two generations of hybridization and backcrossing in the field produced → fertile transgenic weedy plants
- Suggests a possible rapid spread of transgenes from oilseed rape to its weedy relative



Threat: Intolerance, wealth disparity

• **Intolerance:** cultural conflict, mutual distrust, ignorance, racism, religious fundamentalism, repression of women, homophobia; **Politics-** bad politicians, corruption, unstable economy, fascism, capitalism, greed, globalization, economic crash, human error, corporate corruption, poverty, hunger, joblessness, child labor, malnutrition, over-nutrition, misuse of technology, crime, drugs, apathy, illiteracy, devaluing knowledge;

War/ Terrorism- violence nuclear weapons, nuclear proliferation

Threat: intolerance**No genetic basis for racism**

Studies of genetic variation in humans demonstrate that ...

- There is much more genetic variation within races than among races
- Human populations have experienced admixture throughout their histories
- All humanity is a single lineage sharing a common evolutionary fate.

Threat: intolerance

A belief in religion does not rule out a belief in evolution

- An understanding of evolutionary principles leads to a predictive understanding of the natural world.
- An understanding of the history of evolutionary biology, specifically the debate between creationists and evolutionary biologists, reveals the fallacy of fundamentalism.

True or False: The Catholic Church supports the teaching of Evolution.



Your text, Futuyma 3e, points out.....

In the history of evolutionary biological thinking, what were the two major shifts in worldview that took place in the 1700's and 1800's?

- 1) From phenomena explained by divine intervention to phenomena explained by natural processes.
- 2) From a static universe to a changing universe.

More 2012 Gallup Poll Results

“Which of the following statements comes closest to your views on the origin and development of human beings?”

- a) Human beings have developed over millions of years from less advanced forms of life but God guided this process
- b) Human beings have developed over millions of years from less advanced forms of life but God had no part in this process
- c) God created human beings pretty much in their present form at one time within the last 10,000 years or so.

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PEW Trust Poll

- "Humans and other living things have evolved over time"
 - Scientists
 - General US public
- "Humans and other living things have existed in their present form since the beginning of time,"
 - Scientists
 - General US public

PEW Trust Poll

- "Humans and other living things have evolved due to natural processes such as natural selection"
 - Scientists
 - General US public
- "A supreme being guided the evolution of living things for the purpose of creating humans and other life in the form it exists today."
 - Scientists
 - General US public

Presidential words on science, religion, and the teaching of evolution: Barak Obama, George W. Bush, Ronald Reagan, or Woodrow Wilson?

- “Of course, like every other man of intelligence and education I do believe in organic evolution.
- It surprises me that at this late date such questions should be raised.

Source: National Center for Science Education

In 1987, a US Supreme Court decision banned teaching of the biblical story of creation in public schools.

Did this stop proponents of creationism from attempting to insert their religion into the classroom?

Take a Guess: In 2003, in how many US states was legislation introduced to require teaching creationism alongside evolution?



“Well Toto, I don’t think we are in Kansas anymore!”

Some well-known recent challenges to science education:

- 2004 Georgia State K-12 science education standards
- 2005 Kansas State Board of Education public school science standards
- 2005 Warning stickers on Georgia public school science textbooks “evolution is a theory, not a fact”
- Question: What is a theory?

On 7 August 2012, voters in Missouri overwhelmingly approved an amendment to the state constitution regarding religious freedom.

"...no student shall be compelled to perform or participate in academic assignments or educational presentations that violate his or her religious beliefs."

2012- TN passes "monkey bill" to "teach the controversy"

Landmark trials: The Monkey Trial..

Clarence Darrow & William Jennings Bryan, 1925



<http://law2.umkc.edu/faculty/projects/ftrials/scopes/scopes.htm>

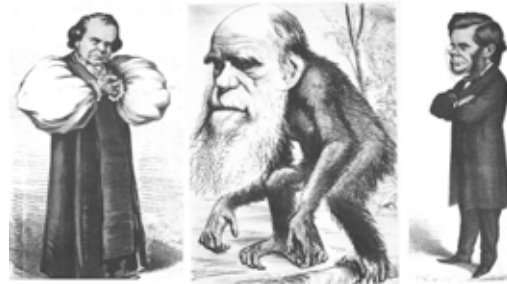
Are humans descended from monkeys?

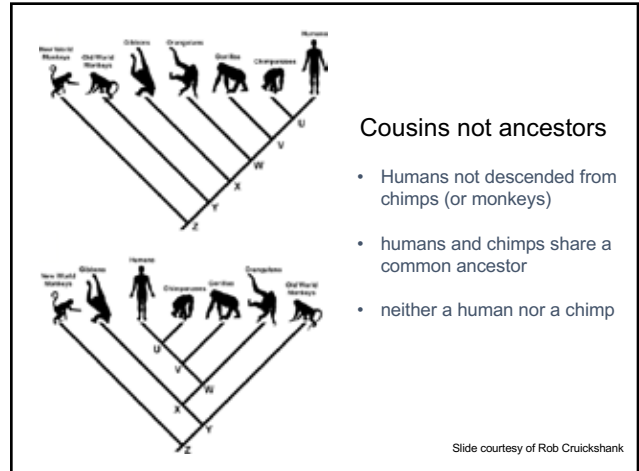
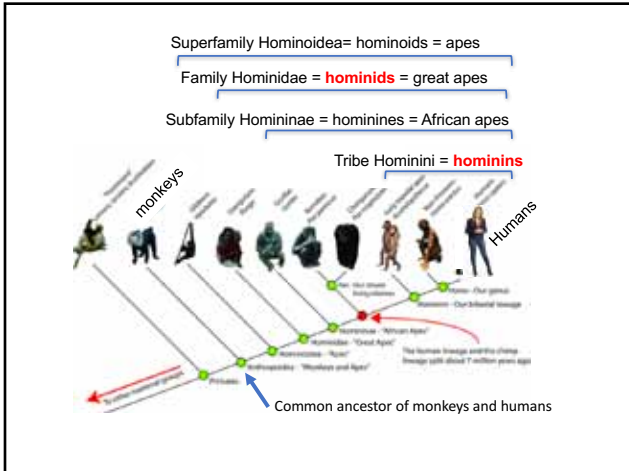
"I believe in Genesis 1:1 -- God created the heavens and the earth...If the governor wants to believe that he is the descendant of a monkey, then he has the right to believe that -- but I disagree with him on this and the many other liberal beliefs.

-- a politician, 2001

1860 Oxford Evolution Debate

Thomas Huxley, Joseph Hooker, Bishop Samuel Wilberforce, Robert Fitzroy





Intelligent Design. A term that originated in the 19th century

Started to take its present form in the 1960's and 1970's; co-opted for political purposes more recently.

Argues for "irreducible complexity"

Impossibility of evolution of complex organs or biochemical systems because, e.g., "half an eye would not work"

Uses reasoning by incredulity, "How could that be?"

Landmark trials-

2005 Kitzmiller vs Dover

<https://www.youtube.com/watch?v=7HZzGXnYL5I>

I highly recommend the entire video for viewing in preparation for the first real quiz.

The Case ...

30:58-36:22 Science teachers asked to read statement (5.5 min)

Intelligent Design vs Evolution...

1:03:31- 1:14 Is a flagellum irreducibly complex? (9 min)

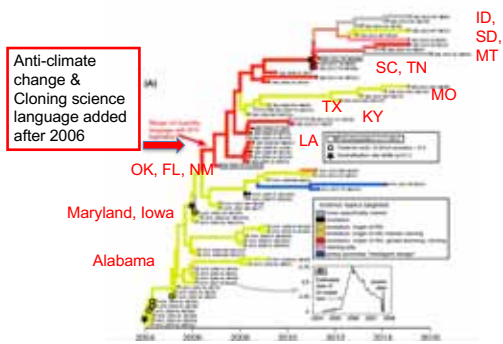
51:16- 58:45 Evolution is testable (ape chromosomes) (7.5 min)

Evidence and Decision ...

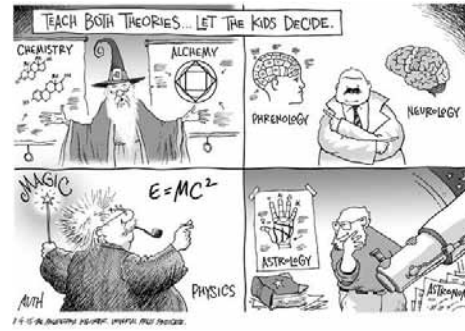
1:22- 1:31 Is ID creationism in disguise? (9 min)

1:44- 1:47 Judges Decision (3 min)

Matzke, N. J. 2016. The Evolution of Anti-evolution Policies [proposed laws]. Science. Published online 17 December 2015. DOI 10.1126/science.aad4057



Science versus Pseudoscience



Arguments against teaching creationism (or “Intelligent Design”) in science class:

- 1) Creationism is not science. It is a belief based on faith. Science is based on facts and testable hypotheses.

Popular misconception of def. of “theory”

Popular def: A idea that is not proven (unreliable)

Science def: A well-substantiated explanation (tested many times) that predicts important aspects of natural world.

Scientists test vs. prove hypotheses- gather data to support or refute- remain skeptical

Religion is a belief system; But “faith” does not mean unquestioning

Arguments against teaching creationism (or “Intelligent Design”) or “the controversy” in science class:

- 2) Evolution is not controversial among scientists.
- 3) Fossil evidence inconsistent with literal interpretation of Christian bible.
- 4) Separation of church and state required by constitution.

Arguments against teaching creationism (or “Intelligent Design”) or “the controversy” in science class:

- 5) There are many versions of creation? Which should be taught? Buddhist, Native American, Muslim, Hawaiian, Christian, etc.
- 6) Religion should be taught by individual faiths outside of public school classrooms.

Religion and science not necessarily incompatible. Literal biblical creation held by few; most churches support evolution/ science.



The great schism is not between science and religion but rather between certainty and uncertainty, tolerance and intolerance.

Turn of the 20th Century: four groups of biologists working independently

- 1) **Paleontologists**- amassed large collections of fossils. Descriptive work.
- 2) **Systematists** (neontologists)- continued describing and cataloging new species. Documented variation. Recognized the importance of reproductive isolation.
- 3) **Geneticists**- working on discrete traits. Discovered that genes were located on chromosomes. Worked with visible mutants. Some traits controlled by many genes.
- 4) **Biometricians**- Statistical analysis of continuous population variation.

“The Modern Synthesis” united those four groups to produce our current science of Evolutionary Biology.

For your reference rather than memorization: Major texts of the Modern Synthesis

- 1930- R.A. Fisher, *The Genetical Theory of Natural Selection*- showed that biometrical results could be derived from Mendelian Genetics.
- 1931 & 32- Sewall Wright- A series of seminal scientific papers on natural selection, random changes, and migration. (and many more papers after these). Published a four-volume treatise at the end of his career (1968-1978).
- 1932- J.B.S. Haldane. *The Causes of Evolution*.
- 1937. Th. Dobzhansky. *Genetics and the Origin of Species* (E.B. Ford in the UK- Ecological genetics)
- 1942. Ernst Mayr. *Systematics and the Origin of Species*
- 1940. Julian Huxley. *The New Systematics*.
- 1942. Julian Huxley. *Evolution: The Modern Synthesis*.

“The Modern Synthesis” (Cont.)

For your reference rather than memorization: Major texts of the Modern Synthesis

- 1944. G.G. Simpson. *Tempo and Mode in Evolution* (revised 1953 as “The Major Features of Evolution”)
- 1947 (1959 translation). B. Rensch. *Evolution Above the Species Level*.
- 1949. Jepsen Simpson & Mayr (eds.) *Genetics, Paleontology, and Evolution*
- 1950. G.L. Stebbins. *Variation and Evolution in Plants*
- 1941-1946- Formation of the Society for the Study of Evolution [WWII 1939-1945]
- 1952- Formation of the Society of Systematic Biologists

The Major Tenets of the Modern Synthesis

- 1) Genetic variation is the raw material of evolution (created by mutation & recombination). Variation is controlled by natural selection, gene flow, and random genetic drift.
- 2) Phenotypic change is gradual.
- 3) Diversification is due to reproductive isolation among populations that results in gradual evolution leading to speciation.
- 4) These same processes, over long periods of time, yield higher taxonomic levels.

The Decades Since the Synthesis...

- 1953- Watson, Crick and Franklin. Structure of DNA. Followed by deeper understanding of nature of mutation and inheritance.
- 1960's- Debate on the relative amount of variation in natural populations (came to a close at end of 60's).
- 1970's- Debate on the relative importance of selection versus drift.
- 1970's, 80's, 90's, and 2000's- Great improvements in methods of constructing evolutionary trees using computers (great advances in computing speed).

The Decades Since the Synthesis...

- 1970's, 80's, 90's, and 2000's (cont.) -Statistical approach to phylogenetics allows great improvement in the estimation of phylogenetic trees.
- Growing recognition of the importance of understanding evolutionary relationships as a framework against which all biology can be interpreted.
- 1990's, 00's. Greater understanding of importance of development to phenotypic change. Increasing realism added to models of evolution used to create trees from DNA data. Genomics provides large amounts of genetic data for evolutionary studies.

Genetic Variation

Variation in traits results in multiple phenotypes within a population or "polymorphism"

Systematists work with "type specimens" but realize importance of studying with-in and among-population trait variability

Thousands of examples of polymorphic traits, e.g., insects will often have green vs. yellow, brown (or pink) morphs.

Albino mutations



<http://www.pogartuk.com/9383734-brothers-albino-tiger-and-bengal-tiger-poster.jpg> <http://www.hedgehogs.org/albino-hedgehog.jpg>
<http://media.ebaumsworld.com/picture/DamianRules/albino1.jpg> <http://rebel5ive.lbbhost.com/AlbinoFawn/AlbinoSquirrel.jpg>

Polymorphism Examples in Futuyma:

- Blue geese vs snow geese (2 alleles, 1 locus)
- Multilocus traits w many alleles such as hair and skin color
- Swallowtail butterfly, *Papilio dardanus*, males non-mimetic, females mimic three very different species

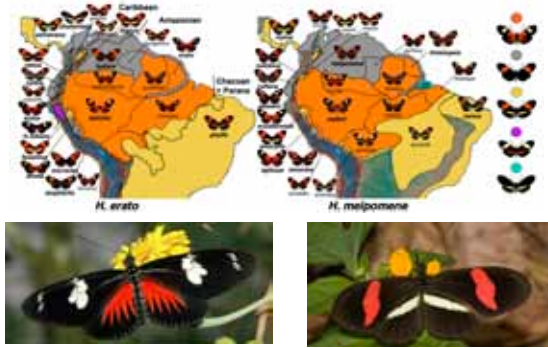
Green/Brown Color Polymorphism *Kikihia peninsularis* from NZ



Orange and purple morphs, *Pisaster ochraceus* starfish Pacific NW

http://resweb.llu.edu/sdunbar/students/Perumal_clip_image002_0002.jpg

Heliconius butterflies- color pattern polymorphisms controlled by one large region of the genome less than one megabase long containing ~ 20 genes differing in expression among the different forms.



Review from basic biology....

Mendel's laws

Dominance- two alleles, one from each parent. recessive alleles will segregate out in the next generation (hidden variation). Dominance can also be incomplete.

•Segregation- paired alleles segregate at random into gametes

•Independent assortment- segregation of one pair of alleles is unrelated to the segregation of any other pair of alleles (we now know about linkage)

Causes of deviation from Mendelian ratios of offspring allele frequencies in crosses

- Meiotic drive (segregation distortion)
- Lethal alleles
- Epistasis (many genes affecting one trait)
- Transposable elements
- New mutations (rare)
- Non-genetic variation
 - Cultural inheritance
 - Maternal effects
- Plastic response to the environment
- Epigenetic inheritance