"Nothing in biology makes sense except in the light of evolution."

Theodosius Dobzhansky, 1973
Before Darwin (1859)

Scientific Understanding:
- Earth/nature unchanging over time
- Special creation by God/Gods
- Everything had a fixed place
- Adaptations: purposeful (J. B. Lamarck)
- Early fossils no connection with other fossils or with living creatures (Trolls, Giants, Titans, Dragons)

To occur, changes need time!
- A “young” Earth did not afford this change
Natural Selection

Charles Darwin (1809-1892)
University of Cambridge

1831 – H.M.S. Beagle, 5 year voyage as a naturalist

The idea of Evolution was not new
THE contribution was the mechanism (how)

Natural Selection

1859 – published On the Origin of Species
1871 – published The Descent of Man, and Selection in Relation to Sex
What is Evolution?

Central unifying concept in all of biology!
Without evolution, biology is just a set of facts

Answers the question: Where did the diversity of life on Earth come from?

It is not goal orientated, directional (we are not the best organism)

The process of descent with modification can be tracked backwards indefinitely
That is, there's no stopping point built into the process: It's happening now!

Organisms are not “better” or more “advanced”, just differently adapted

As valid as any other theory that is based on the scientific method (gravity)
What is Evolution?

Your family tree

Descent with modification

Species don’t replace their ancestors
What is Evolution?

Change in gene frequencies over time (Microevolution)
Formation of new species (Macroevolution)

Acts on populations, NOT individuals

Often takes LOTS of time (thousands of years)

Mechanisms:
- Mutation: random changes in genes (1 in 10,000 to 100,000), can be positive, neutral, negative
- Drift: small populations have low genetic variation e.g., species colonizing an island
- Natural Selection (Darwin): environment “selects” those individuals best adapted

Evolution is more or less a FACT, all mechanisms valid
No scientific study has ever falsified evolution
Natural Selection

Darwin’s Postulates/Tenents
1. Variation exists among individuals in a population
2. Variation is Heritable (genes)
3. Struggle for existence
4. Differential reproduction, some reproduce more successfully due to variation
5. Environmental factors (Nature) are important for determining differential reproduction

Evolution occurs when certain traits become more or less common with respect to other traits

Nature: disease, predators, mates, climate, etc.

Selection acts on individuals, but Evolution is based on changes in populations!
Natural selection: Let’s try it!

Everyone please stand up!

You are turtles!

A new road now separates this population, you cannot interbreed.

Right side is a wooded area (Population 1)

Left side is a cleared area (Population 2)
Brown turtles survive
Population 1:
  Green = Safe
Population 2:
  Brown = Safe
Those left standing:
  Your genes get passed on
Over time:
  Green turtles are more likely in the forest
  Brown turtles are more likely in the open
Given enough time, these two populations could become two species
Tenants:
1. Variation: color
2. Heritability: genes control color, passed on
3. Struggle: avoidance of predators
4. Differential reproduction: those who survive, reproduce
5. Nature: selection by predator
What evidence is there for Evolution?

Age of Earth and other events ("old Earth")
Fossil record: simpler organisms as you go back, extinctions, modifications gradual over time
Developmental patterns among organisms: all vertebrates have gill slits during embryo phase
Genetics: number of functional genes smaller in more recent organisms
Behavior: sexual selection
Myths of Evolution

Humans descended from monkeys
Humans are a great ape, share common ancestor about 5 million years ago

It's only a theory
Scientific meaning of theory vs. everyday use

No one saw it happen
Many phenomenon cannot be observed (e.g., Gravity)
Microevolution: yes, many examples (antibiotic resistance)
Macroevolution: species in flux, new species (Culex molestus)

Evolution is random
Random does not equal meaningless (314159265358979323846)
Complex patterns cannot be predicted

Goal is perfection
assumes humans are “perfect”, all species riddled with flaws

It's not testable
Predictions are made (Darwin: birds had reptile ancestor)

Culex pipiens
invaded London subways 1840
1940s London Blitz
evolved into new species
Why is Evolution controversial?

Science is complicated!
Darwinian evolution challenged, not by new scientific discoveries, but by religious convictions/beliefs
Many Americans reject idea that organisms (Humans) developed from earlier species of animals

Why is this an issue for you?
What is taught in school
Scientific advancement vs. Religious teachings
Legal issues: Freedom of religion, Freedom from religion
Larger issue: How do we pursue knowledge?
   Ask questions and find answers? (science)
   Believe answers and find data to support them? (religion)
Common examples: the eye

Argument: some structures are too complex to have evolved.

Half a _______ is no good (wing, eye, ear, etc.).

Assumes perfection must be instantaneous
Assumes the human eye is “perfect”: less = imperfect
Insects (ultraviolet), Snakes (infrared), Hawks (20/4 vision), fish (5 types color receptors), Owls (50-100x light sensitivity)
Human eye is good, but no where near the “best” eye
Function of a structure is only as good as it needs to be

Steps:

Computer model estimate:
1821 steps.....1% chance of each step.....350,000 generations....350,000 years

http://www.don-lindsay-archive.org/creation/eye_time.html
What else?

What are vestigial structures and how do they support evolution?

What is the bottle-neck effect and how does it help to explain the evolution of small populations?

What are the reproductively isolating mechanisms and how do they help explain speciation?