Darwin and the Theory of Natural Selection

Human Biology and Forensics
http://www.pbs.org/wgbh/evolution/library/11/2/quicktime/e_s_2.html
Evolution

- Evolution is a change in species over time
- Unifying Theme in Biology
- Most associate Evolution with Darwin
Evolution

• Darwin is ONE scientist who tried to explain HOW evolution occurs

• He did this through his Theory of Natural Selection
Darwin and Natural Selection

• Before we discuss Darwin it is important to understand what led to his Theory of Natural Selection and how it relates to Evolution.

• Science is a process that builds up, and the Theory of Natural Selection did not come out of the air.

• Scientific inquiry is gained through a series of small steps rather than giant leaps
Darwin and Natural Selection

- Darwin wasn’t the only one to develop the theory of Natural Selection

- Wallace also presented “On the Tendency of Species to Form Varieties”; “On the Tendency of Varieties to Depart from the Original Type”

- Many others laid the groundwork for Natural Selection
Fixity of Species

• The European world view throughout the Middle Ages was stasis: all aspects of nature are fixed and unchanging.
Fixity of Species

• This static nature supported the hierarchical class system

• Christianity also taught that life on Earth was created exactly as it is today – fixity of species and that God’s creations are arranged in a complex hierarchy (Great Chain of Being); Grand Design; the Earth was made in 4004 BC
Challenges to Evolutionary Thought

• Existing notions:
  – fixity of species
  – Stasis
  – great chain of being
  – grand design

• These were an obstacle to development of evolutionary theory; evolution needs time; needed to change the notion of time and changing species, to open up speculation for evolution
Scientific Revolution

• The scientific revolution started to change notions and pave the way for evolution

• Discovery of New World and circumnavigation of the globe in 15th century: world isn’t flat and there is biological diversity

• Copernicus (heliocentric Earth); Galileo; Descartes and Newton
Paving the Way to Understanding Evolution

• John Ray:
  – Defined concept of species: plants and animals could be distinguished from each other by their ability to reproduce with one another and produce offspring –
  – Species: reproductively isolated organisms
  – Species share similarities with other species (genus)
  – Believed in fixity of species
Paving the Way to Understanding Evolution

- Carolus Linneaus
  - Naturalist developed classification system of plants and animals; basis for taxonomy
  - Binomial nomenclature
  - Included humans in classification *Homo sapiens*.
  - Controversial since humans should be considered outside of the animal kingdom
  - Fixity of species – questioned later
Paving the Way to Understanding Evolution

• Comte de Buffon
  – Recognized relationship between external environment and living forms
  – Stressed importance of change in the universe & underlined the changing nature of species
  – When groups migrated to new areas, each group would be influenced by local climate and would change to adapt to the environment
  – No fixity of species, but didn’t believe that species gave rise to other species
Paving the Way to Understanding Evolution

- Erasmus Darwin
  - Charles Darwin’s grandfather
  - Known in literary circles
  - Expressed evolutionary concepts in verse;
    expressed similar ideas as Charles Darwin (50 years earlier)
  & commented on human evolution.
- Commented on inheritance and sexual selection
- Charles Darwin did read the writings of his grandfather
Paving the Way to Understanding Evolution

- Jean Baptiste Lamarck
  - Tried to explain the evolutionary process (1\textsuperscript{st} to explain)
  - Full name is Jean Baptiste Pierre Antoine de Monet Chevalier de Lamarck
  - Dynamic interaction between organisms and the environment
  - As environment changed, activity would change and lead to use or disuse of body parts, body plan became altered
Paving the Way to Understanding Evolution

• Jean Baptiste Lamarck
  – Inheritance of acquired characteristics
  – Trait acquired during an animal’s lifetime, can be passed on (not so with us- eggs and sperm)
  – Giraffes
  – First to recognize importance of interactions between organisms and the environment in evolutionary process
  – Recognized need for scientific branch that deals with living things – coined the term BIOLOGY
Paving the Way to Understanding Evolution

- Georges Cuvier
  - Opposed Lamarck
  - Introduced the concept of extinction to explain disappearance of animals represented by fossils
  - Insisted on fixity of species
  - Didn’t make connections between fossils and living species
  - Catastrophism: geological landscape is a result of cataclysmic events. These made life forms go extinct; Organisms went extinct and were repopulated by new organisms of modern appearance
Paving the Way to Understanding Evolution

- Charles Lyell
  - Founder of modern geology; Darwin’s friend and mentor
  - Geological processes in present are the same as the ones in the past – uniformitarianism.
  - Earth must be much older than previously realized
  - From few thousand to millions of years – changed how we viewed the geological past; deep time
  - This time frame permitted the possibility of evolutionary change
Paving the Way to Understanding Evolution

• Thomas Malthus
  – Economist
  – Inspired Darwin and Wallace
  – If populations are left unchecked by limited food supplies, their population could double in size every 25 years
  – Population size increases at a much faster rate than food supplies
  – In nature ability for populations to increase in checked by resource availability
  – Constant competition for food and resources.
And now Darwin...

- Darwin (1809 – 1882) background
  - One of 6 children; wealthy lifestyle in rural England
  - As a child, had a keen interest in nature (fished, collected eggs) but performance in school was ordinary
  - Mother died when he was 8, raised by stern father and sisters
  - Since only interested in shooting, hunting in science, his father (a doctor) sent him off to Edinburgh to study medicine; this is where Darwin became acquainted with Lamarck and others
Thoughts on Evolution

• This was the 1820s and this is when notions of evolution were becoming feared in England (association with post-revolutionary France)

• Also a time of growing unrest in Britain. The Reform Movement was underway and many radicals were atheists and socialists who supported Lamarck’s evolutionary theory, so evolution became associated with atheism and subversion
Thoughts on Evolution

• The notion was that if it were generally accepted that nature evolved unaided by God, “the Church would crash, the moral fabric of society would be torn apart and civilized man would turn to savagery” This was the 1820s and this is when notions of evolution were becoming feared in England (association with post-revolutionary France)
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More on Darwin

– While at Edinburgh he studied marine life, studied museum collections and attended natural history lectures; he hated medicine and left after two years

– He then went to Christ’s College to study theology (indifferent to religion but theology seems as a last resort for sons with no interests)

– Here he cultivated interest in natural sciences: participated in botanical and geological expeditions and excursions, especially with Reverend John Stevens Henslow (botany professor)
• When he graduated in 1831 at age 22, he was invited to travel on an expedition around the world.

• They set sail on the HMS Beagle on December 7, 1831. This voyage lasted almost 5 years and changed the course of biological science.
The Beagle

• When Darwin went on the Beagle, he believed in the fixity of species; Soon he started to question the notion of fixity of species (passage of nature from lizards to snakes, fossils looked like living species)
The Beagle

- During famous stopover at Galapagos Islands, Darwin noticed similarities between the flora and fauna of South America and those on Galapagos, with slight differences from one another
Finches

– Darwin collected 13 varieties of Galapagos Finches that shared many structural similarities and were closely affiliated but different with regard to certain physical traits like the size and shape of the beaks.

– He also collected finches from South America and these appeared to represent one group or species.
Finches

• Darwin recognized that all the finches descended from a common mainland ancestor and was modified in response to the different island habitats and diets.
Back In England

• Back in England, Darwin realized the significance of variation in beak structure, here he started thinking about what factors could lead to the modification of 1 species into 13.
Back In England

- Darwin returned to England in 1836 and was accepted into scientific circles. He married his cousin Emma Wedgewood and moved to a village near London where he spent the rest of his life writing about many things but his overlying concern was the question of species change.
Developing Natural Selection

• Here Darwin developed his views on natural selection
• Borrowed from practices of animal breeders who “select” traits that they want to emphasize in offspring
• He applied his knowledge of domesticated specie to naturally occurring species, in non-domesticated organisms, the selective agent was nature, not humans.
Developing Natural Selection

– By the late 1830’s Darwin recognized that biological variation in a species was critically important and acknowledged the importance of sexual reproduction in increasing variation.

– In 1838 he read Malthus and found that populations increase at a faster rate than resources
Developing Natural Selection

- The fact that more offspring were born than survive to adulthood, notions of competitions for resources and biological diversity all led Darwin to develop his theory of natural selection.

- Darwin wrote a summary of natural selection in 1842 and revised in 1844 (similar to 1869’s On The Origin of Species); didn’t publish (not enough data and also worried about upsetting the status quo and bringing dishonor to those he loved; hesitated
Wallace

- Alfred Russel Wallace
  - Born into a family of modest means
  - Went to work at 14 and moved between jobs
  - Interested in collecting plants & animals and went on an expedition to the Amazon, and then Southeast Asia
  - 1855 he wrote a paper to be published in Annals and Magazine of Natural History that suggested that species are descended from other species and that the appearance of other species is influenced by environmental factors.
Wallace & Darwin

– Wallace paper got other people to pressure Darwin to publish, but he hesitated; even corresponded with Wallace

– In 1858 Wallace sent a paper to Darwin which he described evolution as a process driven by competition and natural selection

– Darwin despaired, (feared Wallace would get credit for ideas) and quickly wrote a paper, and both papers were read in 1858 (Linnean Society); Darwin and Wallace were not there (Darwin was mourning death of a very young son)
Darwin and Wallace

- Papers received little notice at the time, but Darwin completed his greater work On the Origin of Species in 1859
- This got lots of attention, a lot of negative feedback
- Scientific community came to Darwin’s support,
- Riddle of species explained: species could change (not fixed) and they evolved from other species through mechanism of natural selection.
Natural Selection

• Natural Selection
  – Darwin realized that selection was the key to evolution
    – Individuals with favorable characteristics would survive and reproduce and those with unfavorable characteristics would not
      – Differential Births and Deaths
Process of Natural Selection

• All species can reproduce at a faster rate than food supplies
• Biological variation exists between all species (except identical twins)
• Since there are more individuals produced than can survive, there is competition (struggle for survival)
• Individuals with favorable traits have an advantage over others; these individuals are more likely to survive and produce offspring
Process of Natural Selection

- The environment determines whether a trait is beneficial or not
- Traits are inherited and passed on to the next generation; more offspring to those with favorable traits (reproductive success), more favorable traits are more common
- Over long periods of time, variations accumulate in a population; a new species may appear
- Geographical isolation may also lead to a new species
Natural Selection Interactive

• http://www.techapps.net/interactives/pepperMoths.swf
Successes of Darwin

• Darwin left us with many successes
  – Natural selection as sifting mechanism
  – Rejected special creations
  – Moved from fixed to changing universe
  – Variation is real (not typological)
  – Changed view on role of extinction
Limitations of Darwin

• Darwin didn’t understand where variation came from
Variation

- Possible explanations for variation
  - Inheritance of Acquired Characteristics where effects in lifetime can be incorporated into the genetic structure of the individual and passed onto next generation; occurs in bacteria and some viral origins
  - Spontaneous generation
  - “sports” mutation where occasionally something weird happened to cause random change
  - hybridization between species (gene flow)
NeoDarwinian Evolution

- Natural Selection is main force of evolution
- Mutation Provides Variation (also crossing over, independent assortment, etc.)
- Gene Flow and Genetic Drift also sort through variation