Evolution

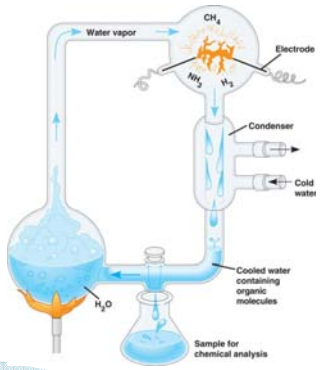
Change Over Time

Issues to Overcome For Life to Form Spontaneously

- Non-living synthesis of organic molecules
- Assembly into polymers
- Self Replication of molecules
- Packaging into membrane bound structures

Theories of How Life Formed on Earth

- Al Oparin
  - Early environmental conditions
- Urey and Miller

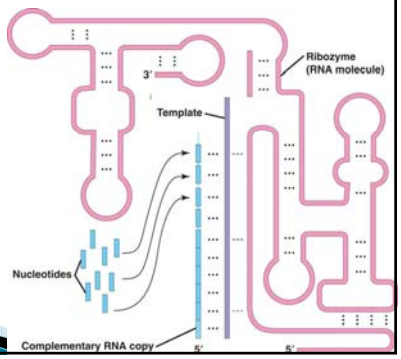


RNA and Clay

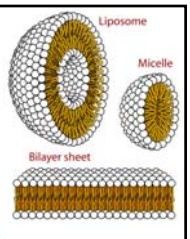
- Certain types of clays are positively charged. The hypothesis is that RNA nucleotides (negatively charged) would be strongly attracted to the clay and therefore be held close to each other, increasing their probability to react.
- Research has shown that they can for 10 mers this way.
- RNA is catalytic and can self replicate
- First Cell Article by Deamer

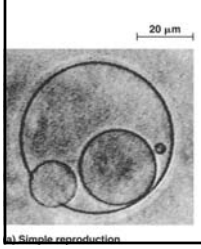
Ribozymes

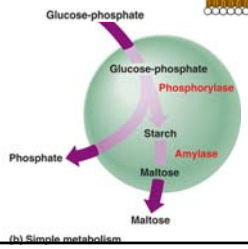
- First functional molecule?
- Nobel Prize in 1989



Micelles and Liposomes and Coacervates (Protobionts)







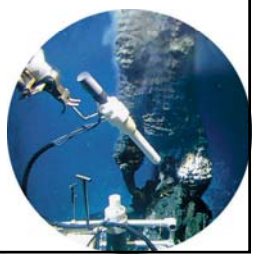
(a) Simple reproduction (b) Simple metabolism

Others Theories

- Panspermia – molecules of life…. Simple life forms delivered to earth from outside of our planet.
  - Earth was heavily bombarded about 4,000 Million Years ago, and organic compounds could have been delivered via comets.

Prokaryote, Eukaryote Origins

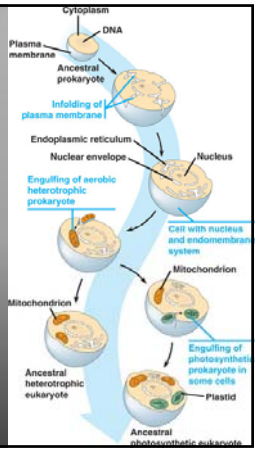
- Locations
  - Deep Thermal Vents in Mid Ocean Ridges.
  - Hot springs
- Autotroph vs. Heterotrophs



Formation of Oxygen Rich Environment

- First were probably anaerobic heterotrophic prokaryotes
- Then Anaerobic Autotrophs (Chemosynthetic that used H_2S as electron sources) that could fix CO_2 into compounds.
- Photosynthetic Prokaryotes
  - Blue-Green Algae (Cyanobacteria)
  - 2.5 billion years ago Cyanobacteria or Photosynthetic bacteria evolved and produced large amount of oxygen that would eventually lead to an protective Ozone layer.

Eukaryote Development



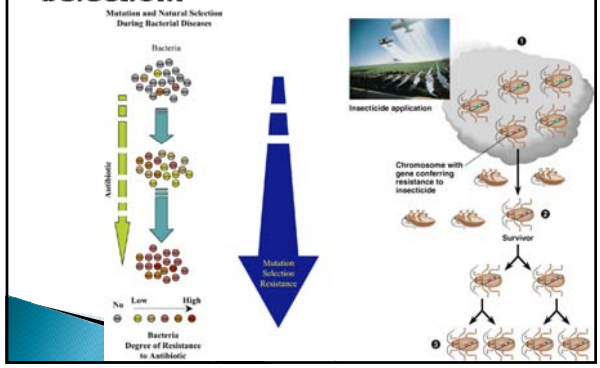
Evolutionary Theory

- Charles Darwin
  - Voyage of Beagle in 1831
  - Spent lots of time observing animals around the globe
  - Spent time on the South American Mainland and the Galapagos Islands.
  - Observed Finches, etc…
  - After his return home he analyzed his data and came up with the Theory Of Natural Selection.
  - Wallace and Darwin were working on the same idea.
  - Darwin Published The Origin of Species" in 1859

Darwin

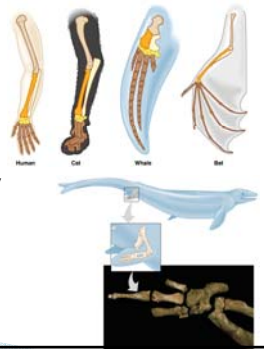
- Main Ideas
  - Natural Selection is differential success in reproduction, and its product is adaptation of organisms to their environment.
  - N.S. occurs from the interaction of the environment and the inherent variability in a population.
  - Variation arise by chance. N.S. isn't a chance phenomenon because reproductive success is due to certain characterisitics.
  - Populations produce more offspring than the environment can support.
  - NS leads to evolution

Artificial Selection or Natural Selection?

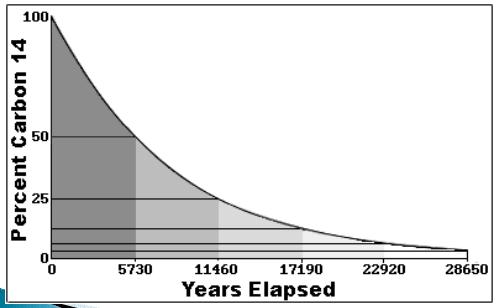


Evidence of Evolution

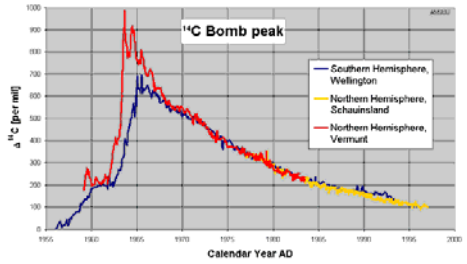
- Macroevolution
  - Biogeography
    - Distribution of Species
  - Fossil Record
    - Change over time
  - Comparative Anatomy
    - Homologous Structures
    - Vestigial Organs
  - Comparative Embryology
    - Gill slits
    - Ontogeny Recapitulates Phylogeny



Isotope Dating Methods

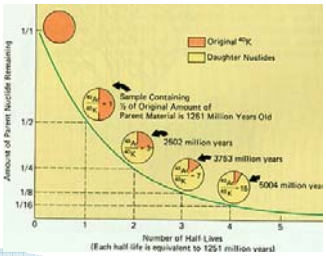


Radiocarbon dating.... validation



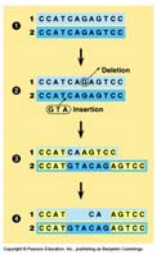
Potassium 40

- Potassium 40 decays to Argon 40 at a predictable rate. Can be used to date very old fossils.

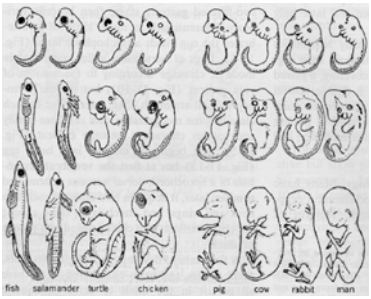


Evidence of Evolution

- Molecular Biology
  - DNA
    - Universal genetic code.
  - Protein
    - Cytochrome c
      - Electron Transport



Comparative Embryology



Population Genetics

- Modern Theory of Evolution
  - Includes the information provided by Gregor Mendel
- Population
  - Localized group of organisms which belong to the same species
- Species
  - Group of populations whose individuals have the potential to interbreed and produce fertile young.

Population Genetics

- **Gene Pool**
  - Total of genes in a population
    - Alleles
    - Loci
    - Normally two or more alleles for a gene
      - Allele frequency
- **Hardy Weinberg Theorem describes a non-evolving population**
  - The frequencies of alleles in a gene pool will remain constant unless acted upon by other agents; this is the HW theorem.
  - Segregation and recombination will not change the overall allele frequency in a population.

Hardy Weinburg

- P = one allele
- Q = second allele
  - Let p = dominant
  - Let q = recessive allele
    - So……. p + q =1

Hardy-Weinberg Equilibrium

$$p^2 + 2pq + q^2 = 1$$

	p	q
p	pp	pq
q	pq	qq

Using H.W. to calculate Allele Frequencies

- 1 out of 10,000 babies are born with Phenylketonuria (PKU)
- Show Calculations on board

Alu and Population Genetics

Hardy-Weinberg Equilibrium

$p^2 + 2pq + q^2 = 1$

	p	q
p	pp	pq
q	pq	qq

+/+ = p^2
+/- = 2pq
-/- = q^2

Calculating Observed Genotypic Frequencies

Genotype	+/+ (p^2)	+/- (2pq)	-/- (q^2)	Total (N)
# of people	25	5	8	38
Observed frequency	0.65	0.13	0.21	1.00

Calculation:

+/+ genotypic frequency = $\frac{\text{\# with genotype}}{\text{total number of people (N)}}$

= 25/38
= .65

Calculating Allelic Frequencies

- **Frequency of p** = $\frac{\text{number of p alleles}}{\text{total alleles}} = \frac{55}{76} = 0.72$
- **Number of p alleles =**
  - +/+ = 25 with two + alleles = **50** + alleles
  - +/- = 5 with one + alleles = **5** + alleles
  - **Total** = **55** + alleles
- **Total number of alleles** = 2N = 2(38) = **76**

Using Hardy–Weinberg

- Determine p^2, 2pq, and q^2 values= Expected genotypic frequencies
- p = 0.72 , so q = 0.28 since p + q = 1

$p^2 + 2pq + q^2 = 1$

$(0.72)^2 + 2(0.72)(0.28) + (0.28)^2 = 1$

$0.52 + 0.40 + 0.08 = 1$

- p2 = 0.52
- 2pq = 0.40
- q2 = 0.08

Calculate Expected Number of Genotypes

Expected number of genotype =
Genotypic frequency x population number (N)

Genotype	Expected number
+/+	0.52 x 38 = 20
+/-	0.40 x 38 = 15
-/-	0.08 x 38 = 3

Chi Squared Test

$$X^2 = \sum \frac{(O-E)^2}{E}$$

	Observed	Expected	$(O-E)^2/E$
+/+	25	20	1.25
+/-	5	15	6.66
-/-	8	3	8.33
		Total	16.24

X^2 Critical Value (from statistics table) = 5.9

16.24 is above 5.9 so the ratio is not accepted.

Causes of Change

- **Causes for Microevolution**
  - Genetic Drift
    - Bottleneck, Founder Effect
  - Gene flow
  - Mutation
  - Non Random Mating
    - Inbreeding
    - Assortive Mating
  - Natural Selection

For Genetic Equilibrium To Be Maintained

- Large Population
- No movement in or out
- No mutations
- Random mating
- No N.S.

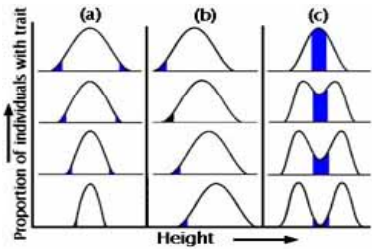
Mutations

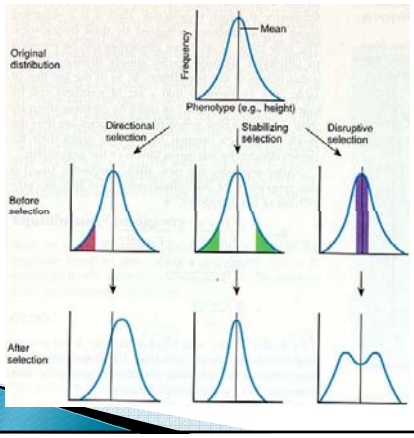
- Can produce new alleles
  - Must be in the gametes to be passed on
- Types of Mutations
  - Point
    - Can be harmless because of redundancy of code (degenerate code)
  - Chromosomal
    - Duplication
    - Inversion
    - Translocation
    - Deletion

Types of Natural Selection

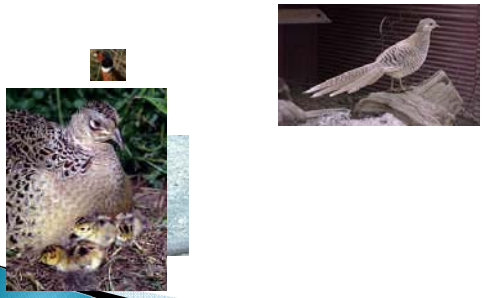
- Directional
- Stabilizing
- Sexual
- Disruptive

Types of Natural Selection





Sexual Selection



Speciation

- Species
  - Population or group of populations whose members have the potential to interbreed and produce viable, fertile offspring.
  - They are reproductively isolated.
    - Prezygotic and Postzygotic barriers

Speciation

- Prezygotic
  - Habitat isolation
  - Behavioral isolation
    - Coloration
    - Dancing
    - Smells
    - etc…
  - Temporal
    - Different timing
      - day or night
      - time of year
  - Mechanical
  - Gamete Isolation
- Postzygotic
  - Reduced hybrid viability
    - Some frogs
  - Reduced Hybrid fertility
    - Mule
  - Hybrid breakdown
    - one generation might be fertile, but over other generations they break down.

Speciation

- Species concept breaks down when:
  - asexual reproduction
- Subspecies may be only isolated by distance.

Types of Evolution

- Convergent vs. Divergent Evolution
- Coevolution

Modes of Speciation

- Sympatric Speciation
  - Without Geographic Isolation
- Allopatric Speciation
  - With Geographic Isolation
    - Grand Canyon
      - Squirrels on each side are different species that look similar

Allopatric Speciation

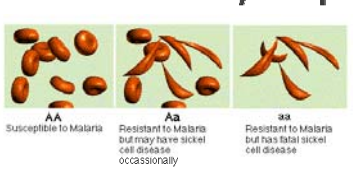
- Adaptive Radiation
  - The evolution of many diversely adapted species from a common ancestor
  - Island chains of the Galapagos
  - Natural Selection drives it with variation selected based on food supply or other advantage

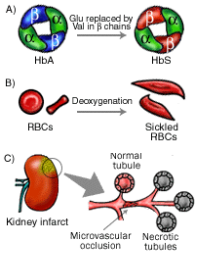
Sympatric Speciation

- Sympatric Speciation – formation of a species within parent range
- Isolation caused by genetic barriers
  - Polyploids
    - Many plant species are polyploids. Since they can double chromosomes and then self fertilize. Many of the Angiosperms came about this way.
- Isolation because of balanced Polymorphism
  - Two distinct beak sizes.
  - Each breeds with it's kind
  - Over time…..

Transient Polymorphism

Balanced Polymorphism



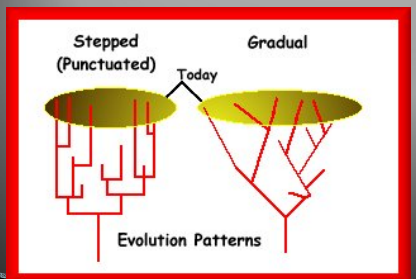


A) Hemoglobin is made up of 4 chanis: 2 α and 2 β. In SCA, a point mutation causes the amino acid glutamic acid (Glu) to be replaced by valine (Val) in the β chanis of HbA, resulting in the abnormal HbS. B) Under certain conditions, such as low oxygen levels, RBCs with HbS distort sickled shapes. C) These sickled cells can block small vessels producing microvascular occlusions which may cause necrosis (death) of the tissue.

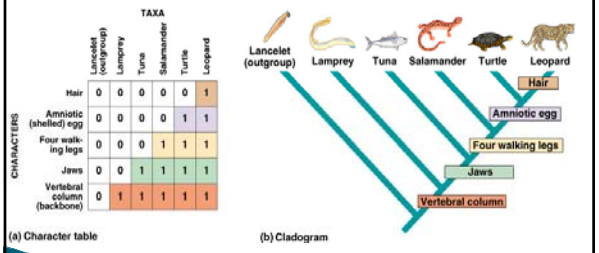
Rate of Speciation

- Punctuated Equillibrium
- Gradualism

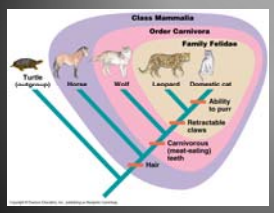
Rate of Speciation



How We Classify Using Cladograms



Characterisitics are used



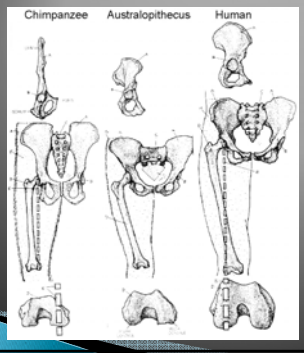
Mass Extinctions Followed by Adaptive Radiation

- Lots of evidence
- Impact hypothesis
- Change in climate
  - Volcano….. CO2
  - Change in Oxygen
  - Hydrogen Sulfide producing bacteria

Hominid Evolution

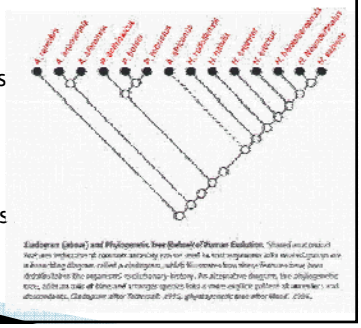
- Look at trends
- Types of Evidence Used
- Adaptations
- Tool making

Human Evolution

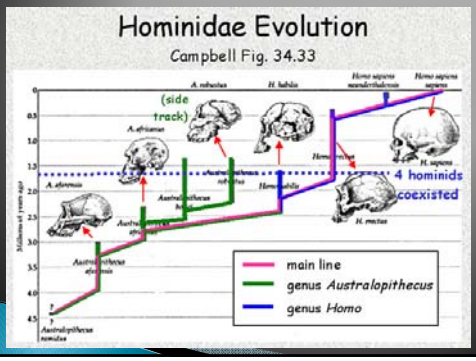


Human Evolution

- Ardipithecus ramidus
- Australopithecus africanis and afarensis
- Homo habilus, erectus, neanderthalensis sapiens

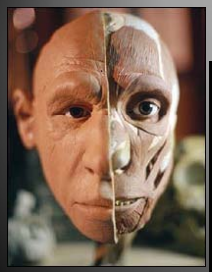


Human Evolution

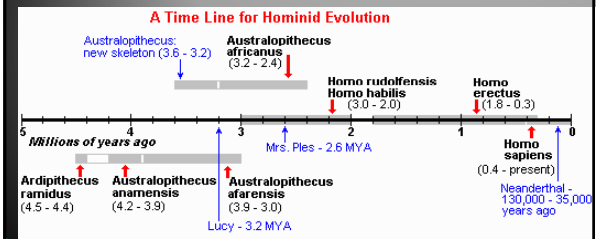


Tools and Intelligence

Human Evolution



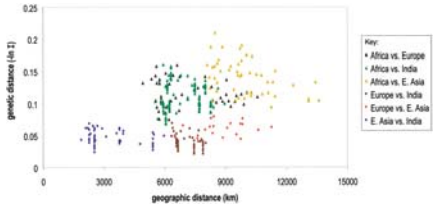
Human Evolution



Y chromosome

100 Alu Polymorphisms

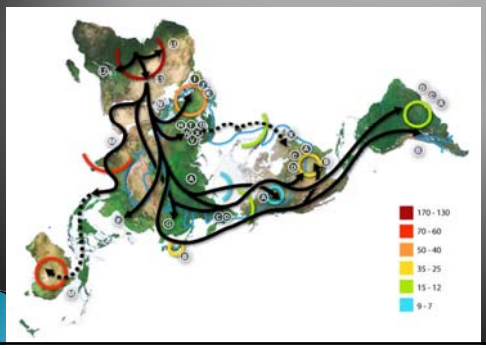
Figure 7 Geographic distance is plotted against genetic distance measured as the negative log of Nei's identity for pairwise comparisons between population groups from Africa, E



W. Scott Watkins et al. Genome Res. 2003; 13: 1607-1618

Cold Spring Harbor Laboratory Press

Mitochondrial Data



Mitochondrial Clocks and uses of Molecular clocks

- Clustal W experiment in the computer lab

Genetic vs Cultural Evolution

Comparison

GENETIC	CULTURAL
The product of natural selection	The product of learning, the transmission of acquired behaviour characteristics
Darwinian	Lamarkian
Innate not modified during the organism's life time	Learned during the life time
Passed on through hereditary information	Passed on to kin (family), social group, population, within a generation and between generations.
Slow change	Fast change