Chapter 16,17 - The Process of Evolution
1. What are the five categories of evidence for evolution? *Briefly* explain each.
2. What is the difference between natural selection and evolution?
3. What is the significance of the Miller-Urey experiment?
Evidence of Evolution

The theory of evolution is supported by evidence that can be found in:

1. **The Fossil Record**: traces the history of life
2. **Biogeography**: study of range and distribution of plants and animals
3. **Anatomy**: homologous, vestigial structures
4. **Embryology**: all vertebrates have the same basic pattern of development
5. **Biochemistry**: DNA, amino acids are similar in related organisms, all life of same few elements
Natural selection is a mechanism of evolution!

**Natural Selection:** organisms best adapted to their environment tend to survive and transmit their genetic characteristics in increasing numbers

**Evolution:** gradual change in a species over time
The Early Earth

1. The earth is about 4.6 BYA

2. Some chemicals present during early earth:
   - water vapor
   - nitrogen
   - carbon dioxide
   - hydrogen
   - methane
   - ammonia
Monomers Evolve

Miller /Urey

Virtual Miller/Urey

http://en.wikipedia.org/wiki/Miller%E2%80%93Urey_experiment
Five Fingers of Evolution

https://www.youtube.com/watch?v=5NdMnl2keE&t=144
MICROEVOLUTION

Population -- all the members of a single species
Population genetics – studies variations in gene pools

Microevolution: Evolution that occurs within a population

Macroevolution: evolution causing speciation (at species or higher level)

Speciation: transformation of one species into new species over time
Gene pool – total of all the allele in the population
Alleles – chromosome sections that code for specific proteins traits

Examples: Humans have alleles for blue eyes / brown eyes / green eyes

curly/straight hair

blood type A / B / O / AB
Industrial Melanism

- Shift in phenotype frequencies
- Light colored moths were reduced and dark color became predominant
- Birds preyed on the light colored moths

A certain allele type was advantages, so it increased in frequency!
Natural selection – the peppered moth

Pale coloured, speckled peppered moth
Natural selection – the peppered moth
Natural selection – the peppered moth
Mechanisms of evolution (microevolution)

1. Genetic Mutations

a) Polymorphism (two or more distinct phenotypes)
   - blood types, eye color..etc

c) Mutations (can be harmful or beneficial)

Some mutations may at first appear harmful, but give an advantage if the environment changes. -- this is referred to as RELATIVE FITNESS
2. Gene Flow

movement of alleles among populations, by migration
- Increases variation
- Continued gene flow decreases diversity, gene pools become more similar
- Can prevent speciation from occurring

*Stop gene flow to increase diversity*
Example of GENE FLOW

• Each rat snake represents a separate population of snakes
• These snake remain similar and can interbreed
• This keeps their gene pools somewhat similar
• They are considered subspecies
3. Nonrandom Mating

- Random mating is pairing by chance
- Nonrandom mating – individuals choose their mates

Inbreeding

a. Inbreeding does not change the allele frequencies.
b. However, inbreeding decreases the proportion of heterozygotes.
c. In human populations, inbreeding increases the frequency of recessive abnormalities.
Types of nonrandom mating

- Assortative mating occurs when individuals mate with those that have the same phenotype.

- Sexual selection occurs when males compete for the right to reproduce and the female selects males of a particular phenotype. (guppies, lions)
4. GENETIC DRIFT

changes in allele frequencies in a certain direction, usually in small populations

Occurs when founders start a new population or after a bottleneck

[Diagram showing genetic drift with examples of founding populations and their descendants]
**Bottleneck Effect** – caused by a severe reduction in population, reduces overall diversity. Ex Cheetah
Cheetahs have very little diversity in their gene pool due to bottleneck
Founder Effect: loss of genetic variation that occurs when a new population is established by a very small number of individuals.

The founder effect is an example of genetic drift where rare alleles or combinations occur in higher frequency in a population isolated from the general population.

Dwarfism in Amish communities
- Due to few German founders
5. Natural Selection

organisms best adapted to their environment tend to survive and transmit their genetic characteristics in increasing numbers
Five in Five, Five Words or Less

1. Gene Pool

2. Microevolution

3. Gene Flow

4. Population Bottleneck

5. Phenotype
5 Agents of evolutionary change

- Mutation
- Gene Flow
- Non-random mating
- Genetic Drift
- Natural Selection
NATURAL SELECTION

• Variation
• Inheritance
• Differential adaptedness
• Differential reproduction

• Fitness – the extent at which an individual contributes fertile offspring
• Relative fitness – compares the fitness of one phenotype to another
1. Directional Selection

One phenotype is favored over another
Causes a shift in the overall appearance of the species
Ex: horses get larger
2. Stabilizing selection

occurs when extreme phenotypes are eliminated and the intermediate phenotype is favored.
Human babies have an average size

Too big and they can't get through birth canal

Too small and they have low survivability
3. **Disruptive selection**—occurs when extreme phenotypes are favored and can lead to more than one distinct form.

- CAN LEAD TO SPECIATION
(a) Directional selection
(b) Disruptive selection
(c) Stabilizing selection
Imagine this scenario....

Sleebos come in many sizes, the most common Sleebo is 4 inches long, but some can be 10 inches and others can be as small as 1 inch. A new predator is introduced to the Sleebo island. Small sleebos are able to hide under rocks and avoid being eaten. Large sleebos are too big for the predator to eat.

What will happen to the Sleebo population?
Types of Natural Selection

- **Disruptive selection**
  - Selection for small and large individuals
  - Two peaks form

- **Stabilizing selection**
  - Selection for midsized individuals
  - Peak gets narrower

- **Directional selection**
  - Selection for larger individuals
  - Peak shifts
Hardy-Weinberg equilibrium

Hypothetical, non-evolving population
- preserves allele frequencies
- Serves as a model (null hypothesis)
- natural populations rarely in H-W equilibrium
useful model to measure if forces are acting on a population measuring evolutionary change

\[ p^2 + 2pq + q^2 = 1 \]
Evolution = change in allele frequencies in a population

hypothetical: what conditions would cause allele frequencies to not change?

Hardy Weinberg (non-evolving) population

REMOVE all agents of evolutionary change

1. no genetic drift - very large population size
2. no migration (no gene flow in or out)
3. no mutation (no genetic change)
4. random mating (no sexual selection)
5. no natural selection (everyone is equally fit)

Real populations rarely meet all five conditions.
Sexual Selection

Sexual selection is a “special case” of natural selection. Sexual selection acts on an organism's ability to obtain (often by any means necessary!) or successfully find a mate and have offspring.

*can result in sexual dimorphism

Read Article:  [How Females Choose Their Mates](#)
MAINTENANCE OF VARIATIONS

Populations that lack variety may find it difficult to adapt to changing conditions.

Genetic Variations are promoted by:

- mutations
- gene flow
- natural selection

Sickle Cell Disease

Heterozygotes resistant to malaria
Homozygotes are normal or sickle celled (early death)
INTERESTING MUTATIONS

SUPERBOY (genetic mutation causes muscle growth)
Evolutionary step towards world domination

Soon, we shall be able to get our own cheezburgers
MACROEVOLUTION

- Evolutionary change above the species level
- Speciation – the splitting of one species into two or more species

Speciation is the final result of changes in gene pool
What is a Species?

- A group of actually or potentially interbreeding populations (isolated from other groups)
- Gene flow can occur between populations of the same species

![Image of crows and hybrids]
Hybrids occur when members of different species produce offspring...

Lion + Tiger = Liger

Tiger + Lion = Tigon
Horse + Donkey = Mule

Zebra + Donkey = Zonkey
Biochemical genetics uses DNA hybridization techniques to determine relatedness of organisms; the phylogenetic species concept uses DNA/DNA comparisons.

Hyenas are now placed with the cat family due to DNA sequencing.
SPECIATION

Flycatcher species

• Empidonax minimus
• Empidonax virescens
• Empidonax tralli

What stops these species from mating with each other?
Each species has a unique song and each species occupies a different habitat during mating season.
REPRODUCTIVE ISOLATING MECHANISMS

PREZYGOTIC Isolation: prevent a zygote from forming
- Habitat Isolation
- Temporal Isolation
- Behavioral Isolation
- Mechanical Isolation
- Gamete isolation

Damselfly penises
REPRODUCTIVE ISOLATING MECHANISMS

POSTZYGOTIC Isolation: prevent reproduction after zygote formation

• Zygote mortality
• Hybrid sterility
• F2 fitness (reduced fitness level)
1. Allopatric Speciation:
   Populations separated geographically
   • Variations accumulate
   • Reproductive isolation

   • separates the population
2. Sympatric Speciation

Sympatric speciation would occur when members of a single population develop a difference without geographic isolation.

Ex. Apple Maggot flies choosing a particular type of apple (Sympatric Speciation)
Ex. Mate preference
Sympatric vs Allopatric

(a) Allopatric speciation

(b) Sympatric speciation
Adaptive Radiation

A single ancestral species become several different species
Adaptive radiation in Galapagos finches

- medium tree finch (Camarhynchus pauper)
- large tree finch (Camarhynchus psittacula)
- small tree finch (Camarhynchus parvulus)
- mangrove finch (Camarhynchus heliobates)
- vegetarian finch (Camarhynchus crassirostris)
- woodpecker finch (Camarhynchus pallidus)
- large cactus finch (Geospiza conirostris)
- warbler finch (Certhidea olivacea)
- cactus finch (Geospiza scandens)
- Cocos Island finch (Pinaroloxias inornata)
- sharp-beaked ground finch (Geospiza difficilis)
- small ground finch (Geospiza fuliginosa)
- large ground finch (Geospiza magnirostris)
- medium ground finch (Geospiza fortis)

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Evolutionary Pace
WORD ATTACK!

1. Phyletic Speciation / Divergent Speciation
2. Zygote mortality / Hybrid Sterility
3. Behavioral / Temporal / Habitat / Geographic Isolation
4. Adaptive Radiation / Polymorphism / Dimorphism
5. Species / Subspecies / Hybrid
6. Premating Isolation / Postmating Isolation
7. Allopatric / Sympatric Speciation
8. Disruptive / Directional / Stabilizing Selection
9. Sexual Selection / Nonrandom Mating / Assortative Mating
11. Microevolution / Macroevolution
12. Founder Effect / Bottleneck Effect