Natural Selection and Origin of Species (Learning Objectives)

• Explain the timeline of appearance of the three domains of living organisms on Earth.

• Explain the specific distinguishing characteristics of Bacteria and Archaea, and the four kingdoms of the domain Eukarya. Focus on the cellular body composition and source of carbon and energy of each.

• Explain the composition of lichens as a symbiotic existence of organisms belonging to different eukaryotic kingdoms and/or domains.

• Explain: a. Darwin’s fundamental question, b. the key evolutionary mechanism identified by Darwin, and c. the four processes of natural selection

  (http://www.pbs.org/wgbh/evolution/library/11/2/e_s_4.html)

• Define the unit of evolution- population not the individual

• Review the basis for the biological species concept.

• Explain how reproductive barriers arise

• Identify each of the prezygotic and postzygotic barriers.

When given a scenario you should identify whether it represents habitat, behavioral, gametic, or temporal isolation.

• Explain the difference between hybrid inviability, breakdown, and sterility
Natural Selection & Origin of species

Major Events in the History of Earth

- **Origin of solar system and Earth**
- **Prokaryotes**
- **Atmospheric oxygen**
- **Multicellular eukaryotes**
- **Single-celled eukaryotes**
- **Animals**
- **Land plants**
- **Cenozoic**
- **Mesozoic**
- **Paleozoic**
- **Archaean**
- **Proterozoic eon**
- **Billions of years ago**
- **Humans**

1. **Archaeon eon**
2. **Proterozoic eon**
3. **Paleozoic**
4. **Mesozoic**
Diverse living organisms are grouped (classified) into three **Domains**

- **Bacteria**- prokaryotic
- **Archaea**- prokaryotic
- **Eukarya**- Eukaryotic
– Domains Bacteria and Archaea

Figure 1.5A

Figure 1.5B
Prokaryotic cell composition and source of carbon & energy

• Prokaryotic
  – Body composition
    • Single-celled (arrange themselves as single, two, several, bunches, and filaments)
  – Autotrophic & heterotrophic
Domain Eukarya includes 4 kingdoms

- Protists (protozoans and algae, including into multiple kingdoms)
- Fungi, Plantae, and Animalia

Figure 1.5C
Evolution of Eukaryotes Cell composition and source of carbon & energy

Eukaryotic Kingdoms

1. Protista
   - Body composition
     • Single-celled
     • Filamentous
     • Colonies- cells with identical function
   - Autotrophic (photosynthetic pigments)
   - Heterotrophic (ingest food particles)
   - Some free living others parasitic
     Examples: protozoa, euglenoids, and algae
Evolution of Fungi

Eukaryotic Kingdom

2. Fungi

– Body composition
  • Single-celled with cell wall.
  • Filamentous

– Heterotrophic
  • Digest organic matter outside their cells and absorb monomers
  • Some free living others parasitic

Examples: yeast, fungus, and mushrooms
**Lichens** symbiosis of two different organisms in very harsh conditions

Fungi + photosynthetic prokaryote or eukaryote
Highlights of plant evolution

Land plants

Bryophytes (nonvascular plants)

Vascular plants

Seedless vascular plants

Seed plants

Origin of land plants (about 475 mya)

Origin of vascular plants (about 420 mya)

Origin of seed plants (about 360 mya)
Phylogenetic tree

- Sponges
- Cnidarians
- Echinoderms
- Chordates
- Flatworms
- Molluscs
- Annelids
- Arthropods
- Nematodes

- Deuterostomes
- Protostomes

- Radial symmetry
  - Bilaterians
    - Bilateral symmetry
      - Eumetazoans
        - True tissues
          - No true tissues
            - Ancestral colonial protist
Chordates

Craniates

Vertebrates

Jawed vertebrates

Tetrapods

Amniotes

Invertebrates

Ancestral chordate

Chordates

Vertebral column

Head

Brain

Jaws

Lobed fins

Lungs or lung derivatives

Legs

Amniotic egg

Milk
A phylogenetic tree of primates

- **Prosimians**
  - Tarsiers

- **Anthropoids**
  - Monkeys
    - Old World monkeys
    - New World monkeys
  - Hominoids (apes)
    - Gibbons
    - Orangutans
    - Gorillas
    - Chimpanzees
    - Humans

- **Millions of years ago**

- **Ancestral primate**
Evolution occurs through action of natural selection

What is the key mechanism of macroevolution identified by Darwin?

What was Darwin’s fundamental question?

What are the four processes of natural selection?
Charles Darwin in 1859, the year he published *The Origin of Species*
Evolution is a core theme of biology

- Life evolves leading to diversity.
- Charles Darwin noted that within a population of species
  a. individuals vary in heritable traits (Individual variation)
  b. individuals overproduce and compete for resources within the environment food etc… (Struggle for existence)
Darwin inferred that

1. the most suited individual for a local environment would produce more offspring (Differential reproductive success-Natural selection)

2. This unequal reproductive success would adapt a population to its environment (Evolutionary Adaptation)

Evolutionary adaptation is a product of Natural selection
Summary of natural selection

Population of organisms

Hereditary variations

Overproduction and struggle for existence

Differences in reproductive success

Evolution of adaptations in the population
How evolution really works
http://www.pbs.org/wgbh/evolution/library/11/2/e_s_4.html

The four processes of natural selection:
• Genetic variation
• Overproduction of offspring
• Struggle for existence
• Differential survival and reproduction
Evolutionary adaptation is a product of natural selection.

1. Populations with varied inherited traits
2. Elimination of individuals with certain traits
3. Reproduction of survivors
4. Increasing frequency of traits that enhance survival and reproductive success
The Darwinian concept of “descent with modification” can account for the major morphological transformations of macroevolution.
A mutation story “Sickle Cell”
http://www.pbs.org/wgbh/evolution/library/01/2/l_012_02.html

Evolution of the eye
http://www.pbs.org/wgbh/evolution/library/01/1/l_011_01.html

On Becoming Human
http://www.becominghuman.org/
The range of the eye complexity in **mollusks** includes:

(a) a simple patch of photoreceptors found in some **limpets**
(b) photoreceptors in an eye-cup,
(c) a pinhole-camera-type eye in **Nautilus**
(d) an eye with a primitive lens in some marine **snails**
(e) a complex camera-type eye in **squid**
How do new species arise

1. What is the biological definition of a species?
2. Reproductive barriers leading to speciation: pre-zygotic and post-zygotic barriers.
The biological species concept

A species is a population or group of populations whose members have the potential to interbreed with each other in nature to produce viable, fertile offspring, but who cannot produce viable, fertile offspring with members of other species.
Species are based on inter-fertility, not physical similarity.
Reproductive barriers can occur before mating, between mating and fertilization, or after fertilization.

**Prezygotic Barriers**
- Habitat isolation: populations live in different habitats and do not meet
- Behavioral isolation: little or no sexual attraction between males and females
- Temporal isolation: mating or flowering occurs at different seasons or times of day

**Postzygotic Barriers**
- Reduced hybrid viability: hybrid zygotes fail to develop or fail to reach sexual maturity
- Reduced hybrid fertility: hybrids fail to produce functional gametes
- Hybrid breakdown: offspring of hybrids have reduced viability or fertility

Viable, fertile offspring
**Prezygotic Barriers**

- **Habitat isolation**: populations live in different habitats and do not meet.

- **Behavioral isolation**: little or no sexual attraction between males and females.

- **Temporal isolation**: mating or flowering occurs at different seasons or times of day.

**Mating**

- **Mechanical isolation**: structural differences in genitalia or flowers prevent copulation or pollen transfer.

- **Gametic isolation**: female and male gametes fail to attract each other or are inviable.

**Fertilization**
Fertilization

POSTZYGOTIC BARRIERS

Reduced hybrid viability: hybrid zygotes fail to develop or fail to reach sexual maturity

Reduced hybrid fertility: hybrids fail to produce functional gametes

Hybrid breakdown: offspring of hybrids have reduced viability or fertility

Viable, fertile offspring