WHAT IS BIODIVERSITY AND WHY IS IT IMPORTANT?
Biodiversity is a crucial part of the Earth’s natural capital

• The biodiversity found in genes, species, ecosystems, and the ecosystem processes of energy flow and nutrient cycling that sustain all life.

• Biodiversity includes a number of components.
  – **Species diversity**, or the number and variety of the species present in any biological community.
    • A species is a set of individuals that can mate and produce fertile offspring. Every organism is a member of a certain species
    • Species diversity estimates range from 8 million to 100 million.
Biodiversity is a crucial part of the Earth’s natural capital

- **Genetic diversity**, which is the variety of genes found in a population or in a species.

- **Ecosystem diversity** refers to the earth’s variety of deserts, grasslands, forests, mountains, oceans, lakes, rivers, and wetlands.

- **Functional diversity** includes a variety of processes such as energy flow and matter cycling occurring within ecosystems.
Major Components of Biodiversity

**Functional Diversity**
The biological and chemical processes such as energy flow and matter recycling needed for the survival of species, communities, and ecosystems.

**Ecological Diversity**
The variety of terrestrial and aquatic ecosystems found in an area or on the earth.

**Genetic Diversity**
The variety of genetic material within a species or a population.

**Species Diversity**
The number and abundance of species present in different communities.
The Major Biomes Found Along the 39th Parallel Across the U.S.

- Coastal mountain ranges
- Sierra Nevada
- Great American Desert
- Rocky Mountains
- Great Plains
- Mississippi River Valley
- Appalachian Mountains

- Coastal chaparral and scrub
- Coniferous forest
- Desert
- Coniferous forest
- Prairie grassland
- Deciduous forest
How does the earth’s life change over time?
Biological evolution by natural selection explains how life changes over time

- Fossils reveal the history of life.
- Biologic evolution is the process whereby Earth’s life changes over time through changes in the genes of populations in succeeding generations.
- The theory of evolution by natural selection is a scientific explanation of how the process of evolution takes place.
- Natural selection is the process in which individuals with certain traits are more likely to survive and reproduce under a particular set of environmental conditions than those without the traits.
Mutations and changes in the genetic makeup of populations lead to biological evolution by natural deflection

- **Genetic variability** occurs through mutations, which are random changes in the DNA molecules of a gene in any cell.

- An **adaptation**, or an adaptive trait, is any heritable trait that improves the ability of an individual organism to survive and to reproduce at a higher rate than other individuals in a population under prevailing environmental conditions.
Mutations and changes in the genetic makeup of populations lead to biological evolution by natural deflection

• Natural selection can result in the evolution of genetic resistance, the ability of one or more organisms in a population to tolerate a chemical designed to kill the population.

  – Examples include antibiotic-resistant bacteria and pesticide-resistant insects.
Evolution By Natural Selection

(a) A group of bacteria, including genetically resistant ones, are exposed to an antibiotic.

(b) Most of the normal bacteria die.

(c) The genetically resistant bacteria start multiplying.

(d) Eventually the resistant strain replaces all or most of the strain affected by the antibiotic.
Adaptation through natural selection has limits

- Organisms can adapt to a change in environmental conditions only if the necessary genetic traits are already present in a population’s gene pool.

- Another limit is that even if a beneficial heritable trait is present in a population, the population’s ability to adapt may be limited by its reproductive capacity.
There are three **incorrect** ideas about evolution through natural selection

1. “Survival of the fittest” meaning “survival of the strongest”.

2. Organisms develop certain traits because they need them.

3. Evolution by natural selection involves some grand plan of nature in which species become more perfectly adapted.
The Venus Flytrap
Section 4-3

HOW DO GEOLOGICAL PROCESSES AND CLIMATE CHANGE AFFECT EVOLUTION?
Geologic processes affect natural selection

- Tectonic plates shift slowly on the planet’s mantle, changing the earth’s surface.
- The location of continents affects climate and thus species distribution.
- Movement of plates allowed the spread and evolution of species.
- earthquakes can cause changes in earth’s surface that result in geologic isolation of populations.
- Volcanic eruptions can destroy habitats and reduce, isolate, or wipe out populations of species.
Movement of Earth’s Tectonic Plates

225 million years ago

Present

- PANGAEA
- NORTH AMERICA
- EURASIA
- SOUTH AMERICA
- AFRICA
- AUSTRALIA
- ANTARCTICA
Climate change and catastrophes affect natural selection

- Cooling and warming periods have covered much of the earth with glacial ice, or melted the ice and drastically raised sea levels.
  - Long-term climate changes determine where different types of plants and animals can survive, and caused the extinction of some species.

- Catastrophic events, such as collisions with large asteroids, have caused:
  - Destruction of ecosystems and extinction of large numbers of species.
  - Shifts in the locations of ecosystems and created opportunities for the evolution of new species.
Glacial Ice Coverage During the Past 18,000 Years

Legend
- Continental ice
- Sea ice
- Land above sea level

18,000 years before present
Northern Hemisphere
Ice coverage
Modern day (August)
HOW DO SPECIATION, EXTINCTION, AND HUMAN ACTIVITIES AFFECT BIODIVERSITY?
How do new species evolve?

• Speciation is the process where one species splits into two or more different species.

• Geographic isolation occurs when different groups of the same population of a species become physically isolated from one another for a long period of time.

• Reproductive isolation occurs when mutation and change by natural selection operate in the gene pools of geographically isolated populations.
Geographic Isolation

Early fox population spreads northward and southward and separates into Northern population and Southern population.

Arctic Fox: Adapted to cold through heavier fur, short ears, short legs, and short nose. White fur matches snow for camouflage.

Different environmental conditions lead to different selective pressures and evolution into two different species.

Gray Fox: Adapted to heat through lightweight fur and long ears, legs, and nose, which give off more heat.
Sooner or later all species become extinct

- Biological extinction is the process by which an entire species ceases to exist.
- Local extinction occurs when a population of a species becomes extinct over a large region, but not globally.
- Endemic species are found in only one area and are thus especially vulnerable to extinction.
- Background extinction has occurred over most of Earth’s history.
There have been several mass extinctions of life on the Earth

- Mass extinction is a significant rise in extinction rates above the background level, in which large groups of species are wiped out.
- Fossil and geological evidence indicate that there have probably been five mass extinctions during the past 500 million years.
- Mass extinctions have been followed by an increase in species diversity as new species have arisen to occupy new habitats or to exploit newly available resources.
- There is growing evidence that we are experiencing the beginning of a new mass extinction, with much of the increase in extinctions and loss of biodiversity due to human activities.
WHAT ROLES DO SPECIES PLAY IN ECOSYSTEMS?
Each species plays a role in its ecosystem

- An ecological niche is a species’ way of life in an ecosystem, everything that affects its survival and reproduction.
- Niche is different from habitat, which is the place where an organism lives.
- Generalist species have broad niches.
  - They can live in many different places.
  - They can eat a variety of foods and tolerate a wide range of environments.
  - Flies, cockroaches, rats and humans are generalists.
Each species plays a role in its ecosystem

- Specialist species have narrow niches.
  - They live only in very specific environments.
  - This makes them more prone to extinction when environmental conditions change.
  - If the environment is constant, specialists have fewer competitors.
  - China’s giant panda is a specialist with a specialized diet of mostly bamboo.
Specialized Feeding Niches of Various Bird Species in a Coastal Wetland

- Black skimmer seizes small fish at water surface.
- Brown pelican dives for fish, which it locates from the air.
- Avocet sweeps bill through mud and surface water in search of small crustaceans, insects, and seeds.
- Dowitcher probes deeply into mud in search of snails, marine worms, and small crustaceans.
- Herring gull is a tireless scavenger.
- Ruddy turnstone searches under shells and pebbles for small invertebrates.
- Flamingo feeds on minute organisms in mud.
- Scaup and other diving ducks feed on mollusks, crustaceans, and aquatic vegetation.
- Louisiana heron wades into water to seize small fish.
- Oystercatcher feeds on clams, mussels, and other shellfish into which it pries its narrow beak.
- Knot (sandpiper) picks up worms and small crustaceans left by receding tide.
- Piping plover feeds on insects and tiny crustaceans on sandy beaches.
Species can play four major roles within ecosystems

1. Niches can be classified further in terms of specific roles that certain species play within ecosystems. A species can be described as native, nonnative, indicator, or keystone.

2. Native species are those that normally live and thrive in a particular ecosystem.

3. Nonnative species, also called invasive, alien, and exotic, are those that migrate into, or are deliberately or accidentally introduced into, an ecosystem.

4. Nonnative species can threaten native species.
Indicator species serve as biological smoke alarms

- Indicator species provide early warnings of damage to a community or an ecosystem.
  - Birds are excellent biological indicators because they are found almost everywhere and are affected quickly by environmental changes, such as loss or fragmentation of their habitats and introduction of chemical pesticides.

_Silent Spring_… by Rachel Carson
CASE STUDY: Why are amphibians vanishing?

• Amphibian species are also believed to be indicator species.
• Populations of amphibians are declining or disappearing throughout the world; more than 30% of all known species are threatened with extinction and populations of another 43% are declining.
• Natural immigration of, or deliberate introduction of, nonnative predators and competitors.
Many factors can affect frogs and other amphibians at various points in their life cycles:

- Habitat loss/fragmentation.
- Prolonged drought.
- Increases in UV radiation.
- Parasites.
- Pollution.
- Viral and fungal diseases.
- Climate change.
- Overhunting.
Three reasons to care if amphibians become extinct

1. Amphibians are sensitive biological indicators of changes in environmental conditions such as habitat loss and degradation, air and water pollution, UV radiation, and climate change.

2. Adult amphibians play important ecological roles in biological communities.

3. Amphibians represent a genetic storehouse from which hundreds of pharmaceutical products could be developed.
Keystone species play critical roles in their ecosystems

• Keystone species are species whose roles have a large effect on the types and abundance of other species in an ecosystem, even though they may exist in relatively limited numbers in their ecosystems.
  – Examples are the wolf, leopard, lion, some shark species, and the American alligator
Keystone Species: The American Alligator
Keystone Species: The American Alligator

• A keystone species due to a number of important roles that help maintain the sustainability in the subtropical wetland ecosystems where it is found.
  – Alligators dig deep depressions, or gator holes, which hold freshwater during dry spells, serve as refuges for aquatic life, and supply freshwater and food for fishes, insects, snakes, turtles, birds, and other animals
  – Large alligator nesting mounds provide nesting and feeding sites for some birds and turtles.
  – Alligators eat large numbers of gar, which helps to maintain populations of game fish such as bass and bream that the gar eat
  – Gator holes and nesting mounds help to keep shore and open water areas free of invading vegetation.
Keystone Species: The American Alligator

http://www.youtube.com/watch?feature=endscreen&NR=1&v=JJx-pi_vloM
CASE STUDY: The American alligator—A keystone species that almost went extinct

• Between the 1930s and 1960s, hunters and poachers wiped out _____ of the alligators in the U.S. state of Louisiana, and the alligator population in the Florida Everglades was also near extinction.

• Since being classified as an endangered species in 1967, American alligators have recovered enough to be removed from the endangered species list.
Three Big Ideas

• Populations evolve when genes mutate and give some individuals genetic traits that enhance their abilities to survive and to produce offspring with these traits (natural selection).

• Human activities are degrading the earth’s vital biodiversity by causing the extinction of species and by disrupting habitats needed for the development of new species.

• Each species plays a specific ecological role in the ecosystem where it is found.