

# Evolution and Biodiversity

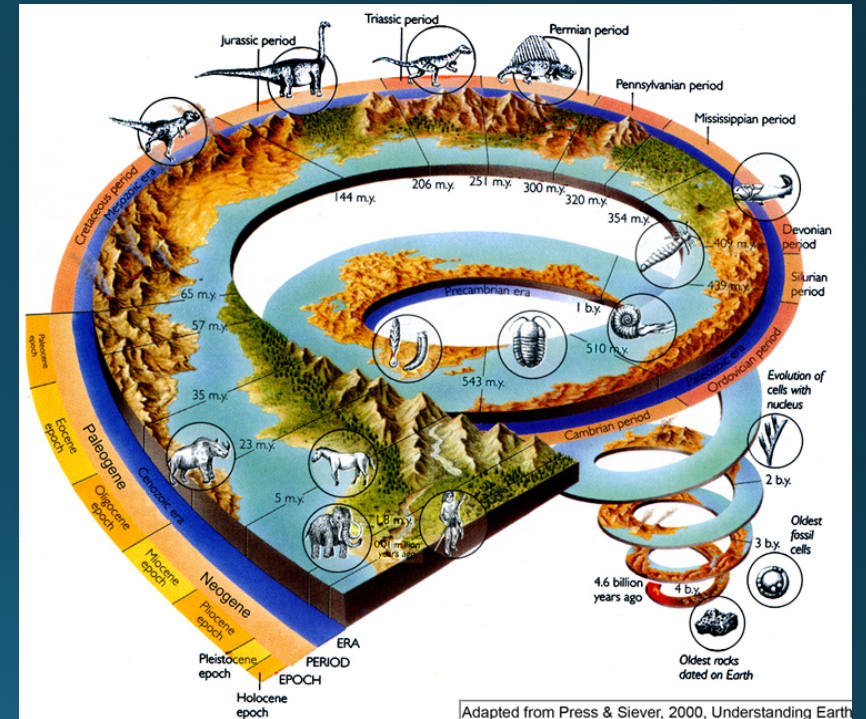
# Earth: The Just Right Adaptable Planet

- What makes Earth so perfect for life?
  - Earth is the right distance from the sun to allow for the existence of liquid water
  - Earth has just the right amount of gravitational mass to keep iron and nickel core molten and to keep the atmospheric gases in place
  - Earth has about 21% O<sub>2</sub> in the atmosphere
  - The ozone layer protects from UV rays
  - Uniquely suited for life
    - Allowing biodiversity
    - Allowing sustainability



# Origins of Life on Earth

- Earth's life is the result of
  - 1B years of chemical change to form the first cells
  - 3.7B years of biological change to produce a variety of species
- Cornerstones of life on Earth
  - Natural Selection: the process by which a particular beneficial gene (or set of genes) is reproduced in succeeding generations more than other genes
  - Biological evolution: Change in the genetic makeup of a population of a species in successive generations



# Extinctions

## The 5 major mass extinctions:

### 1. End Ordovician, 439 mya

60% of marine invertebrate genera go extinct.

### 2. Late Devonian, 367 mya

57% of marine invertebrate genera go extinct.

### 3. End Permian, 245 mya

82% of marine invertebrate genera go extinct.

### 4. End Triassic, 208 mya

53% of marine invertebrate genera go extinct.

### 5. End Cretaceous, 65 mya

47% of marine invertebrate genera go extinct.

**mya = million years ago**



# What is Biological Diversity?

- The variety of the Earth's species, the genes they contain, the ecosystems where they live, and the ecosystem processes such as energy flow and nutrient cycling that sustain all life.
- Biodiversity is a vital, renewable resource.

## components of biodiversity

### 1. Genetic biodiversity:



Genetic variation or diversity within a Species.

### 2. Species biodiversity:



Diversity between different Species.

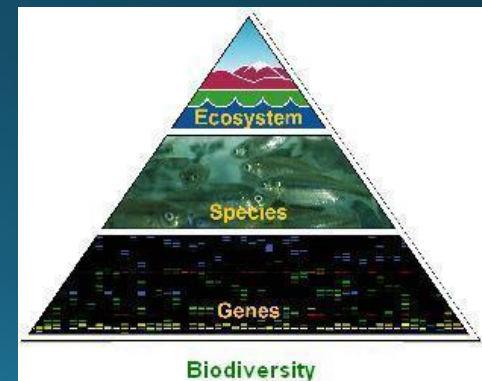
### 3. Ecosystem biodiversity:



Diversity within a Region.

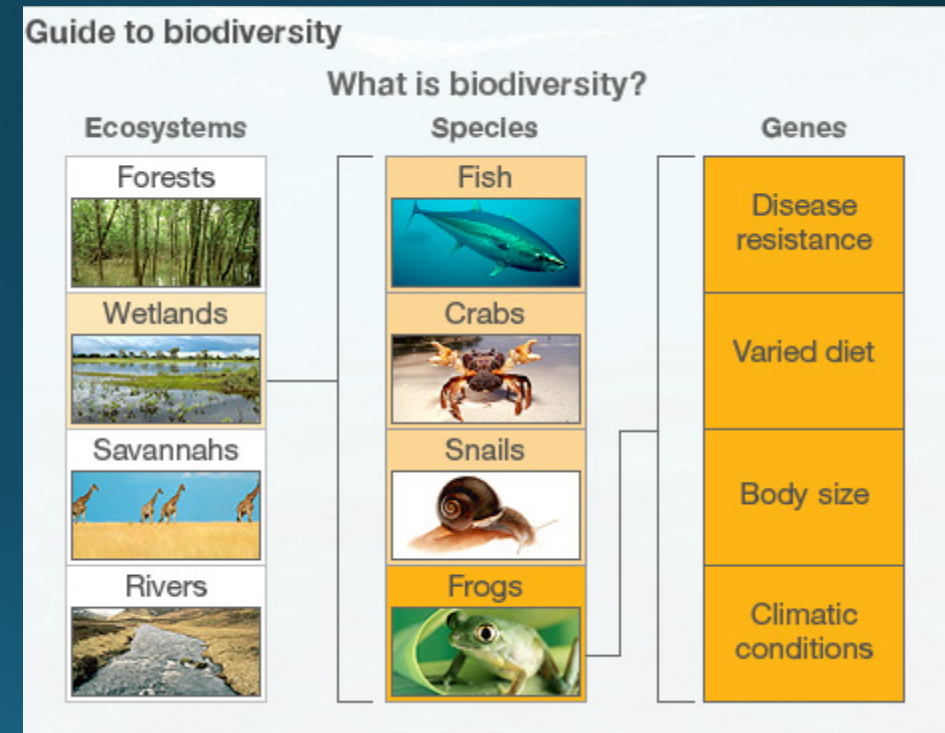
# Components of biodiversity

- **Species diversity:** the number of different species and their relative abundances in a given area
- **Genetic diversity:** Variability in the genetic makeup among individuals within a single species
- **Ecosystem diversity:** the earth's variety of deserts, grasslands, forests, mountains, oceans, and wetlands—each is a genetic and species storehouse of diversity
- **Functional diversity:** biological and chemical processes or functions such as energy flow and matter cycling needed for survival of species and biological communities



# The so what of biodiversity...

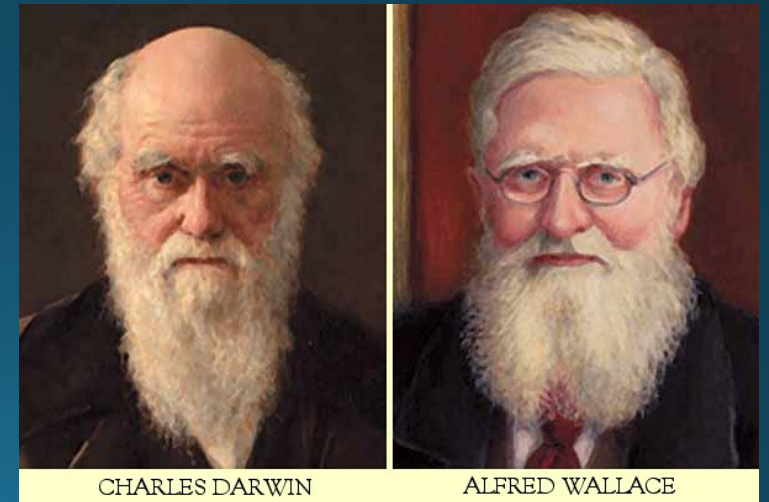
- It is a vital part of the natural capital that keeps us alive:
  - It supplies food, wood, fibers, energy and medicines
  - It helps preserve the quality of air, water and the fertility of soils
  - It helps us dispose of wastes
  - It helps control populations of pests
  - It preserves Earth's natural capital and helps to sustain life as we know it on Earth
  - It provides for raw materials and opportunities for a global economic





# How did we end up with so many species?

- **Biological evolution:** the process where earth's life changes over time through changes in the genes of populations
- The idea that organisms change over time has been around for a long time.
- Charles Darwin and Alfred Russel Wallace independently proposed a credible explanation for how it happens: **natural selection as a mechanism for biological evolution**



CHARLES DARWIN

ALFRED WALLACE

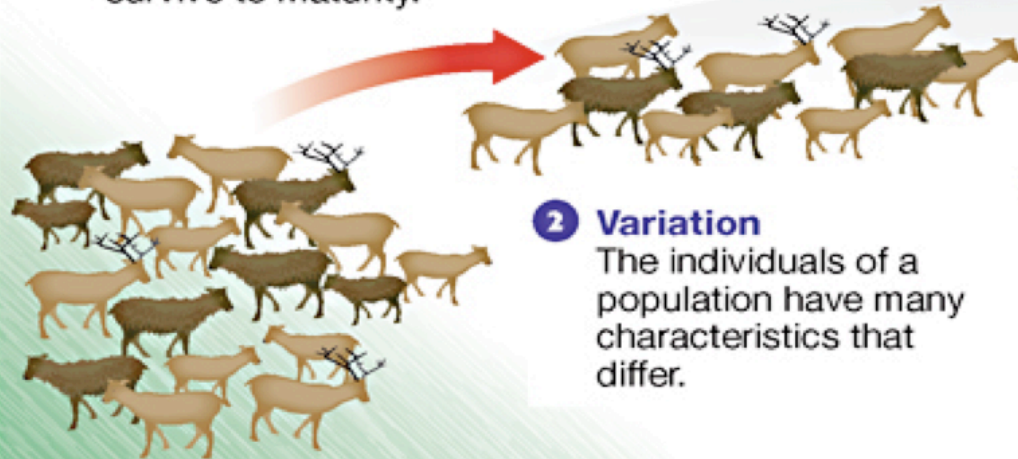


# Natural Selection

## The Theory of Evolution by Natural Selection

### 1 Overproduction

Every species tends to produce more individuals than can survive to maturity.



### 2 Variation

The individuals of a population have many characteristics that differ.



### 3 Selection

Some individuals survive longer and reproduce more than others do.

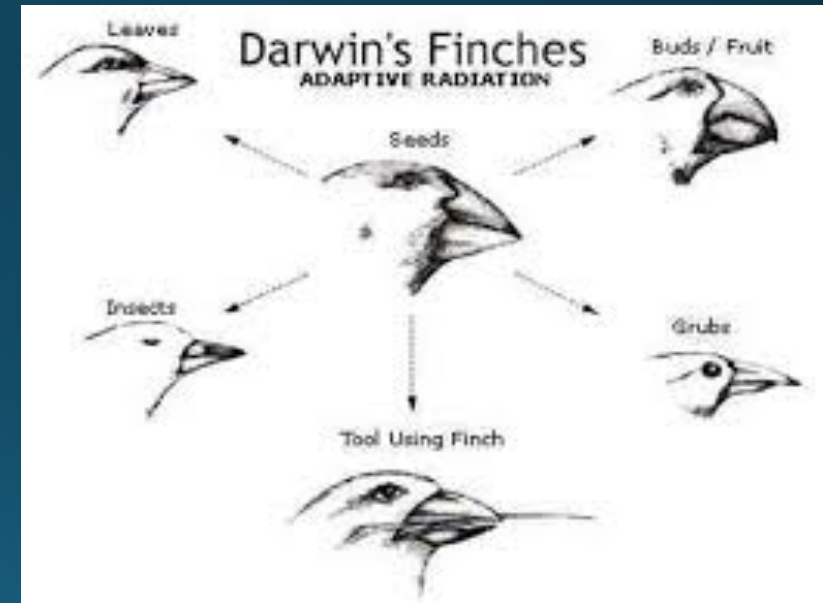


**4 Adaptation** The traits of those individuals that survive and reproduce will become more common in a population.



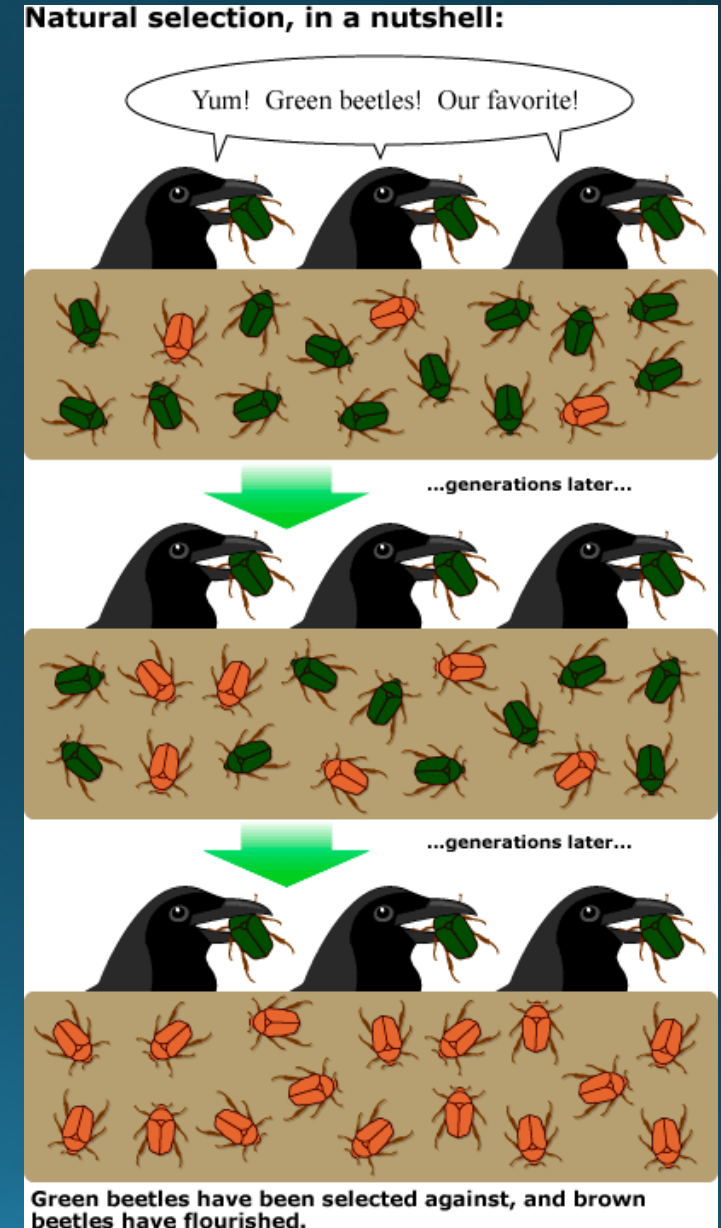
# Biological evolution by natural selection

- Organisms must constantly struggle to obtain enough food and other resources to survive and reproduce
- Individuals in a population with a specific advantage over other individuals are more likely to survive, reproduce and have similar skilled offspring
- The advantage passed on was due to a characteristic—trait—possessed by these individuals but not by others



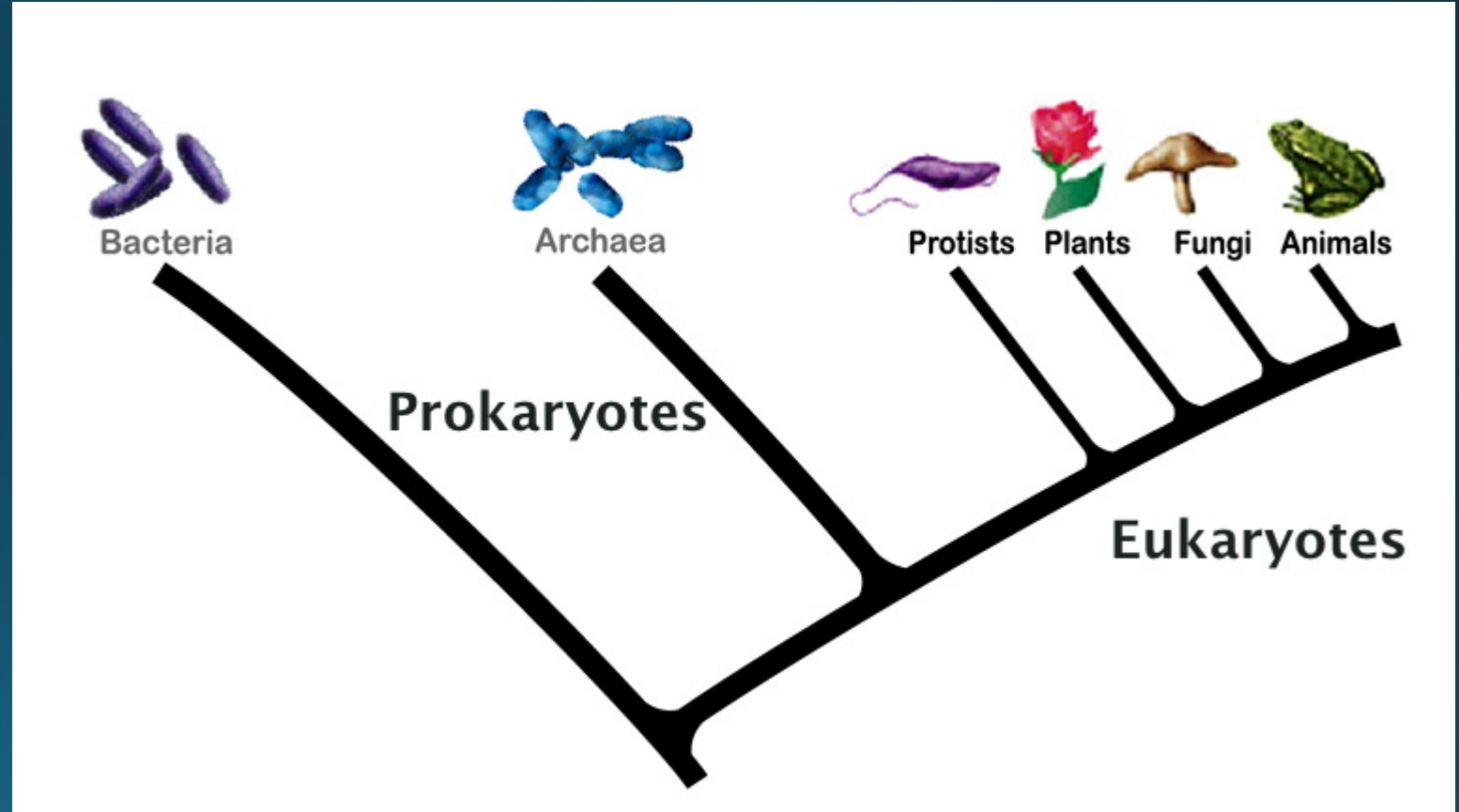
# Natural Selection

- These survival traits would become more prevalent in future populations through natural selection
- A change in the genetic characteristics of a population from one generation to another is known as biological evolution



# Tree of life

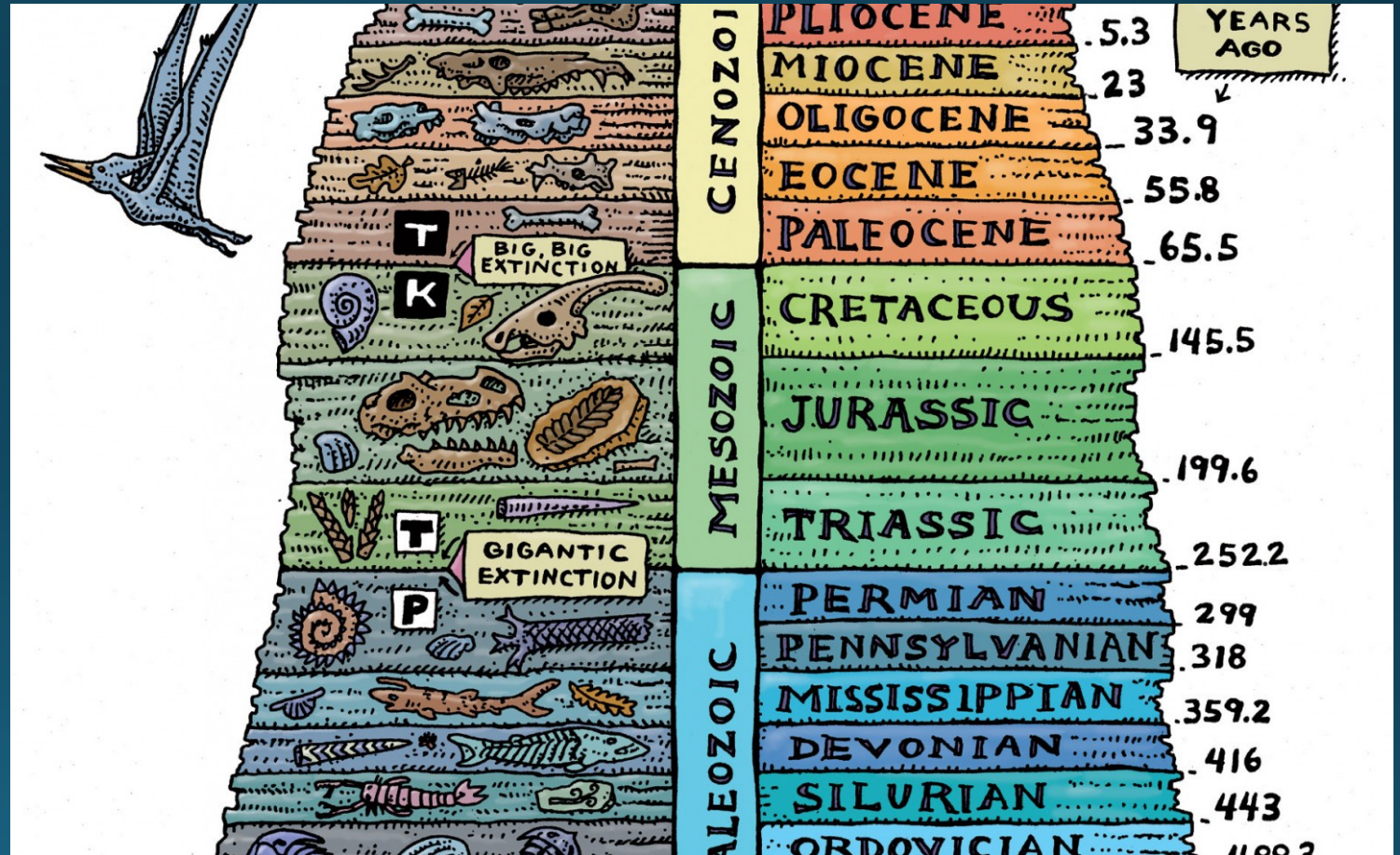
- As a result of biological evolution, life has evolved into six major groups of species—kingdoms—as a result of natural selection.





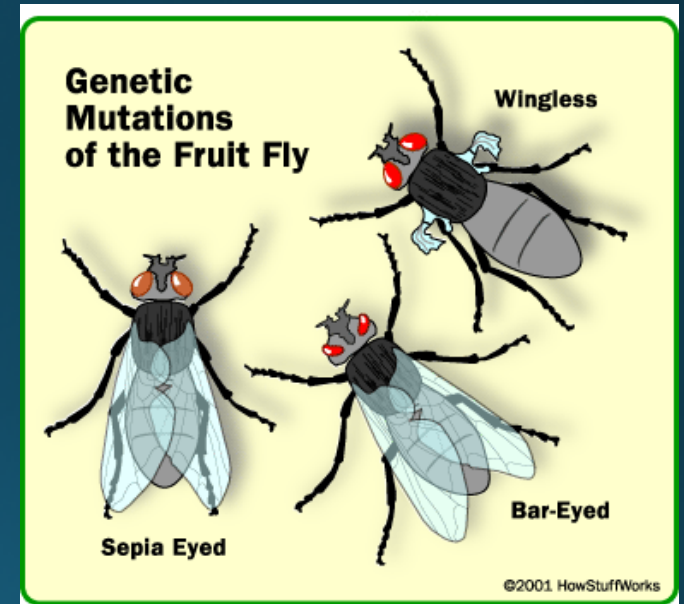
# The fossil record tells much about evolution

- Most of what we know about the earth's life history comes from fossils
  - Mineralized or petrified replicas of skeletons, bones, teeth, shells, leaves, seeds, impressions—found in rocks
  - Represent only 1% of all species that have ever lived
- Glacial ice also shows earth history in layers
- Fossil record--the world's cumulative record of fossils



# The genetic makeup of a population can change

- **Populations—not individuals—evolve by becoming genetically different**
- **Steps:**
  - Genetic variability in a population—occurs through mutations
  - Mutations are random change in the structure or number of DNA molecules in a cell that can be inherited by offspring
  - Mutations can occur in any cell—but only those taking place in reproductive cells are passed on to offspring





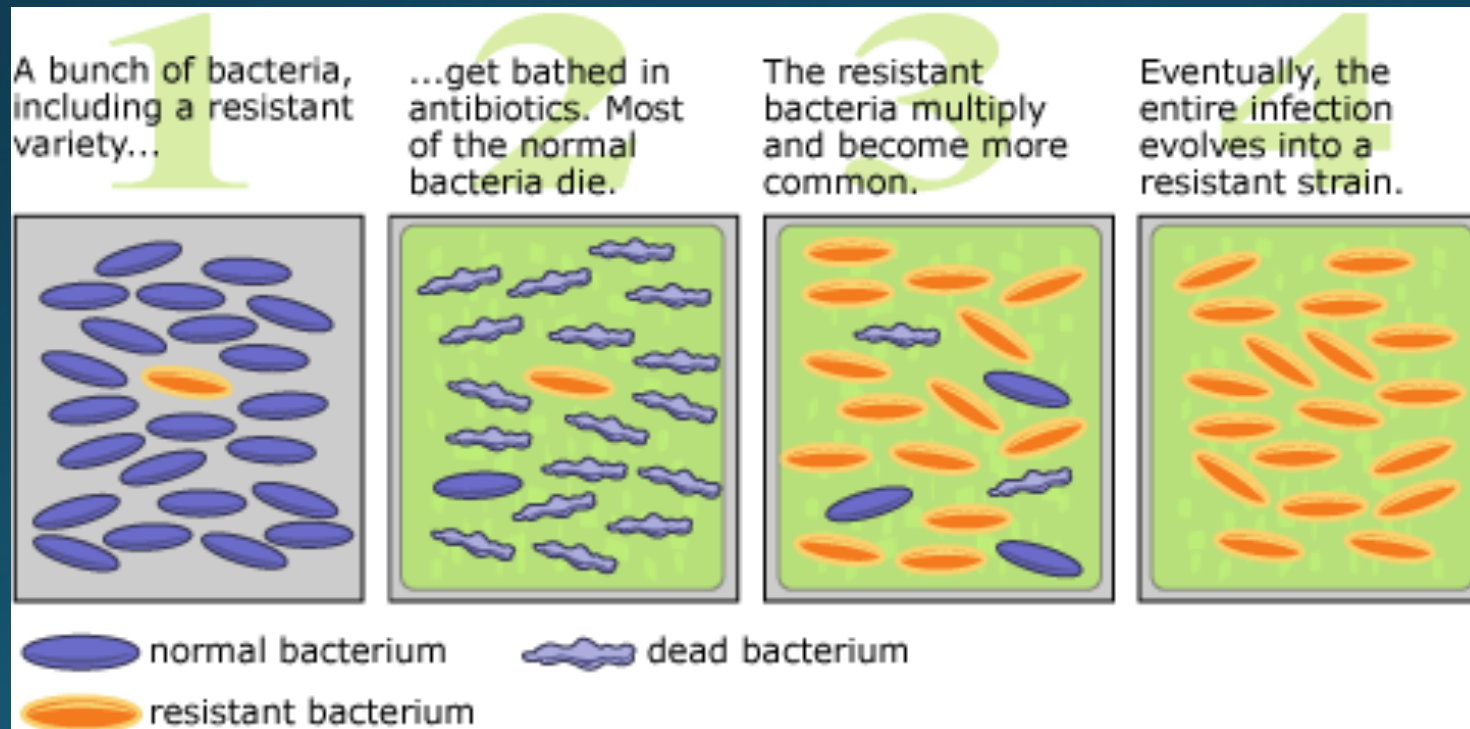
# Beneficial traits

- Next step in biological evolution is natural selection--some individuals of a population have genetically based traits that enhance their ability to survive and produce offspring with these traits.
  - **Adaptation**—any heritable trait that enables an individual organism to survive through natural selection
  - **Heritable**—can be passed on from one generation to the next
  - **Differential reproduction**—an individual can leave more offspring than other members of the population
  - Examples: Gray wolves with thicker fur in areas with snow and cold, white arctic rabbits



# Beneficial traits

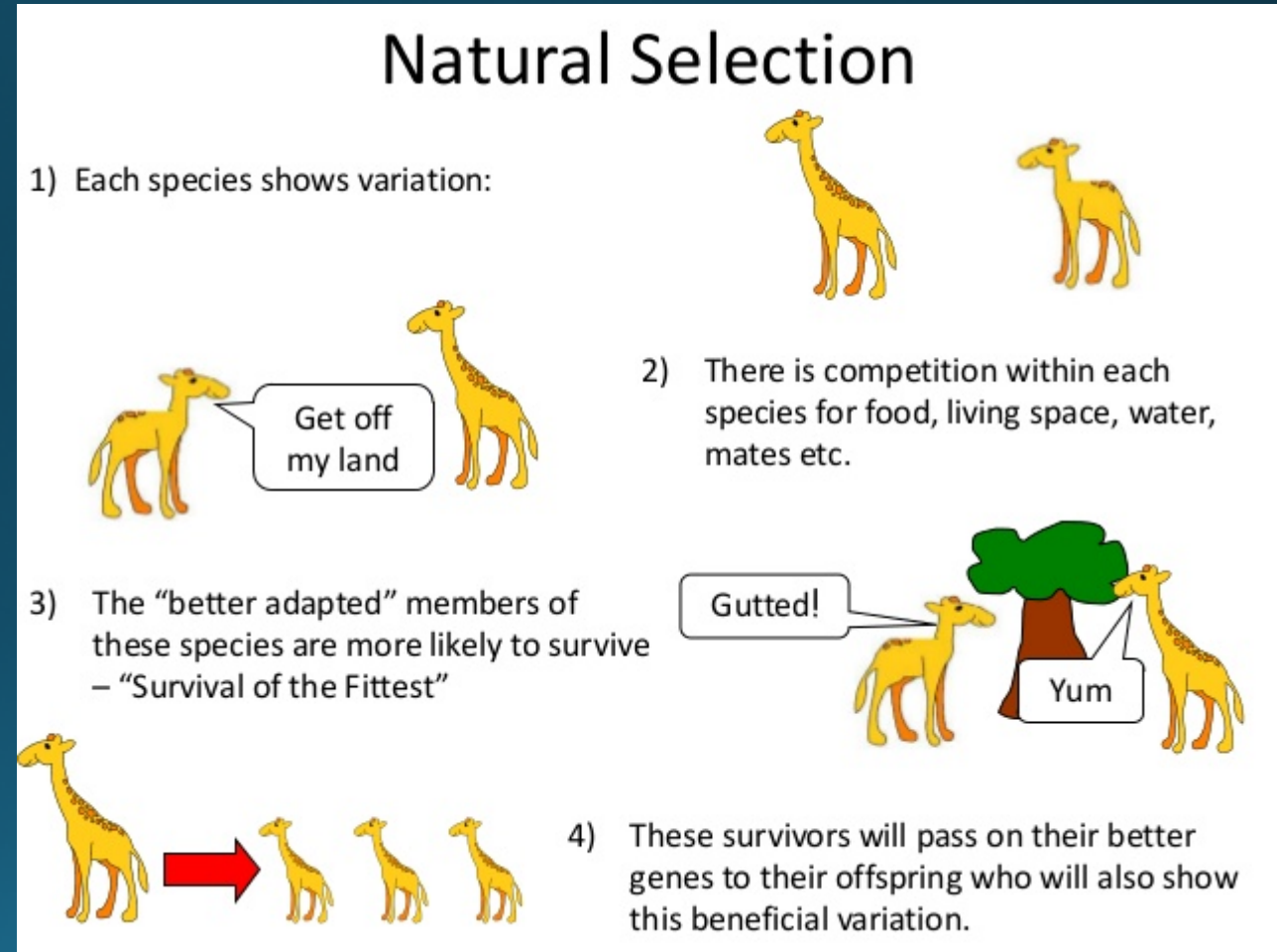
- **Genetic resistance**—the ability of one or more organisms in a population to tolerate a chemical designed to kill it
- Example: Antibiotic resistance in disease causing bacteria





# Summary

- Natural selection acts on individuals
- Evolution occurs in populations
- When an environment changes an individual has 3 choices:
  - Adapt
  - Migrate
  - Become extinct



# Adaptation through natural selection has limits

- A change in environmental conditions can lead to an adaptation only for genetic traits already present in a population's gene pool or for traits resulting from mutations
- The population's ability to adapt may be limited by its reproductive capacity

# Common Myths about evolution through natural selection

- Survival of the fittest means survival of the strongest
  - Fitness is a measure of reproductive success—not strength
- Organisms develop traits because the need or want them
  - Some ancestor had a gene that allowed the advantage (giraffes and long necks)
- There is some grand plan of nature which will allow species to become perfectly adapted
  - No plan or goal has been identified in the evolution process

# Geologic Process and Evolution

**Figure 2.** Continental Drift and the Completion of the Land of North Carolina

**b.** Silurian Period (395-435 million years ago)



**b.** Devonian Period (345-395 million years ago)



**c.** Carboniferous Period (293-345 million years ago)



**d.** Cretaceous Period (65-136 million years ago)



Source: J. W. Clay, P. D. Escott, D. M. Orr Jr., and A. W. Stuart, Land of the South (Birmingham: Oxmoor House, 1989).

- Locations of continents and ocean basins greatly influence the earth's climate and determine where plants and animals can live.
- The movement of continents has allowed species to move, adapt and form new species through natural selection
- Earthquakes can separate and isolate populations of species



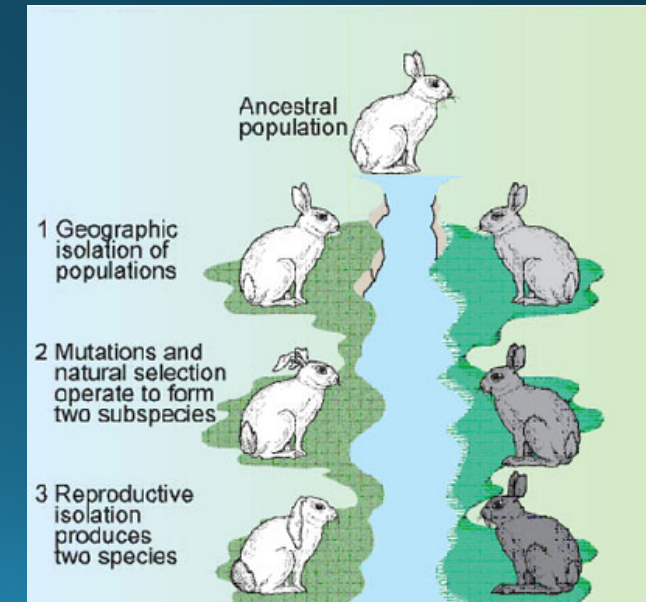
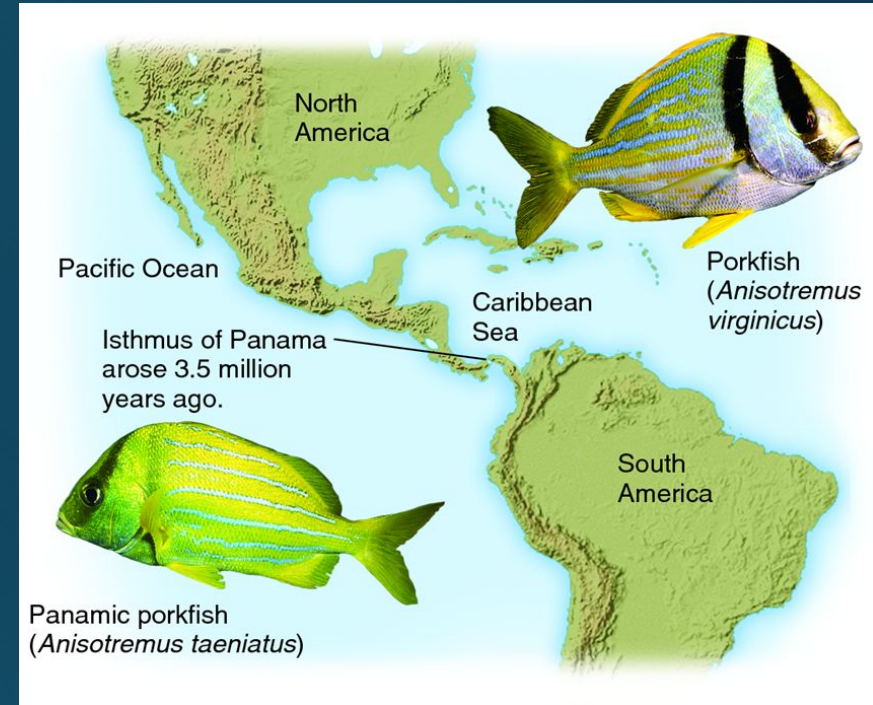
# Climate change and Evolution

- Long term climate changes determine where different types of plants and animals can survive and thrive
- Some species become extinct due to rapid changes
- Earth collisions with asteroids (catastrophic events) led to widespread destruction—often due to resulting climate change



# Speciation

- Speciation occurs when two species arise from one
  - One member of a population evolves to the point where they no longer can breed with other members to produce fertile offspring
  - Usually due to geographic isolation followed by reproductive isolation
  - May occur rapidly (within 100 years) but usually takes 10k to 1000k years to occur



# Extinctions

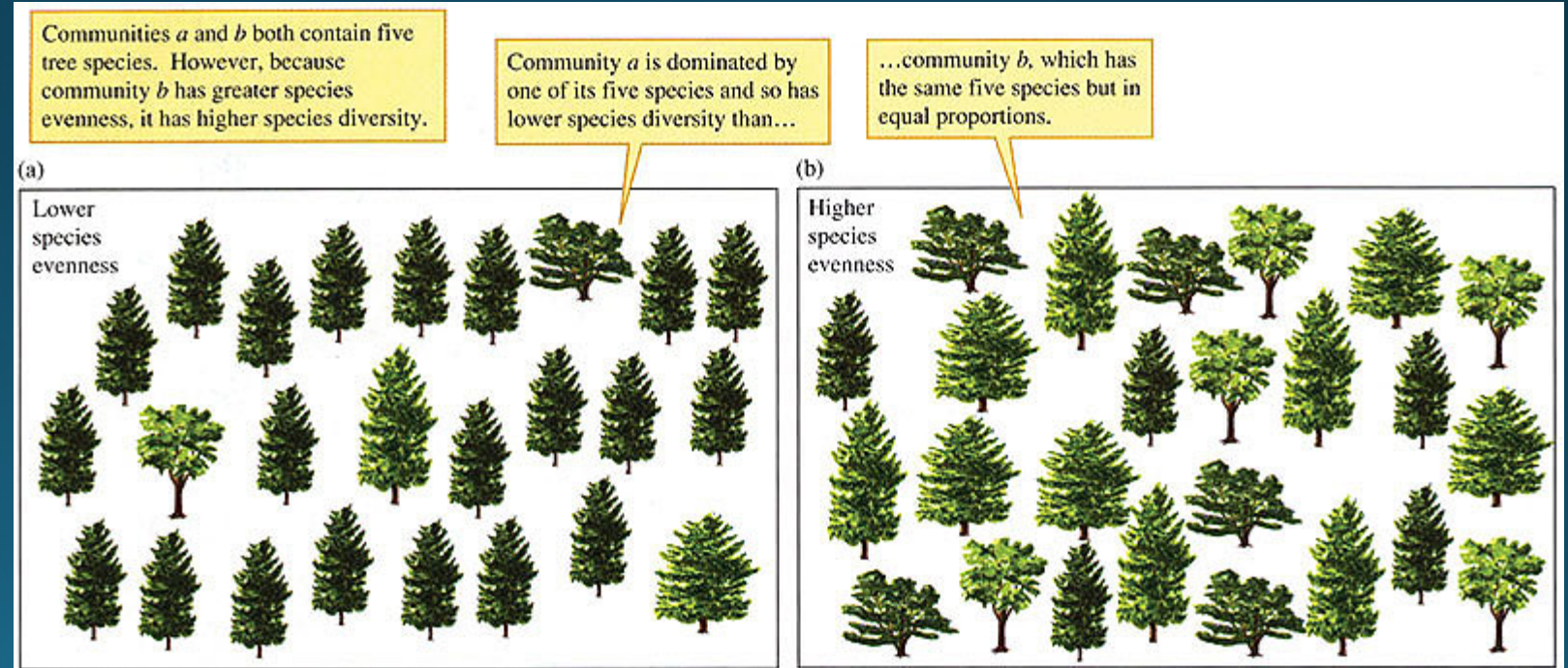
- Extinction is forever—an entire species ceases to exist
- Endemic species—found in only one area and are especially vulnerable to extinction
- Background extinction—disappearance at a low rate
- Mass extinction—catastrophic, widespread event where 25-70% of all species are wiped out
  - 5 mass extinctions have occurred during the past 500 M years





# Why species diversity is important

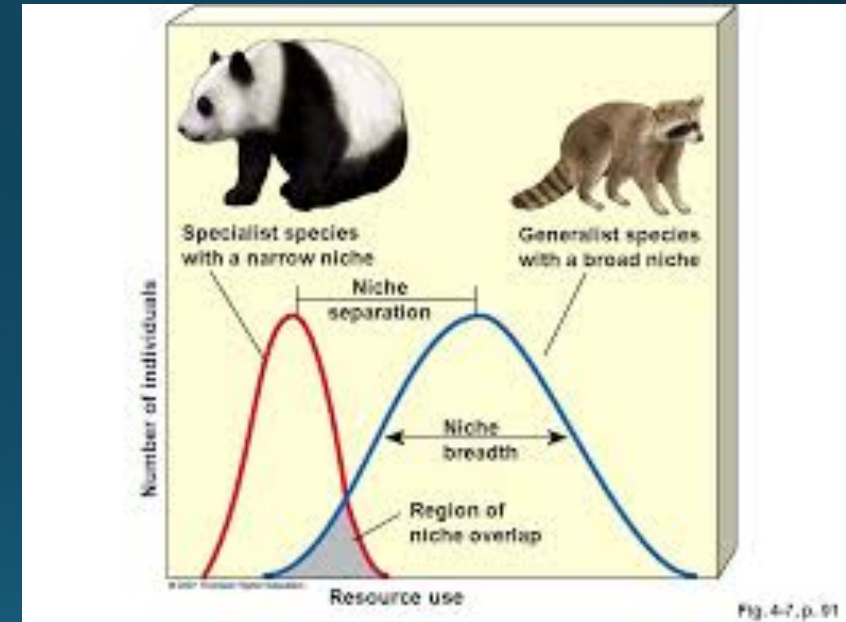
- Species diversity
  - Species richness—the number of different species in an ecosystem—tends to enhance the stability and productivity of an ecosystem
  - Species evenness—the relative abundance of individuals within each of the species





# Roles of species in an ecosystem

- Each species plays a unique role in its ecosystem
  - Ecological niche—the role the species plays (way of life—how much water and sunlight it needs, how much space it requires, temperatures it can tolerate). It is a pattern of living
  - Generalists: broad niches-- live in many places, eat a variety of foods, tolerate a wide range of conditions
  - Specialists: narrow niches—limited habitat, few types of foods, narrow climactic conditions



# Cockroaches—ultimate survivors

- You love to hate them! They've been around for over 350M years
- They eat almost anything, they can live and breed almost anywhere, they can go for a month without eating and withstand doses of radiation. Some can be frozen for 48 hours and still live
- They evade predators—their antennae can detect minute movements
- They have high reproduction rates



# Native vs Nonnative species

- Native species—species that normally live and thrive in a particular ecosystem
- Nonnative species—species that migrate into or are introduced into an ecosystem
  - Includes domesticated animals
  - Includes many crops



# Indicator species

- Indicator species: provide early warnings of damage to a community or ecosystem
  - Presence or absence of trout (water temperature)
  - Birds (loss of habitat)
  - Butterflies (plants—habitat loss)
  - Amphibians (habitat loss)
- Coal miners used canaries to indicate the presence of dangerous gases





# Keystone and Foundation species

- Keystone species—have a large effect on the types and abundances of other species in an ecosystem
  - Usually limited in numbers
  - Eliminating a keystone species alters the structure and function of a community
  - Can be key predators regulating the food web or butterflies pollinating flowers
- Foundation species—plays a major role in shaping communities by changing the habitat to benefit other species
  - Elephants in Africa
  - Beavers building dams

# Why should we care?



- The American alligator has no natural predators—except humans.
  - Humans hunted alligators for sport, hatred and profit
  - By 1960s, the alligator population of the Florida Everglades was near extinction
- Alligators play many roles in the ecosystems where they are found
  - Gator holes hold freshwater during dry spells
  - Supply freshwater and food for fish, insects, snakes, turtles, birds and other animals
  - Feeding grounds for herons and egrets
  - Nesting space for red-bellied turtles
- Alligators are sometimes classified as a **keystone species** because of its important ecological role
- Declared “threatened” in 1967, alligators are making a comeback—a success in the wildlife conservation story

# Convergent Evolution

- **Convergent evolution** occurs when similar environmental pressures and natural selection produce similar (analogous) adaptations in organisms from different evolutionary lineages



Falcon



Ancestral  
bird



Bat



Ancestral  
mammal



Pterodactyl



Ancestral  
reptile