Chapter 5
Interactions: Environments and Organisms


Youtube: Tom Strocchia

Questions 1-4 refer to the following concepts related to energy:

- (A) Heat flow
- (B) Kinetic energy
- (C) Potential Energy
- (D) First law of thermodynamics
- (E) Second law of thermodynamics

- 1. Matter in motion has energy
- 2. Energy is transferred from one object to another as the result of a temperature difference.
- 3. An energy transformation occurs and results in increased disorder
- 4. The amount of energy in an isolated system stays constant.

Ecology:

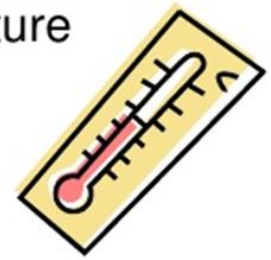
- The study of the way organisms interact with each other and their nonliving surroundings.

Environment:
Everything that affects an organism over its lifetime

Biotic vs. Abiotic Factors

- Living
- Examples
  - Plants
  - Animals
  - Fungi
  - Bacteria

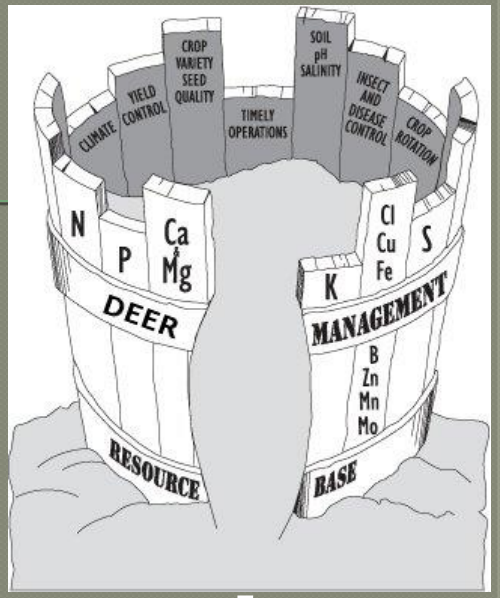
- Non-Living
- Examples
  - Water
  - Sunlight
  - Soil
  - Air
  - Temperature



WHY DO SPECIES LIVE WHERE THEY DO?

- Abiotic factors determine who lives where (temperature, humidity, terrain, etc.)
- Other species determine who lives where (whether it be through competition, feeding relationships, etc.)

Limiting Factor:



The most deficient essential resource that ultimately limits the growth and well-being of an organism.

The **law of tolerance** states that for each physical factor in the environment a minimum and maximum limit exists called the tolerance limit beyond which the organism does not thrive or survive. The range of tolerance is the degree to which a species is able to withstand environmental variation.

TOLERANCE LIMITS

- Tolerance limits are an organism's breaking points beyond which they do not function – they cannot tolerate environmental factors that occur beyond a certain range.

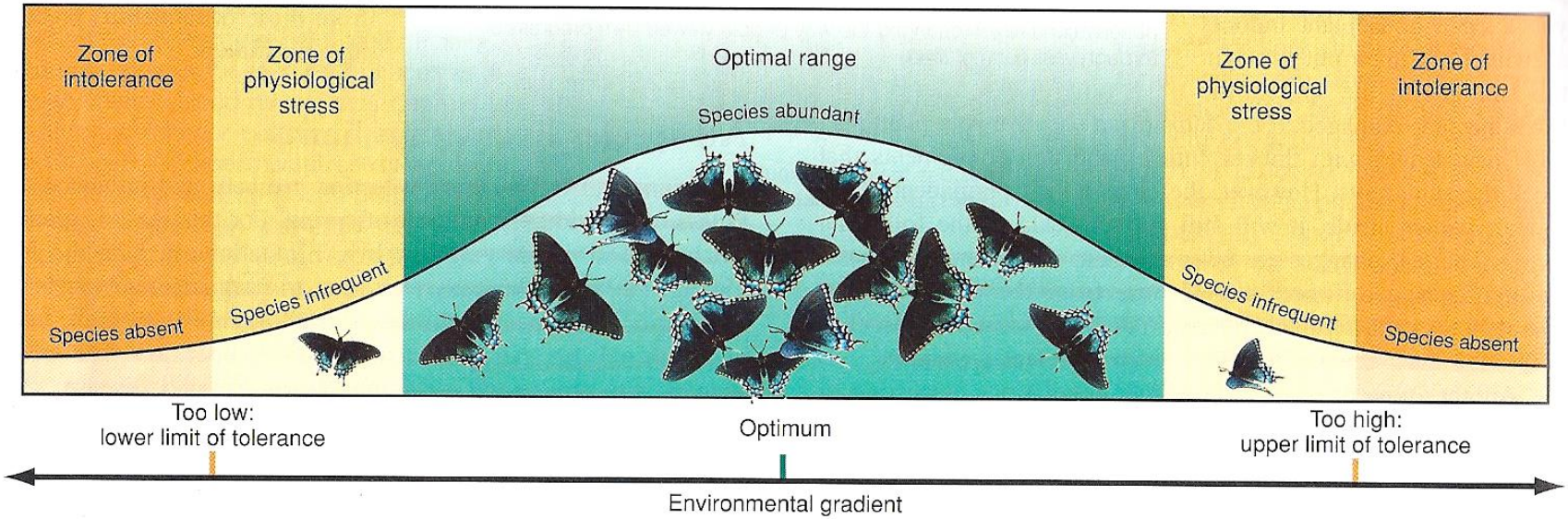


FIGURE 3.3 Tolerance limits affect species populations. For every environmental factor, there is an optimal range where a species is most abundant. As an organism moves away from locations with optimal conditions, the harder life becomes. At some point along the environmental gradient for that factor, individuals become physiologically stressed and few, if any, survive those conditions.

(Cunningham et. al 2008)

The environmental gradient could be: the amount of rain; or it could be the number of food plants available for that butterfly; or it could be the number of predators that like to eat the butterfly.

Range of tolerance examples:

Narrow range:

Pika

Wide range:

Raven

NICHE – definition #1

- Every organism plays or fills a role in the ecosystem it lives in - this role is called the organism's niche
  - The sum total of all of an organism's activities and its uses of resources within its ecosystem

NICHE – definition #2

- A niche is also the environmental factors (both abiotic and biotic) that determine where a species lives.

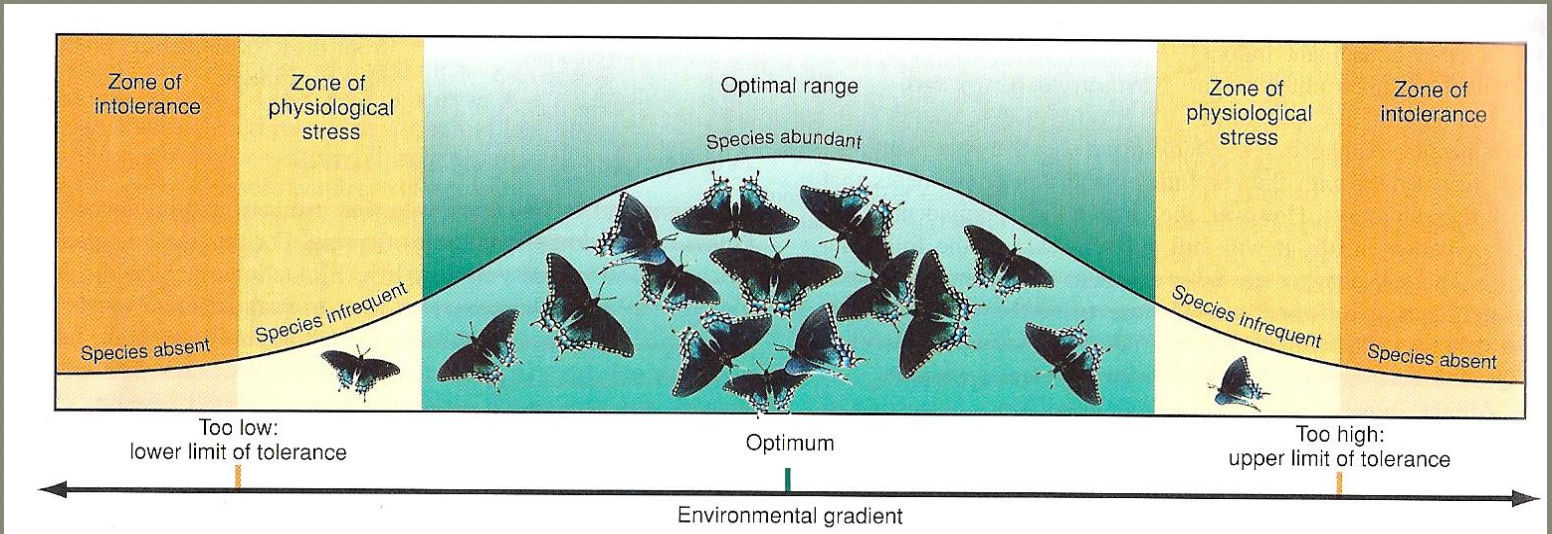
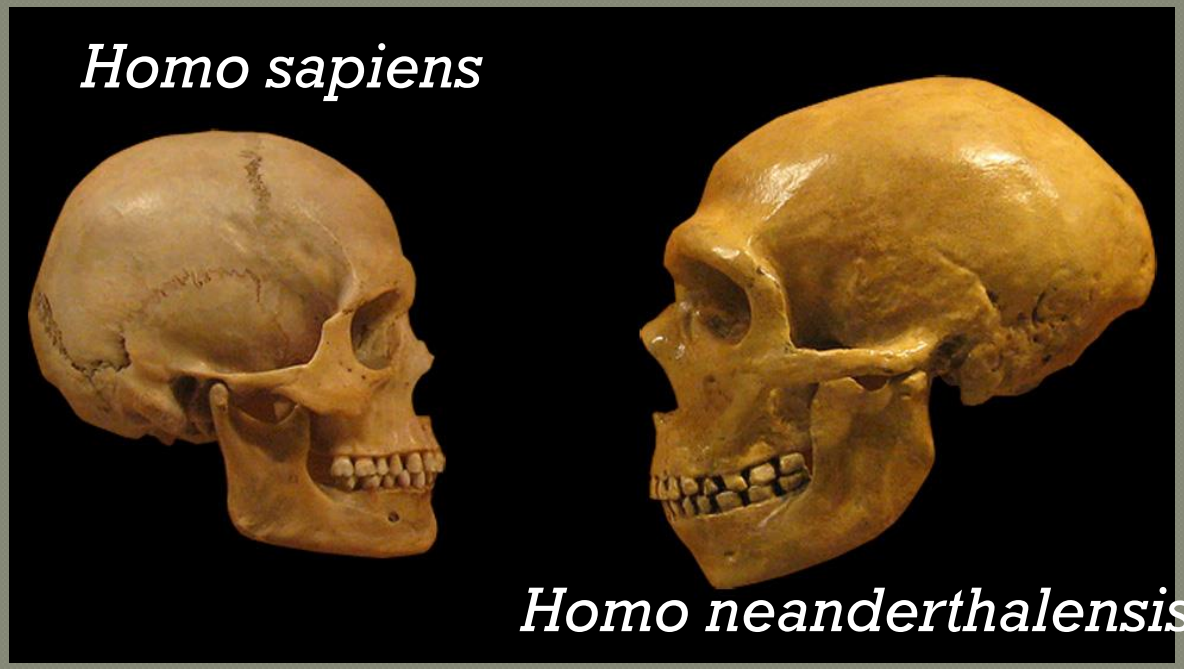


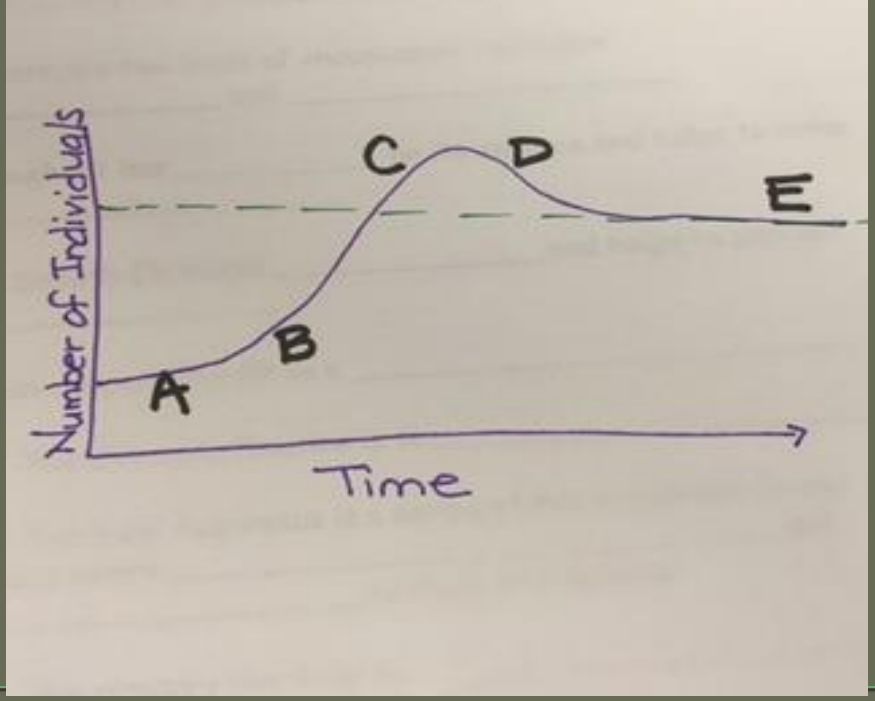
FIGURE 3.3 Tolerance limits affect species populations. For every environmental factor, there is an optimal range where a species is most abundant. As an organism moves away from locations with optimal conditions, the harder life becomes. At some point along the environmental gradient for that factor, individuals become physiologically stressed and few, if any, survive those conditions.

NICHE OVERLAP LEADS TO COMPETITION FOR RESOURCES

Having a unique niche is key to survival.



So the goal is to reduce their niche overlap, or competition, with other organisms in their environment



The diagram above illustrates how the number of individuals in a population changed with time as a result of external stresses and resource limitations. Which lettered portion of the curve most likely corresponds to the carrying capacity of the ecosystem?

(A) A (B) B (C) C (D) D (E) E

2 TYPES OF NICHES

GENERALISTS (wide niches)

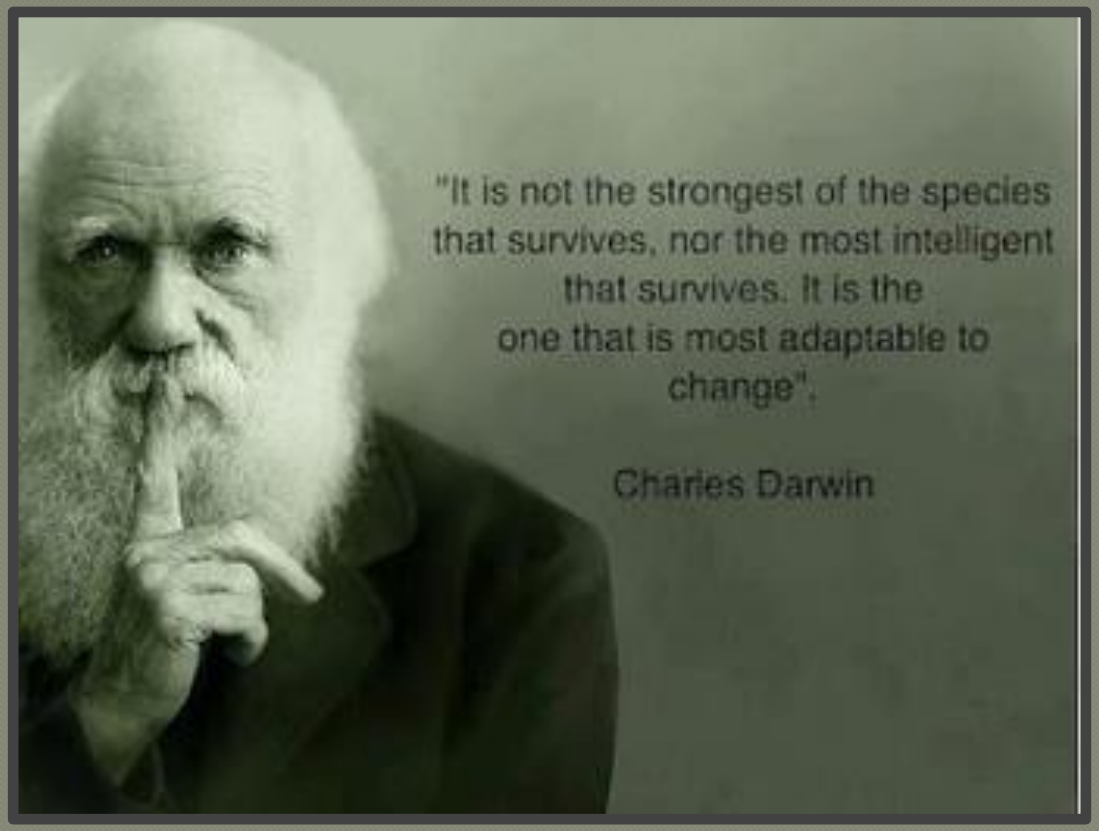
- These species can make use of a variety of ecosystems and food sources.
- They adapt more easily to changes in their environments.
- There are more individuals among generalist populations.
- Examples: Rock Pigeons, Coyotes, Cockroaches

SPECIALISTS (narrow niches)

- These species depend on very specific environmental conditions.
- They do not adapt readily to changes in their environments.
- There are fewer of them, and they are more likely to be on Threatened or Endangered Species lists.
- Examples: Fringe-toed Lizard, Northern Spotted Owl, Kit Foxes

ADAPTATIONS

Adaptations are specific traits that an organism has or does that allows or helps that organism survive in its environment and therefore promotes the success of the species.



Two Types of Adaptation

Structural Adaptation:

- Physical features of an organism that aid in survival/reproduction (i.e. fins, beaks, opposable thumbs etc.)

Behavioral Adaptation:

- Things an organism does that aid in survival/reproduction (mating dance, migrations, etc.)

STRUCTURAL ADAPTATION: these are visible traits, **things you can see** about an organism that allows them to survive in their habitat

Example: Camouflage

The walking stick insect has a cryptic shape and coloration that prevents predators from seeing it.

Example: Shape

The peregrine falcon is the fastest animal in the world. It can dive at speeds over 100 mph because it has an aerodynamic structure that enables them to chase smaller birds in flight.

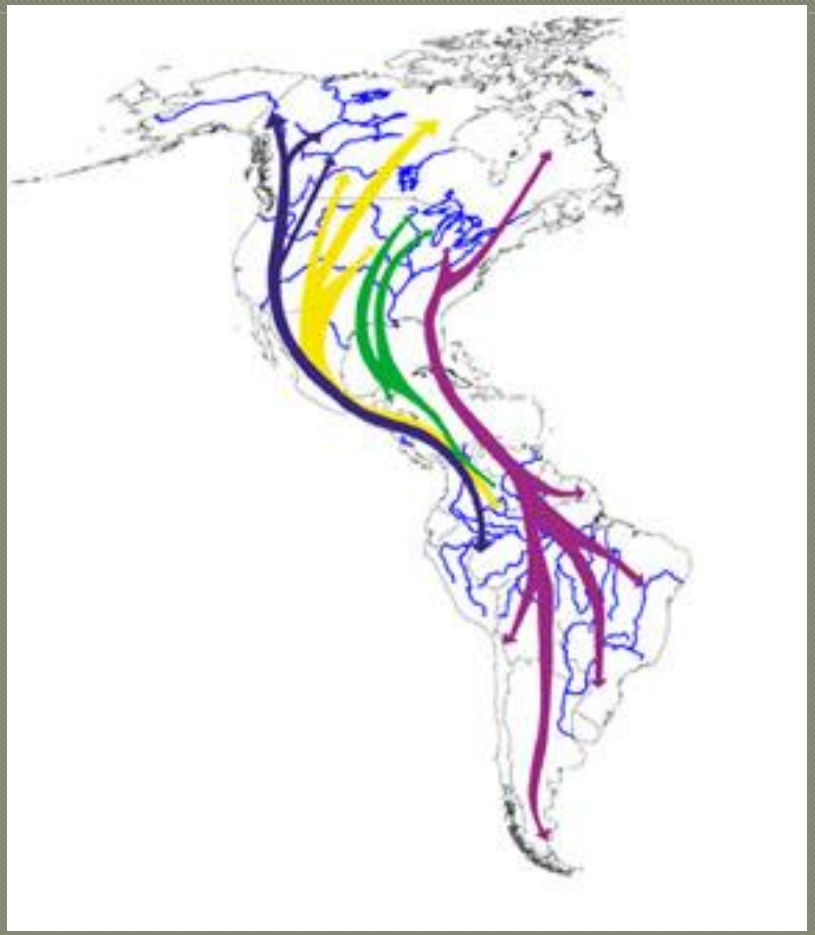
BEHAVIORAL ADAPTATION: something an organism chooses to do; usually a conscious decision, but not always

Example: Camouflage

Mimic Octopus

ANOTHER EXAMPLE OF BEHAVIORAL ADAPTATIONS: Mating Dances and Migrations

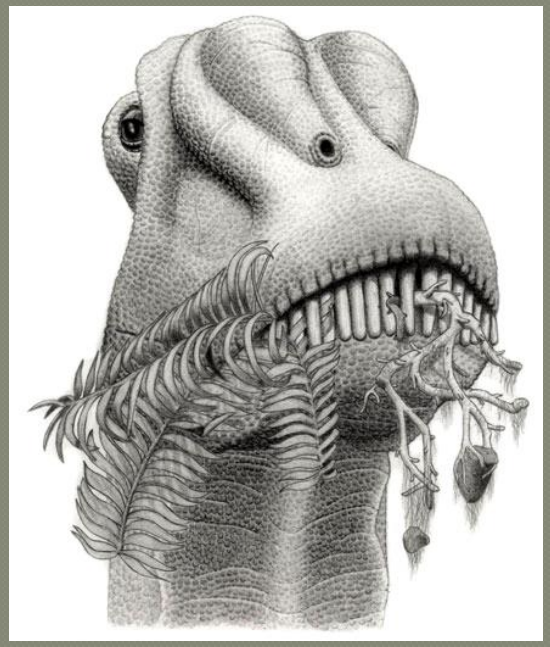
Birds of Paradise have intricate mating dance rituals



Many birds migrate 100s and 1,000s of miles twice a year to follow abundant food sources . Above is a map of American bird flyways.

ANOTHER EXAMPLE OF A BEHAVIORAL ADAPTATION: Gastroliths

Many reptiles, birds and even some mammals ingest stones to aid in digestion and possibly other functions



BEHAVIORAL ADAPTATION: can be a service provided by an organism's body - this is involuntary - it happens internally, the animal doesn't have control

Example: Hibernation

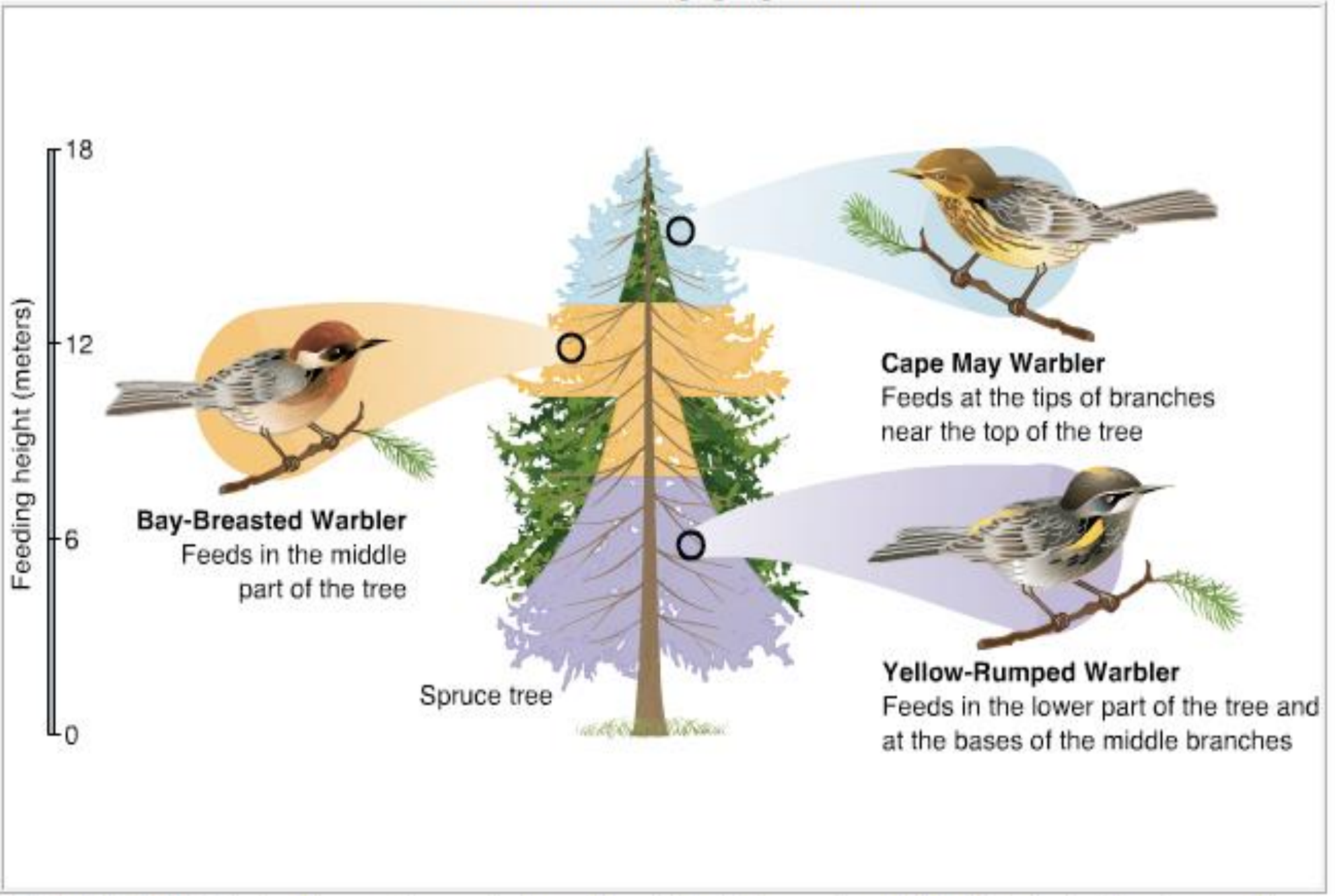
Desert tortoises hibernate during the winter months to avoid cold weather. Being cold-blooded, they cannot produce their own heat.

Hibernation is when one's metabolism slows significantly to only use a minimal amount of the food reserves.
It is not a choice, but rather a survival mechanism.

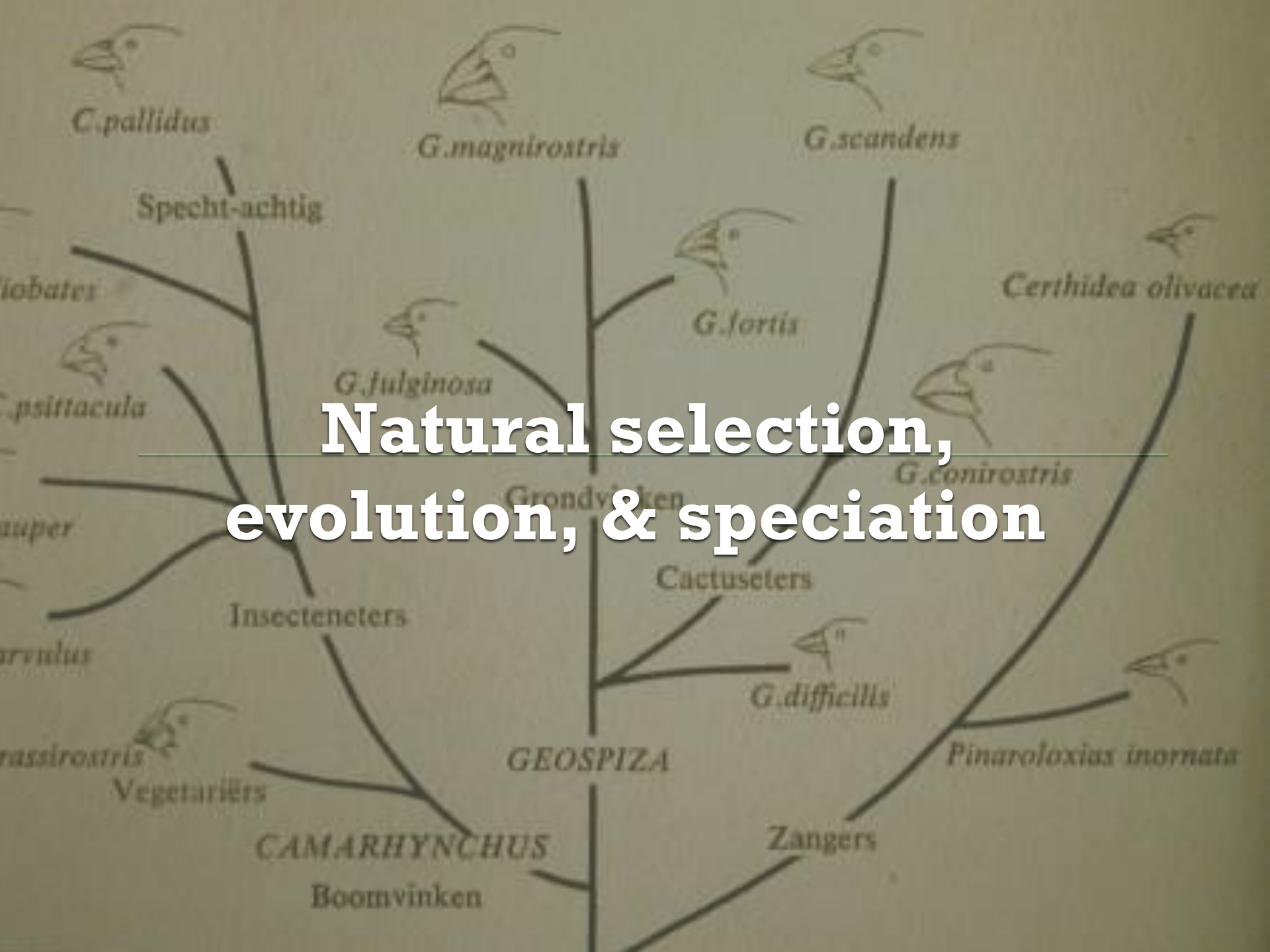
WESTERN DIAMONDBACK RATTLESNAKES' ADAPTATIONS

Behavioral: they will seek the sun to warm up and the shade to cool off.

Structural: they have a rattle on the end of their tail which enables them to warn potential predators and have a heat sensing pit behind each nostril to help locate prey.



Warbler Niches Each of these warbler species has a different niche in its spruce tree habitat. By feeding in different areas of the tree, the birds avoid competing with one another for food. **Inferring** ***What would happen if two of the warbler species attempted to occupy the same niche?***



Natural selection, evolution, & speciation

Population: all organisms of the same kind found within a specific geographic region.

Species: Population of all the organisms potentially capable of reproducing and offspring can also reproduce

NATURAL SELECTION

Natural selection is the theory that seeks to explain how changes in species take place over time.

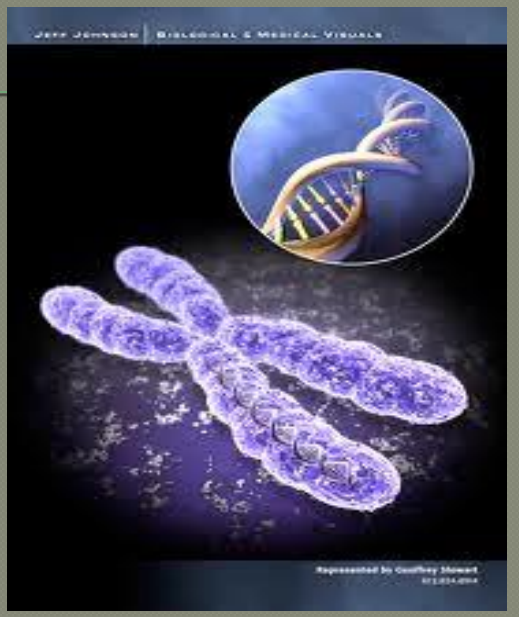
NATURAL SELECTION (continued)

- In 1858, Charles Darwin and Alfred Russell Wallace both proposed natural selection as the mechanism of evolution. They noticed that:

  - Organisms face a constant struggle to survive and reproduce.
  - Organisms tend to produce more offspring than can survive.
  - Individuals of a species vary in their characteristics.

Some individuals are better suited to their environment and will survive and pass their genes on to their offspring. -- This is the basic foundation of how natural selection works.

QUICK OVERVIEW OF GENETICS



- The genes found in the nucleus of an organism's cells contains the DNA of that organism
- The genes contain the codes for various traits/characteristics that an organism has.
- DNA is translated from the code for the various traits into the proteins that produce the necessary functions in the organism for that trait.

GENETIC MUTATIONS

- Most mutations are benign/non-harmful.
- Some mutations, however, are harmful and/or lethal,
- While other mutations are helpful, giving that organism an advantage over others of its population! – hence, better suited for its environment.

GENETIC VARIATION

- Genetic variation in a species comes from 2 different sources:
  - Non-lethal mutations that occur in organisms
  - Sexual reproduction, which involves the recombining or mixing of parental genes

This picture shows genetic variation within butterfly species in their wing patterns

NATURE'S SAFETY NET

Having genetic variation in a species is good, and is nature's way of providing a safety net.

Lack of variation can lead to extinction

SURVIVAL OF THE FITTEST

Over many generations, natural selection ends up leading to overall changes in a population and eventually the whole species - at this point we say the species has evolved!

SELECTIVE PRESSURES

Selective Pressures are the environmental factors or pressures that organisms face such as:

- the constant search for food, water, & shelter
- finding a mate
- avoiding competition for these resources
- raising young
- evading predators, etc…

THE PEPPERED MOTH
(an example of natural selection)

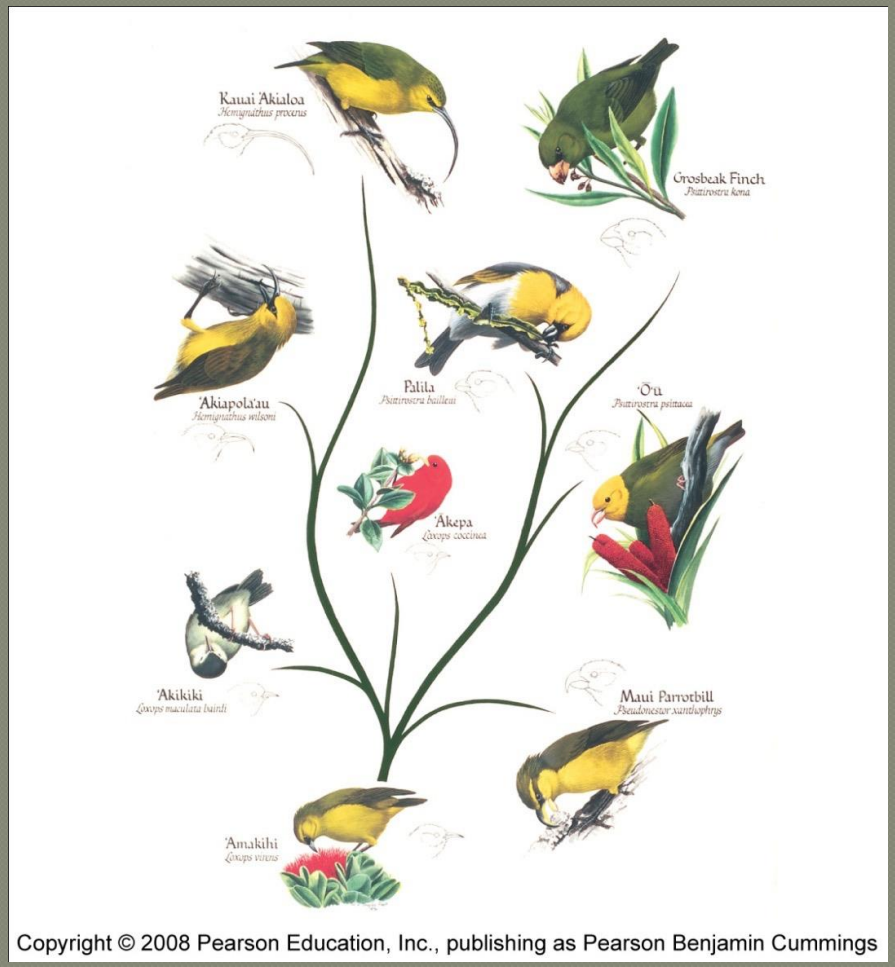
- The white colored moth (aka the typical type species *Biston betularia f. typica*
- A **genetic mutation** was discovered that produced all black individuals - *Biston betularia f. carbonara*
- Prior to 1811 the *Briston betularia f. typica* was the only peppered moth recognized.
- By 1848 A **genetic mutation** was discovered that produced all black individuals - *Biston betularia f. carbonara*

Pre Industrial Revolution

Post Industrial Revolution

Eventually, those with the white variation were more easily seen and picked off by predators. This example shows how genetic variation within a species allows a species to survive when its environment changes.

EVIDENCE OF NATURAL SELECTION IS EVERYWHERE



- The results of natural selection are evident in every adaptation of every organism.
- Evident in experiments with bacteria and fruit flies
- Selective breeding of animals that exaggerates preferred traits (e.g. dogs, cats, pigeons)

SPECIATION: emergence of a new species

- Over time populations change because individuals pass on successful/advantageous genetic traits. Given enough time, a new species may emerge . . .

Evolution

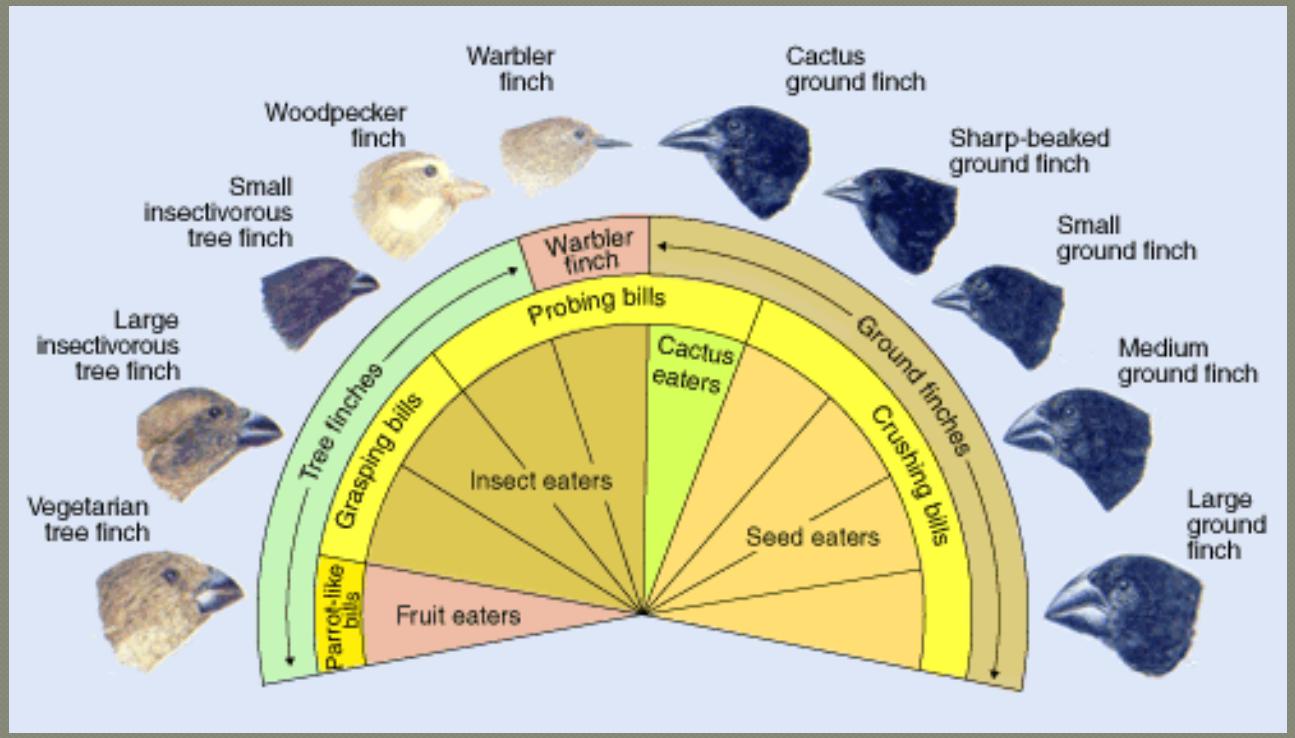
- **There are several ways in which speciation occurs:**

  - **Divergent Evolution (also called Allopatric Speciation)**
  - **Convergent Evolution**
  - **Co-Evolution**

It is important to understand the difference between the natural selection and evolution: Natural selection is the tool, or the process, and evolution is the outcome, the result.

DARWIN'S FINCHES

When Darwin visited the Galapagos, he noted that there were many different species of finches that looked different from one another. Some had short stout beaks for cracking seeds. Others had small thin beaks for plucking insects out of bark, and so forth.



DIVERGENT EVOLUTION:
Speciation via Separation

- The story of the finches describes a form of divergent evolution.
- Divergent evolution: When related species split, or *diverge*, into two separate species due to a separation.
- This separation can occur 2 ways:

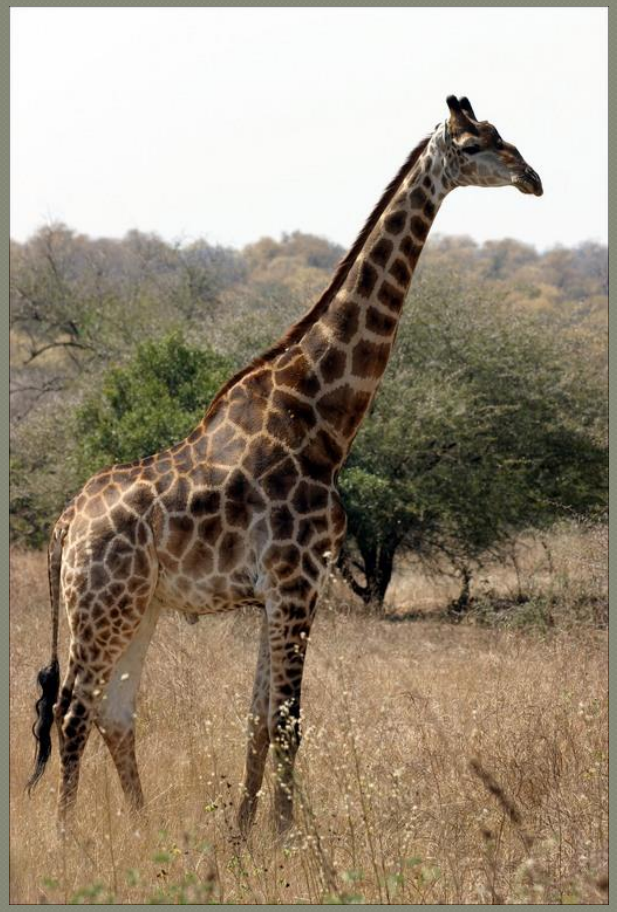
1. A new species emerges because a new niche is made in the same place due to a change in behavior. (Galapagos finches)
2. A new species emerges because of physical separation. (Giraffe and Okapi)

ALLOPATRIC SPECIATION

The word "allopatric": allo = other, and patric = fatherland. It refers to being separated from your original land.

For the purposes of this class, allopatric speciation = divergent evolution, where a separation of individuals within a population occurs

EXAMPLE OF DIVERGENT EVOLUTION (or Allopatric Speciation)



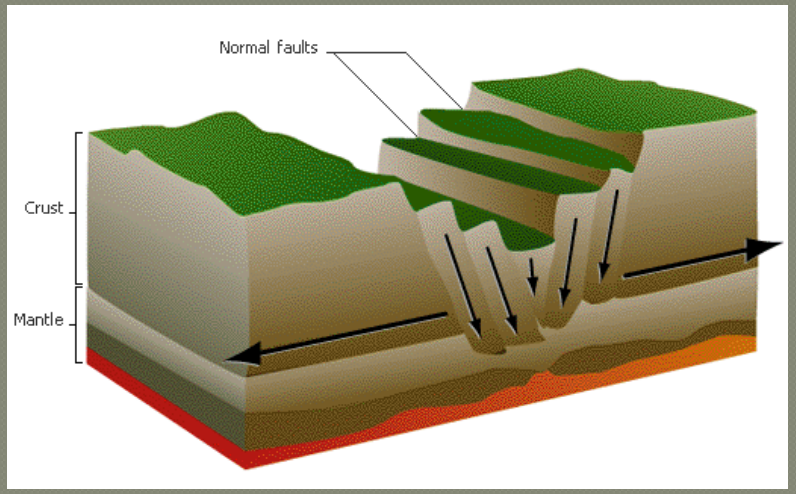
Giraffe

Okapi

These 2 species are related and they branched off from the same ancestor.

- Giraffe ancestors that ended up on the rain forest side of the crack evolved shorter necks and darker colors, which helped it fit into the dark and dense rainforest ecosystem (Okapi).

- On the savannah side evolved longer necks and lighter color patterns, which helped that species find a unique niche, that of feeding above all the other grassland animals on the tops of trees. The lighter color also helped keep them cooler in the hot sun (Giraffe).



This shows how the valley formed

Brown area represents the Great Rift Valley

CONVERGENT EVOLUTION:

- Convergent evolution is when unrelated species that live in different geographic locations, develop similar traits because their locations have similar selective pressures. Their respective ecosystems are similar.
  - This is usually based on physical appearance
  - Unrelated species fill similar niches in different locations
- This is also known as parallel evolution.

Convergent Evolution – Unrelated species develop similar adaptations because they live under similar selective pressures.

Cacti grow in North and South America.

Euphorbias grow in Africa.

whale

shark

Example of Convergent Evolution:
Both are unrelated, but live under similar selective pressures, and have evolved similar structural adaptations for swimming in the ocean.

CO-EVOLUTION

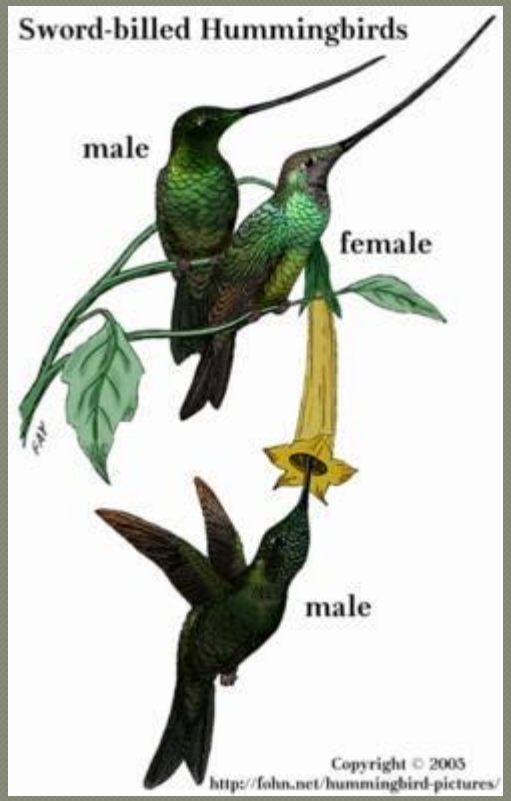
- Co-evolution happens when 2 species force or encourage changes in one another over time.

EXAMPLES OF CO-EVOLUTION

Thompson's Gazelle – a favorite prey animal for cheetahs. They can run up to 55 m.p.h.

The cheetah can run up to 70 m.p.h.

MORE EXAMPLES OF CO-EVOLUTION



The Sword-billed hummingbird of the Andes Mtns. evolved with especially long tubular flowers. Their long beaks are the only beaks that can extract the nectar from those flowers – so they are the only pollinators of this flower. Sword-billed hummingbirds have a food source all to themselves.

Termites and gut protozoa (Trichonympha)

SPECIATION RESULTS IN DIVERSITY

- **Phylogenetic trees**: represents the history of species divergence
  - Scientists can trace when certain traits evolved and when new groups of organisms came about.
  - Shows relationships between species, populations, or genes