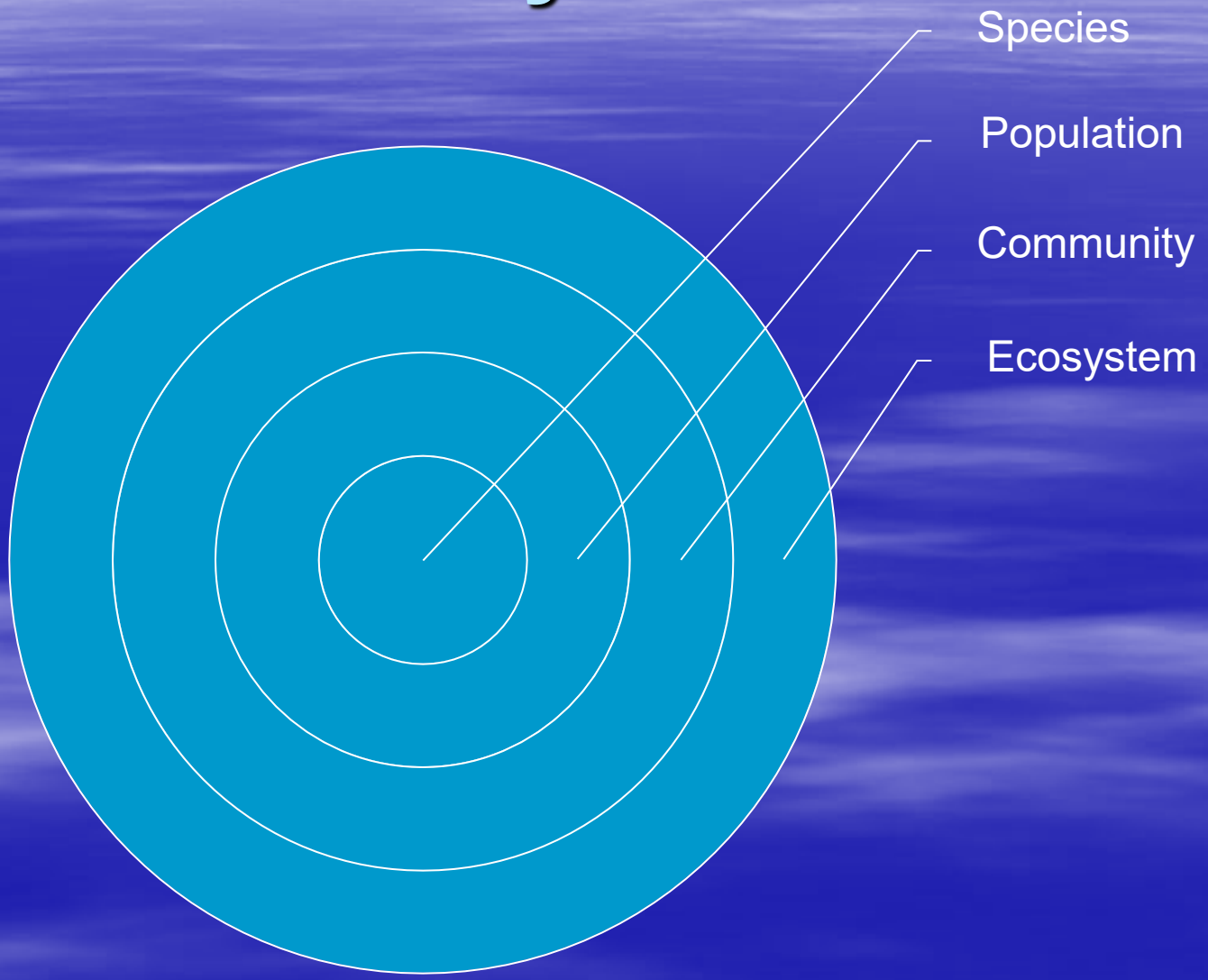
Chapter 3

Ecosystems and Their Diversity

Organisms and Their Environment

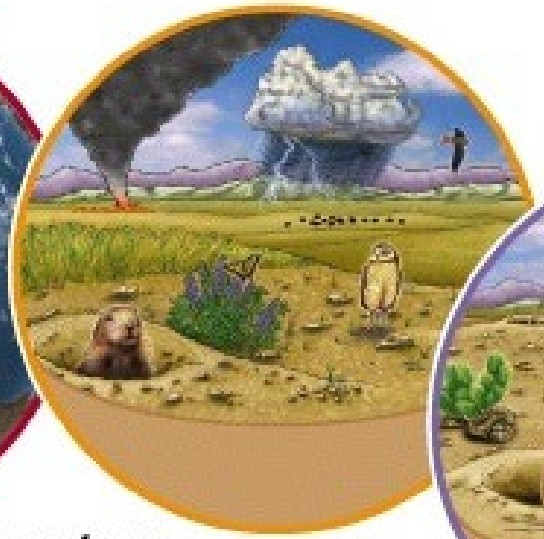
- Within the environment, organisms will interact with both biotic and abiotic factors
- Within an ecosystem, we can study any one of many interacting subsystems

Divisions Within the Ecosystem

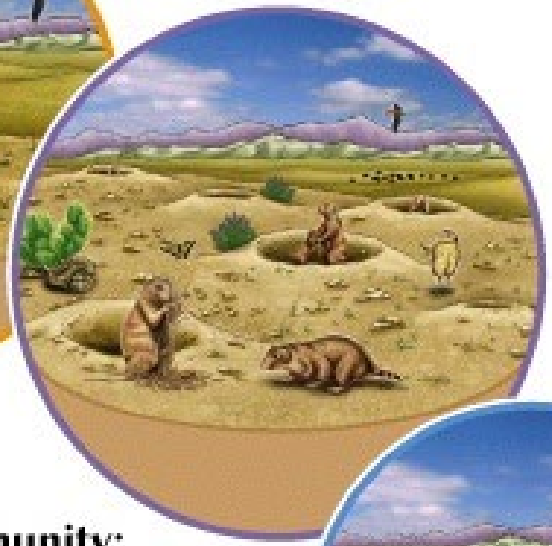


LEVELS OF ORGANISATIONS IN ECOLOGY

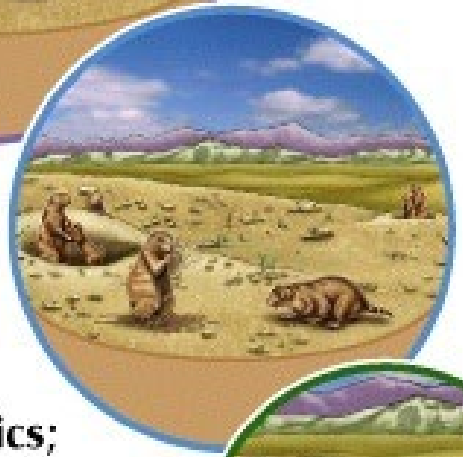
Biosphere:
Global processes



Ecosystem:
Energy flux and cycling of nutrients



Community:
Interactions among populations



Population:
Population dynamics; the unit of evolution

Organism:
Survival and reproduction; the unit of natural selection

Biological Hierarchy

Atoms → Molecules → Genes → Organelles → Cells → Tissues → Organs → Organ systems → Organisms → Populations of one species → Ecosystems of different species

Physiology is the science of life

Divisions in Ecosystem

- Species: individuals of the same species are those that can breed with one another to produce fertile offspring
- Population: a group of individuals of the same species living in a specific area at a specific time
  - *Population ecologists* describe the changes in size of a population over time. They investigate whether a population is decreasing or increasing in size, the rate of change, and the factors that determine the change.

Divisions in Ecosystem

- Communities: many individuals of many different populations in a given area at a given time.
  - *Community ecologists* study the interactions between members of different populations. They are interested in which species are present in a community and how many individuals of each species are there.
- Ecosystems: the populations (biotic factors) in an area as well as the abiotic factors that surround and affect those populations.

Ecosystems

- Biotic factors are the other *living organisms* that an animal comes into contact with: a predator that hunts it, the prey it hunts, animals it lives with, even bacteria
- Abiotic factors are those things within the environment that affect the organism but are *not living*, such as climate, sunlight, water, and minerals, $O_{2\ (aq)}$ concentration in water
- Ecologists study how certain abiotic conditions can affect that distribution of organisms (where they can and cannot live).

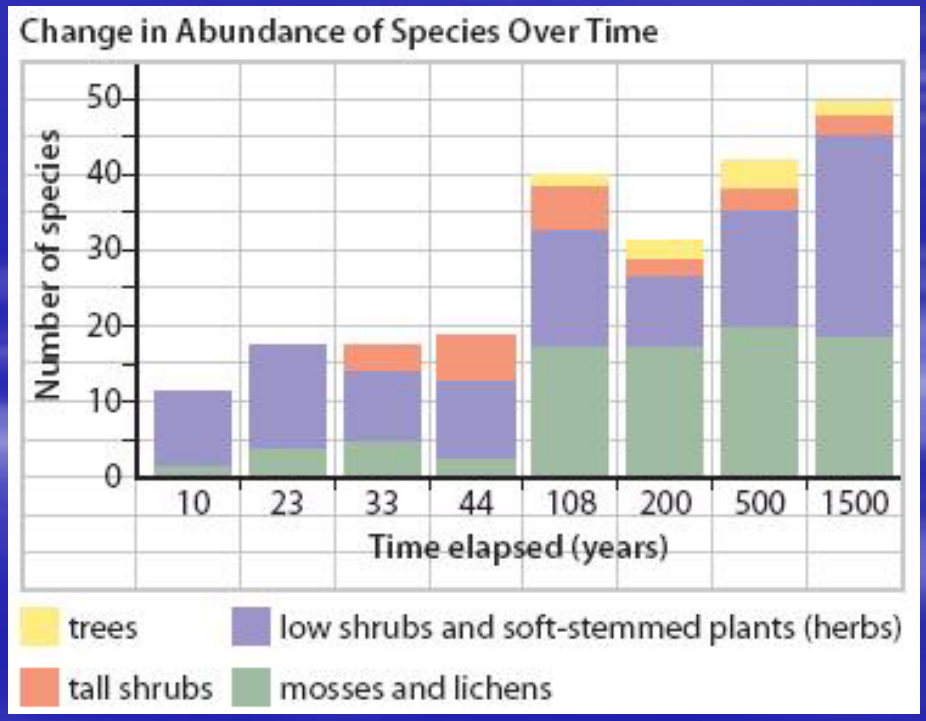
Environments Change Over Time

- Most communities are in a state of change; they are *dynamic*
- As abiotic factors change, the environment also changes, and thus the organisms that can live there
- As well, as one population within the ecosystem changes, those populations that interact with them will also change
- Populations are also able to change their environment over time, particularly after a major change to that environment

Environments Change Over Time

- Abiotic elements of a community change over time, affecting organisms and their interactions on all levels.

The number and type of species change over time as land is exposed by a melting glacier.



Ecosystems and the Biosphere

- An ecosystem encompasses all of the living and nonliving parts of an environment
- The biosphere is the largest possible ecosystem – it encompasses everywhere on Earth where living things can be found, from several meters into the earth to several kilometers into the air and it includes all the living organisms within it and all the abiotic factors that make it up.

Ecosystems and the Biosphere

- Life on Earth is not evenly distributed
- Each area on Earth has its own characteristic abiotic factors such as climate, latitude, elevation, temperature, humidity, moisture, salinity, and light which affect patterns of distribution of life
- The abiotic factors that dictate the productivity of an ecosystem will often have a major effect on the distribution of living things
- Organisms can withstand some variation, but only within an optimal range
- Every species has its own place or role in the biosphere (niche)

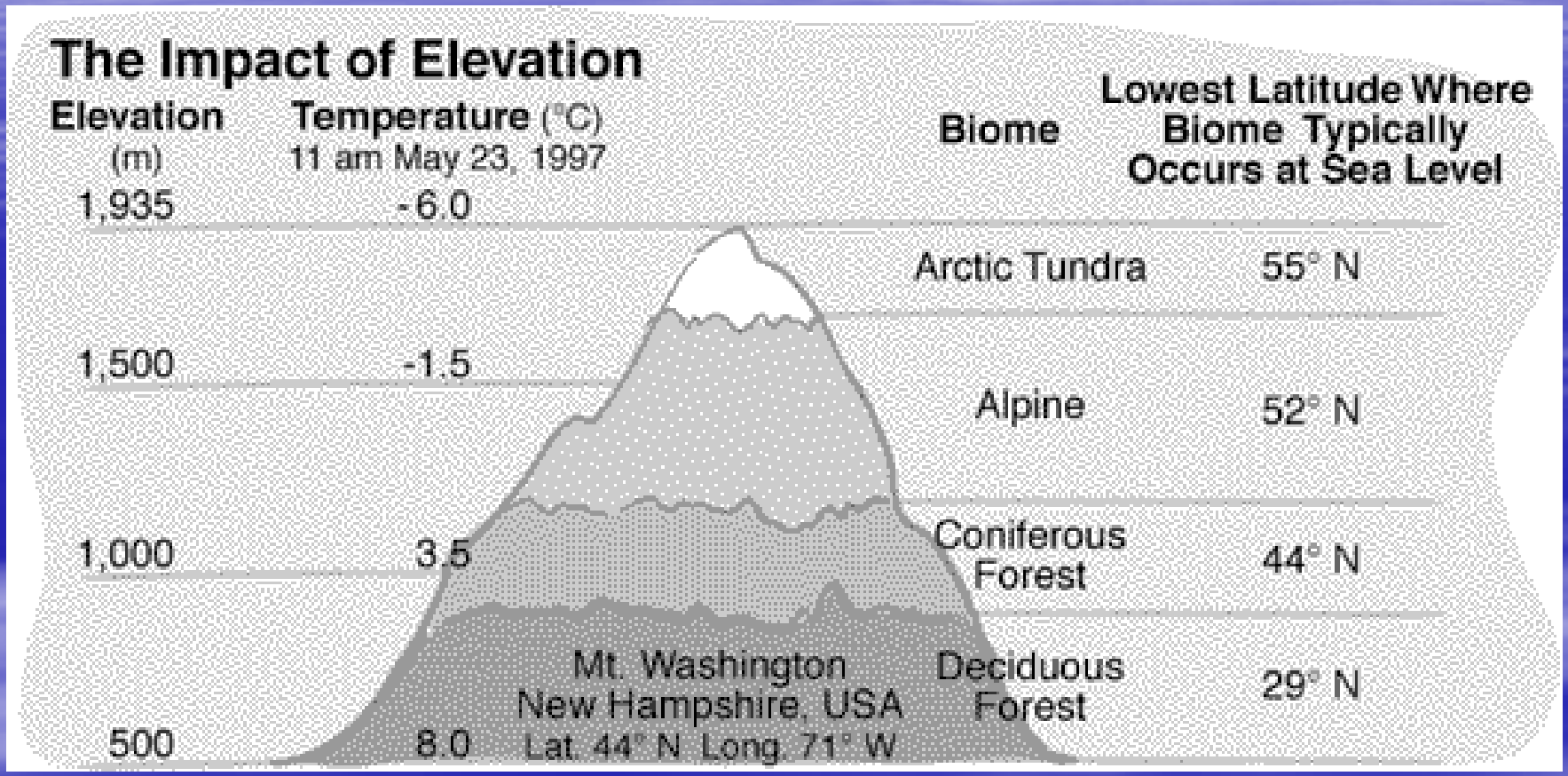
Climate and Biomes

- Recall that the Earth heats unevenly
- This not only affects surface temperatures, but also the movement of ocean and atmospheric currents
- Both latitude and altitude have similar effects on the distribution of living things

Kurzgesagt Gulf Stream Current

EAC

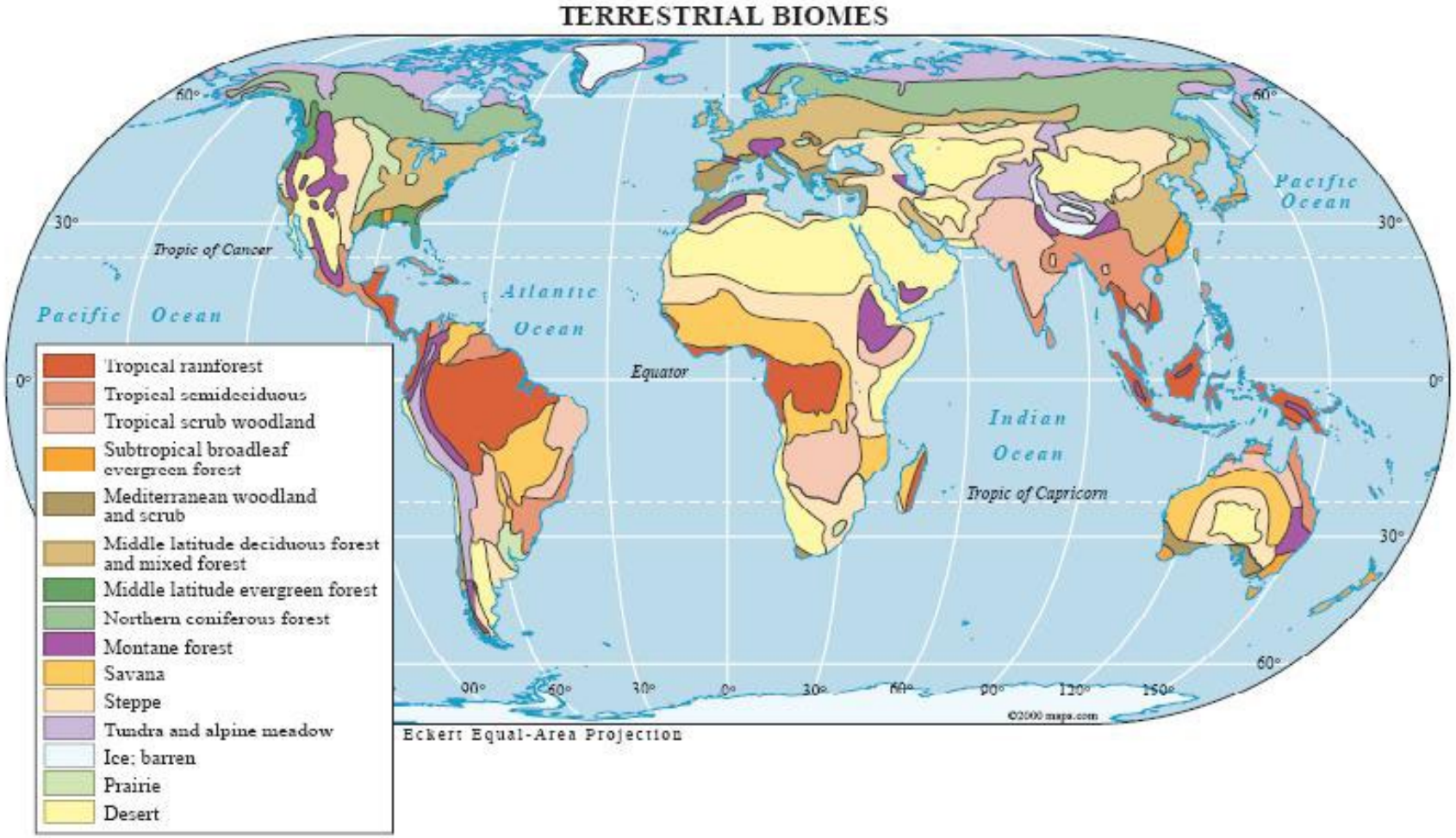
Effects of Latitude and Altitude



Biomes

- Biomes are identified based on their mean annual temperatures and precipitation levels
- In general, as temperature and precipitation both increase, the abundance of organisms will also increase
- It should be noted that biomes do not have set fixed barriers, but rather blend into other nearby biomes in most cases

Global Biomes

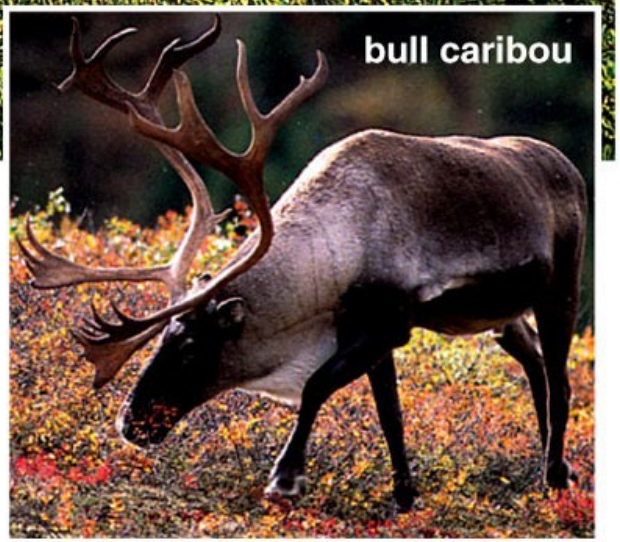


Terrestrial Biomes

- Tundra
  - Encircles Earth around arctic circle in the Northern Hemisphere
  - Very cold and dark most of the year – short growing season
  - Only 20 cm. a year of precipitation
  - Permafrost
  - Vegetation - lichens, grasses, shrubs
  - Animals- lemmings, ptarmigans, caribou, reindeer, wolves, polar bears

Tundra

a.



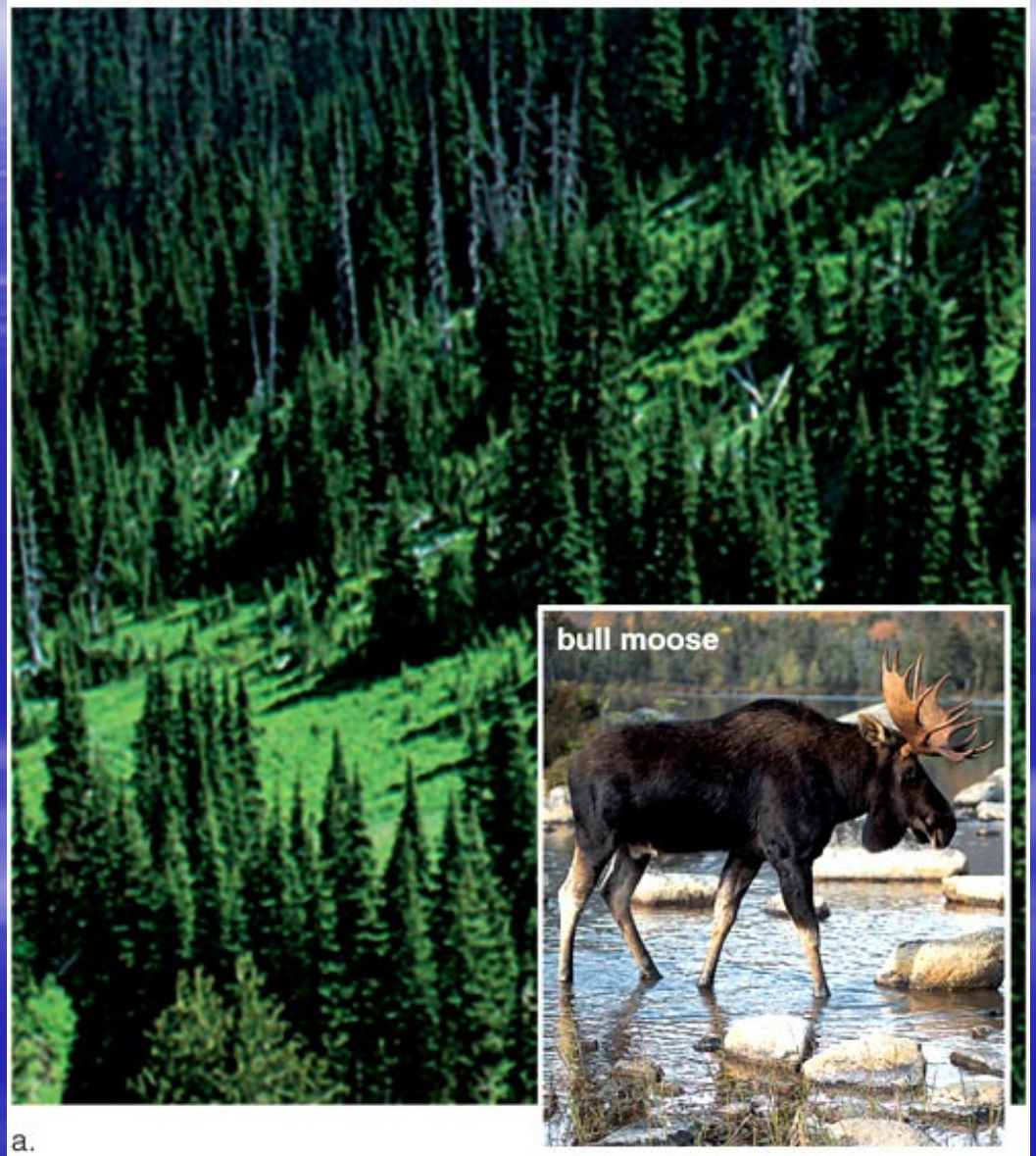
b.

Terrestrial Biomes

- Taiga / Boreal Forest
  - Northern part of North America and Eurasia, Pacific coast
  - Temperature is below freezing for half the year
  - Long nights in winter, long days in summer
  - Vegetation – cone-bearing trees (pine, firs, spruce), mosses, lichens
  - Animals – bears, deer, moose, beaver, muskrats, wolves
- Other coniferous forests exist on mountain tops and temperate rainforests (like in BC and California - redwood forests)

Keystone Species

Taiga



Terrestrial Biomes

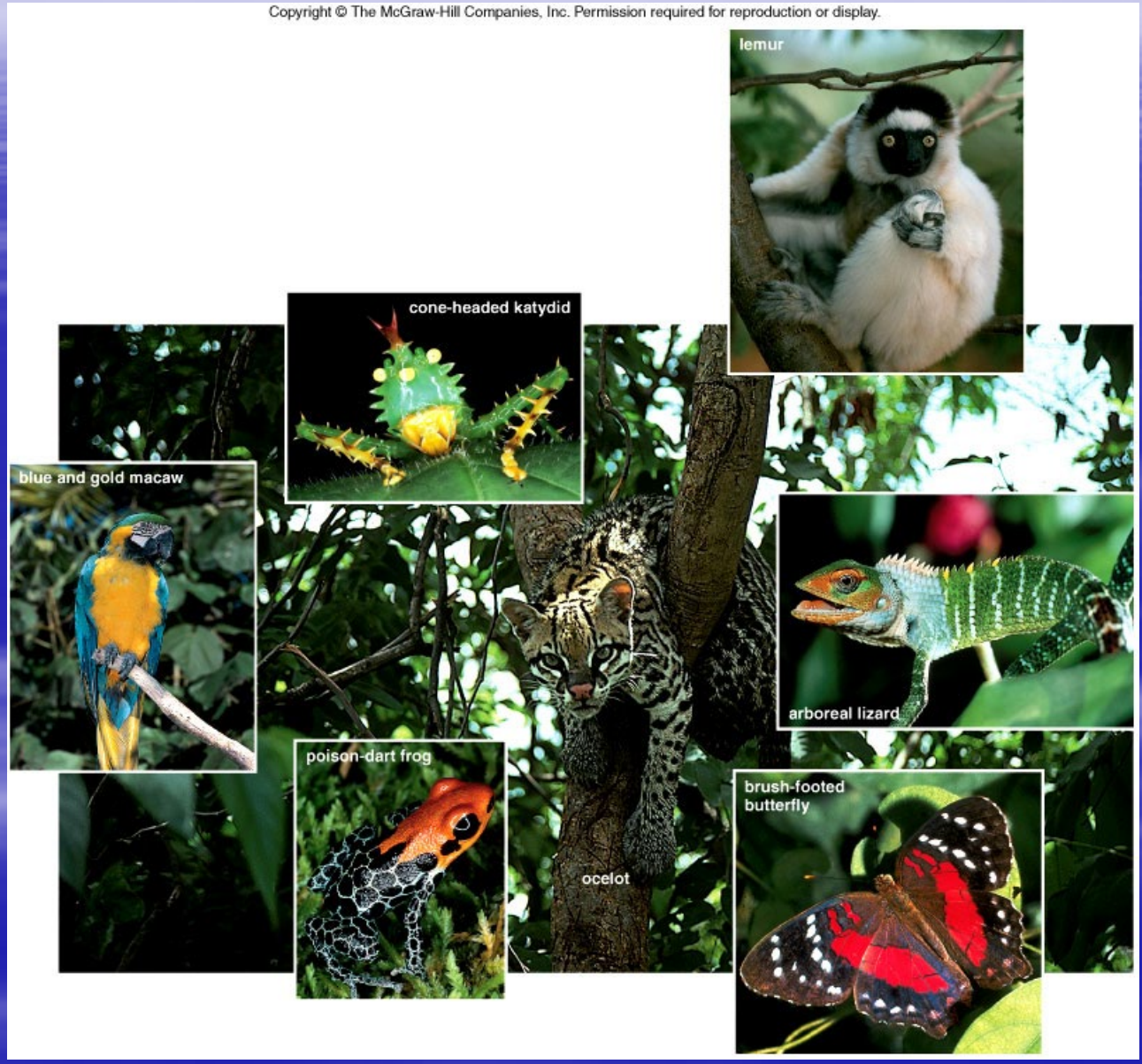
- Temperate deciduous forests
  - Eastern U.S., Canada, Europe, parts of Russia
  - Well-defined seasons, long growing season, moderate precipitation
  - Vegetation - oak, beech, maple, tall trees form canopy, shrubs and shorter trees below, lichens and ferns on forest floor
  - Animals - squirrels, chipmunks, foxes, deer, black bears

Temperate Deciduous Forest

Terrestrial Biomes

- Tropical Rainforests
  - South America, Africa, Indo-Malayan region
  - Weather is always warm, abundant rainfall
  - Biome with the greatest diversity of species of plants and animals
    - 10 km^2 area may contain 750 species of trees and 1500 species of animals!

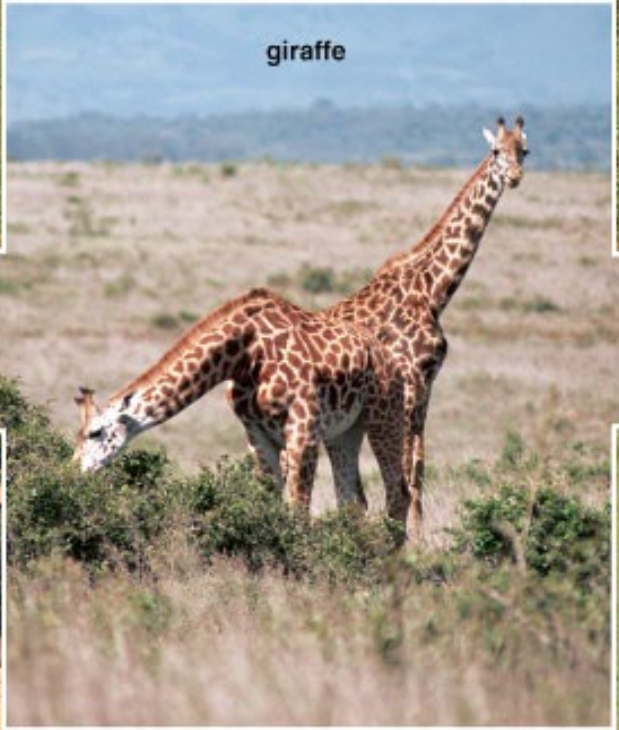
Tropical Rainforest



Terrestrial Biomes

- Grasslands
  - Rainfall is around 25 cm/year - not enough to support trees
  - Grasses well adapted to changing environment
  - Prairies – grasslands in Alberta, Saskatchewan, parts of USA
  - Savannas - grasslands that contain some trees
    - African savanna - greatest variety of large herbivores

The Savanna



Terrestrial Biomes

- Deserts
  - Characterized by low precipitation- less than 25 cm per year
  - Vegetation – succulents (ex: cacti)
  - Animals – insects, arachnids, lizards, birds, mammals adapted to arid conditions, wide temperature variations
    - Many are burrowing animals
    - Nocturnal to avoid heat

The Desert

bannertail kangaroo rat

greater roadrunner

Habitat vs Range

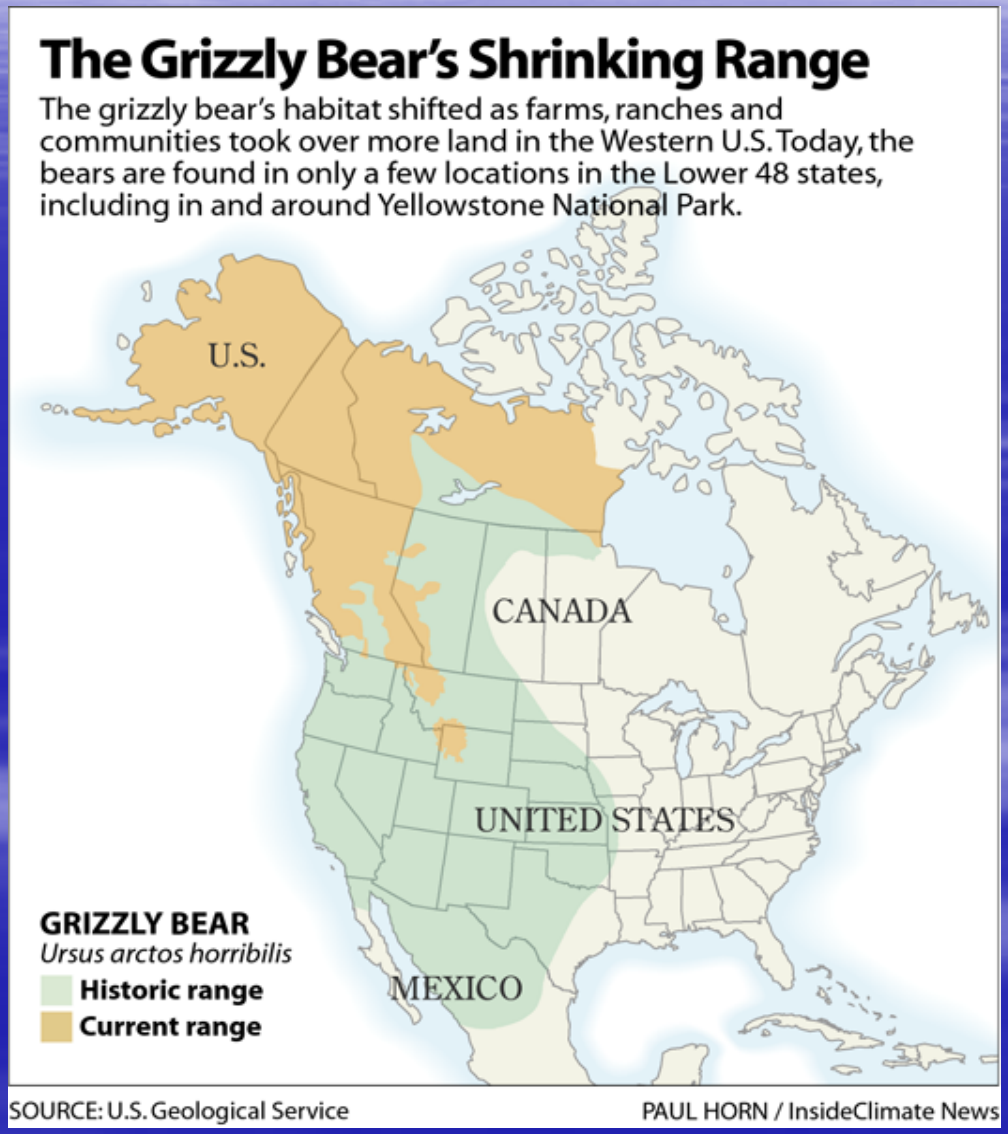
- Within a biome, there is a huge amount of varied vegetation and terrain
- Therefore, a number of different habitats (the natural environment of a plant, animal, or other organism) can be created that can suit the requirements of different organisms
- Related to a species' habitat is its range
- The range of a species refers to the geographical area in which the species can be found

Habitat vs Range

- However, not all places within a range will have a suitable habitat for those organisms
- Therefore, organisms do not live throughout their range, but rather in its particular habitat within that range
- However, the range of a particular species may change as humans interfere or modify the environment

Habitat vs Range

- This map shows the historical and current range of the Grizzly bear in the western United States and Canada
- As you can see, the range of the bear has greatly decreased since 1850



Ecological Niches

- Although many species may share the same ranges, they often have different niches – their specific role in the ecosystem (ex: predator, prey, producer, decomposer, etc)
- Often trouble occurs when one organism either occupies another organisms' niche, or destroys its niche (such as the mountain pine beetle destroying pine trees)

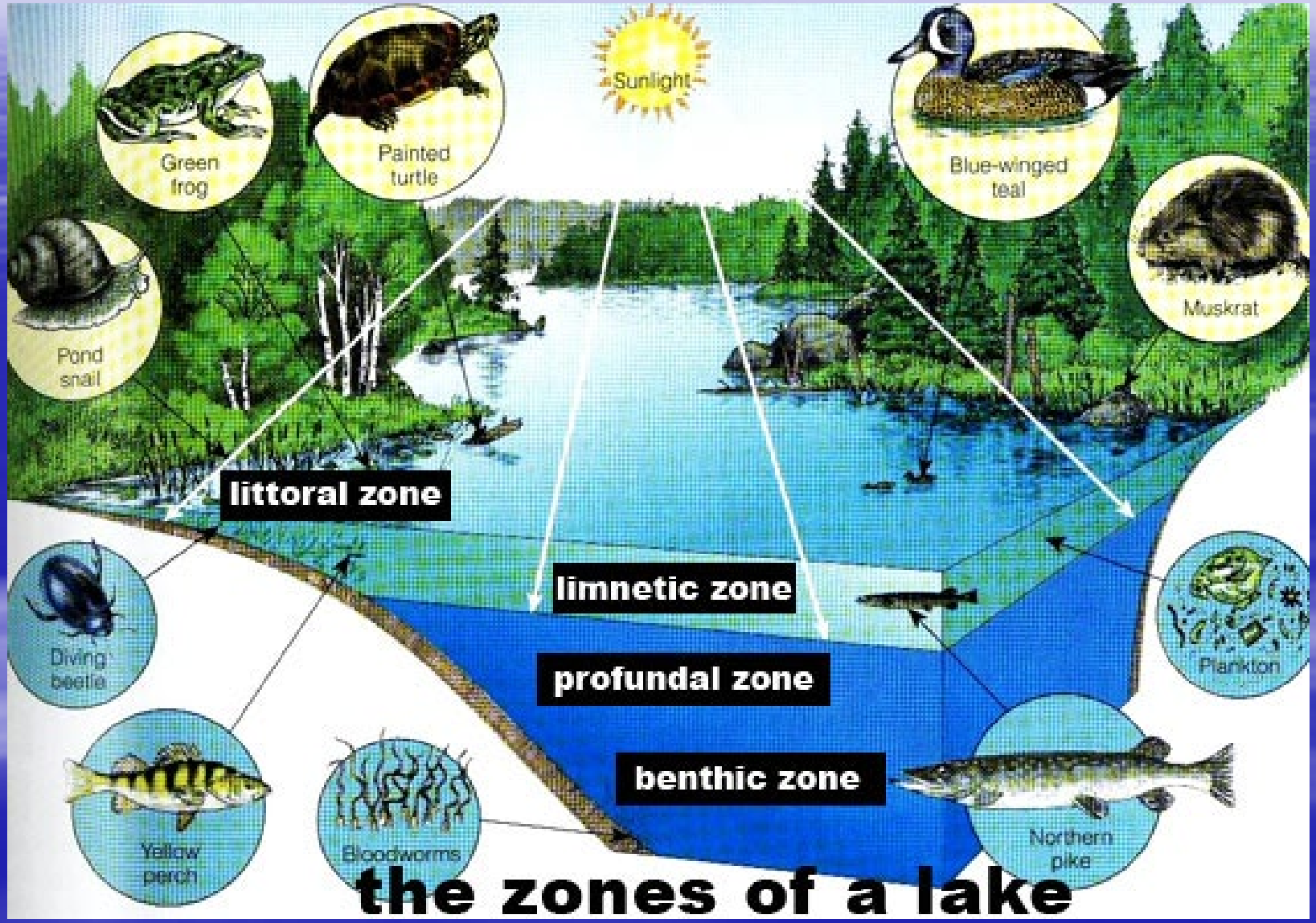
Niches in Aquatic Ecosystems

- Niches are determined by the available biotic and abiotic factors
- In aquatic ecosystems, the amount of available light or dissolved oxygen is often the main determining factor in the available aquatic niches
- Therefore, each zone of a lake, for example, will have distinct groups of organisms (more on this later…)

Aquatic Ecosystems

- There are many types of aquatic ecosystems, but we will look at two main ones:
  - Lakes
  - Coastal Ecosystems
- Others include seashore, river, and ocean ecosystems

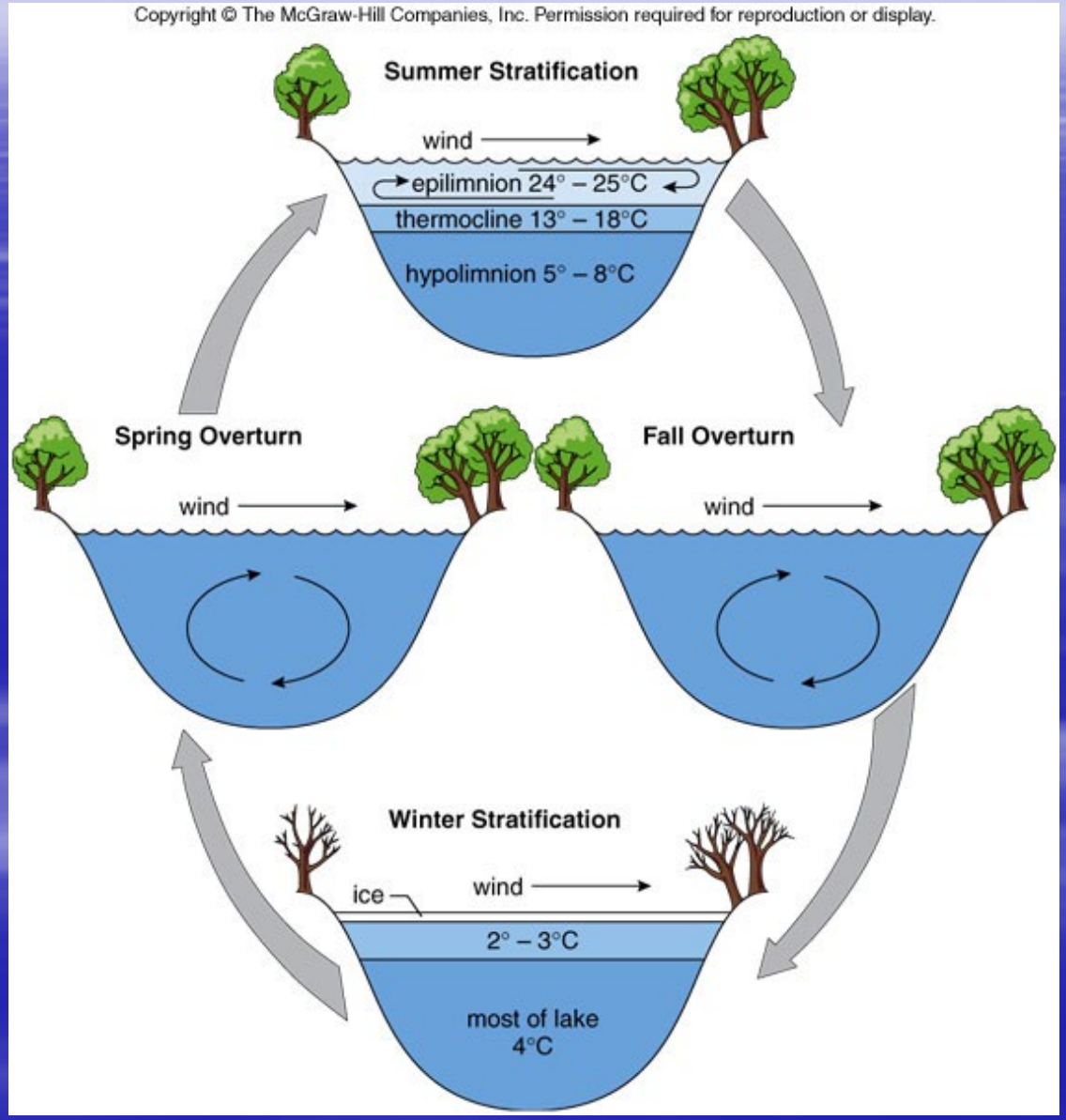
Zones of a Lake



Lake Zones

Zone	Abiotic Factors	Organisms
Littoral	-shallow, warm water -lots of light	-rooted plants, insects, small fish
Limnetic	-open water -lots of light	-algae, small and large fish
Profundal	-dark, cold water	-mostly decomposers, bottom dwellers
Benthic	-mud & sand -little or no light	-decomposers, filter feeders, worms

Lake Stratification and Thermal Zones



Overturn vs. Stagnation

- **Spring/Fall Overturn:**
  - Refers to the overall mixing of the layers of the lake during these seasons
  - We know that water's density properties change when the temperatures range from 0 to +4 °C. Due to this change, the water thermal layers begin to mix.
  - This allows for more oxygen and other nutrients to be dissolved into the lake.
  - This is good because during winter/summer, there is NO mixing!

Overturn vs. Stagnation

- **Summer/Winter Stagnation:**
  - During these seasons the water is either higher than 4 °C or lower than 0 °C (usually lower than -5 °C in the winter)
  - At these temperatures, water's density properties revert to NORMAL
  - As a result, there is NO mixing (and thus no oxygen or nutrients dissolving) during these seasons.
  - Whatever nutrients/oxygen is present during these seasons, it must last the whole season until it can be replenished in the fall/spring.

Thermal Zones of a Lake

There are 3 thermal zones in a lake:

1. Epilimnion: the highest temperature zone (located at the top of the lake)

2. Thermocline: medium temperature zone located in the middle of the lake (profundal)

3. Hypolimnion: the coldest temperature zone located at the bottom of the lake (benthic)

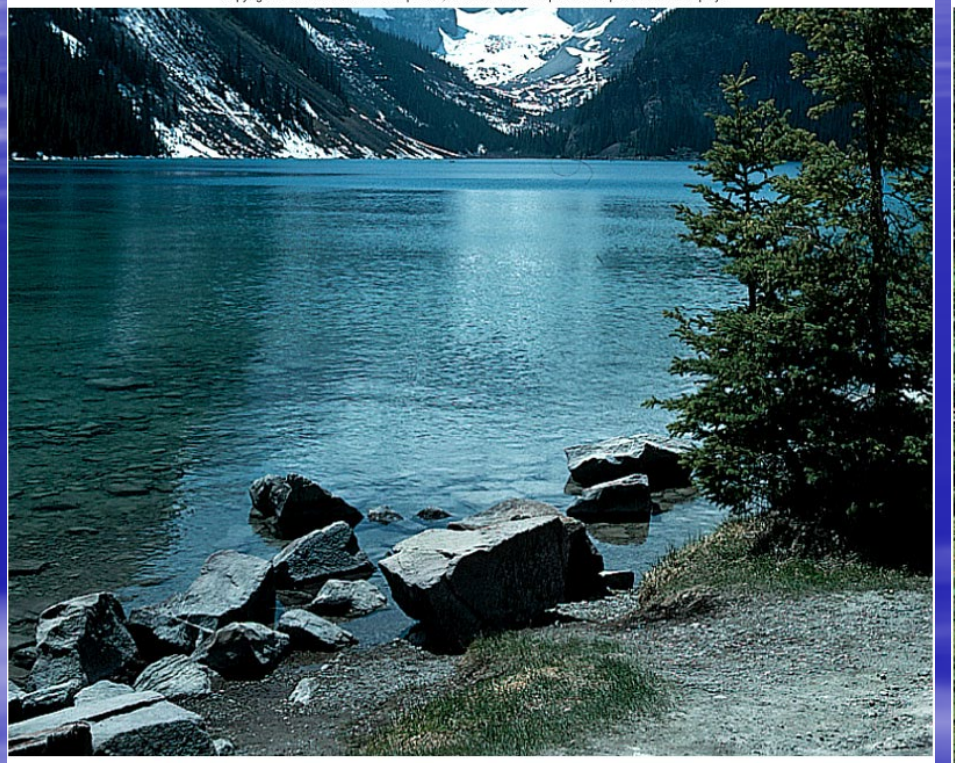
Types of Lakes

1. Oligotrophic: young lakes, cold lakes, deep lakes. As well very little vegetation or detritus.

2. Eutrophic: older lakes, warmer lakes (lots of productivity and decomposing action), shallow lakes. Contain lots of vegetation and detritus.

**Note: Eutrophication is the process in which lakes go from being oligotrophic to eutrophic. (refers to the filling in of a lake with vegetation and detritus)

Types of Lakes



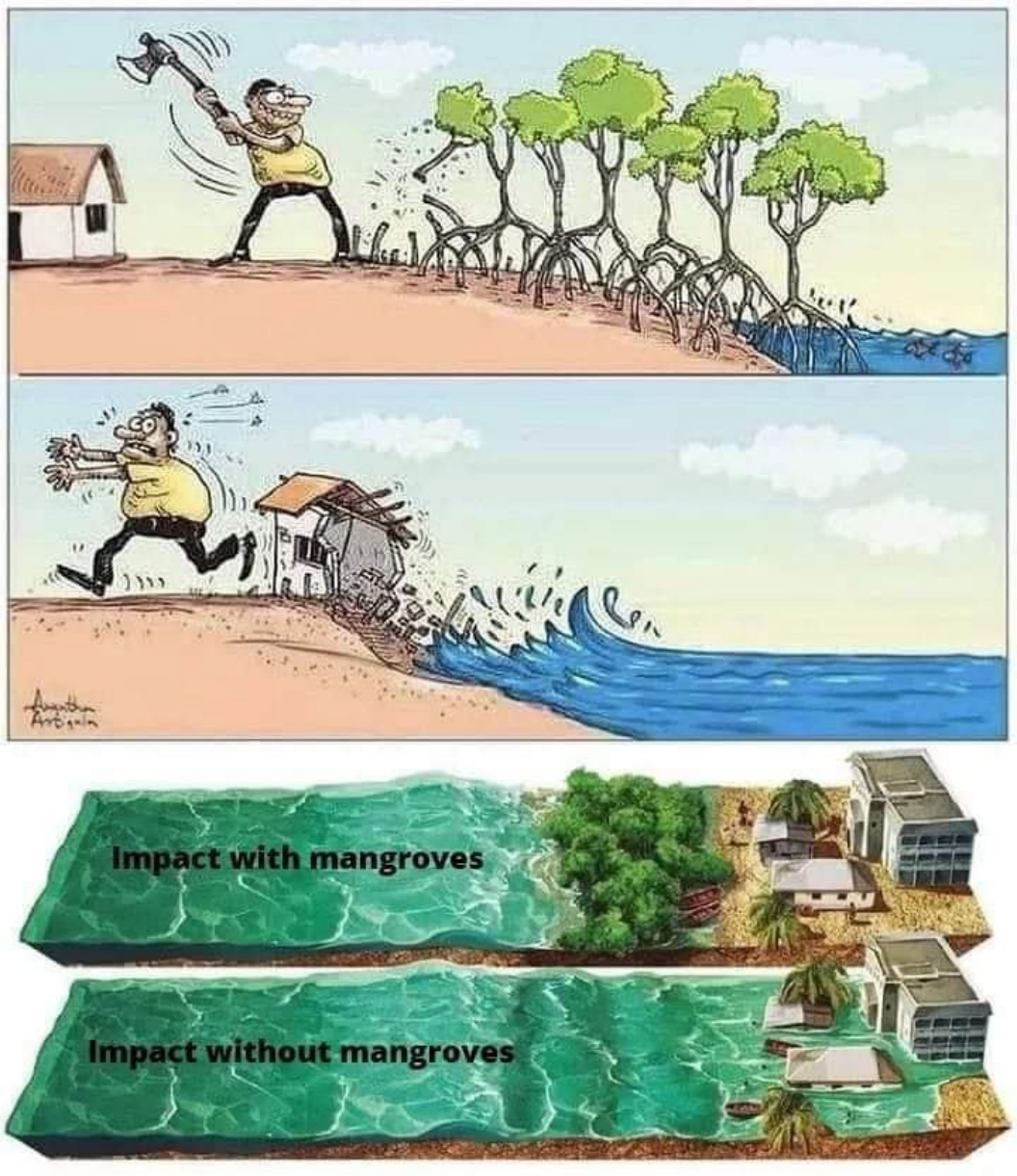
a.

b.

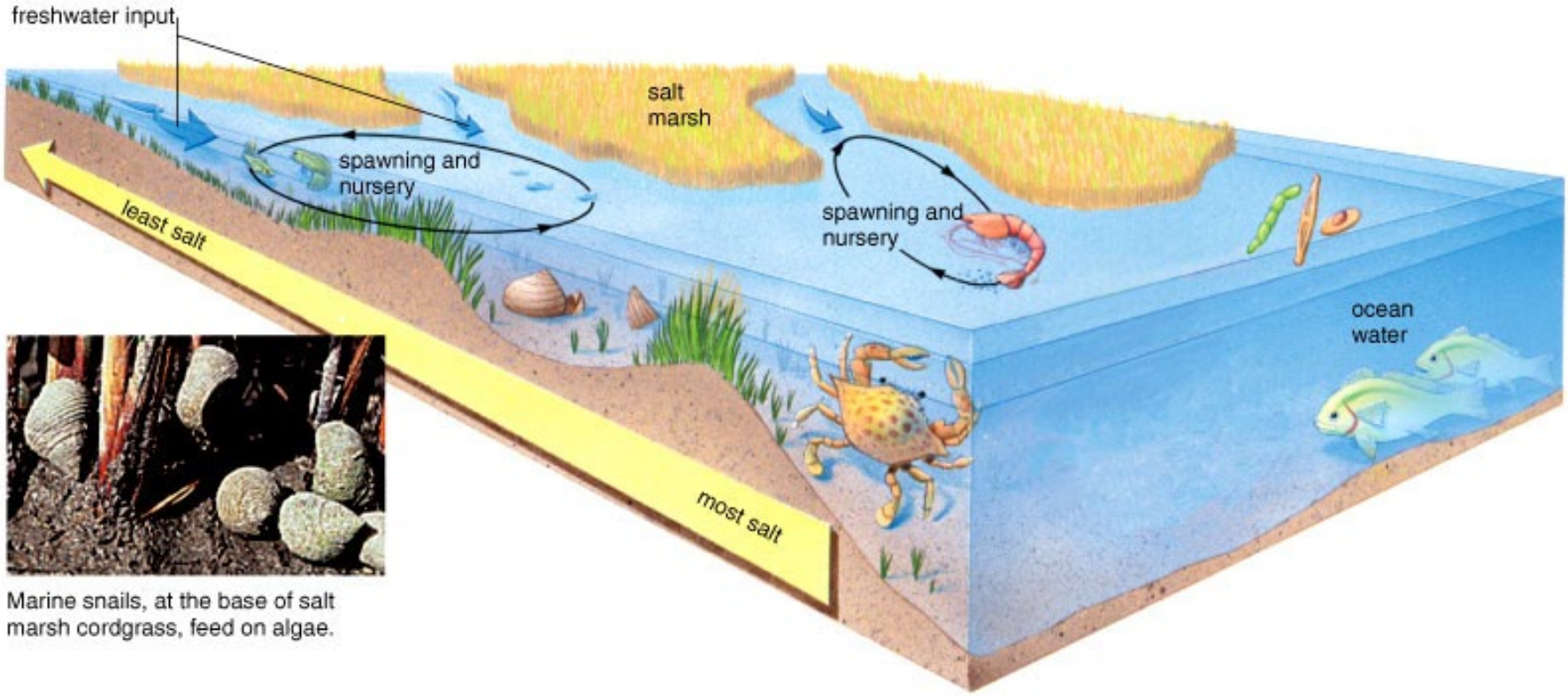
Aquatic Ecosystems

- Coastal ecosystems
  - Salt marshes, mudflats, mangrove forests
  - Estuaries
    - Near the mouth of rivers
    - "nurseries" of the sea - very productive
      - Half of all marine fish mature in estuaries
      - Feeding grounds of many birds, fish, shellfish
      - Brackish water – mix of salt and fresh water (supports more diversity)

Mangroves and Climate Change



Estuary Structure and Function



Marine snails, at the base of salt marsh cordgrass, feed on algae.

Dolphins hunting in estuaries

Niches in Terrestrial Ecosystems

- There is a great amount of diversity among terrestrial ecosystems
- The biodiversity in these ecosystems also depends on the biotic and abiotic factors present
- The greater the number and variety of organisms in an ecosystem, the greater the number of niches

Growth-Limiting Factors

- Consider the following scenario:
- If a small population of bacteria doubled in size every few hours, then at the end of 20 hours there would be about 1×10^{12} bacteria
- Within 4 days, the mass of the bacterial colony would be greater than the mass of the Earth
- Obviously, this does not happen because there are limiting factors to their growth

Abiotic Limiting Factors

- Some limiting factors are the abiotic factors present in the environment
- Producers, in particular are limited by the abiotic factors of their environment
- Many producers rely on changes in the abiotic factors of their environment to initiate different phases of their life cycle

Biotic Limiting Factors

- Biotic factors also affect the rate of growth
- In general, these factors may be classified as one of the following:
  - Competition
  - Predation
  - Parasitism

Competition

- There are finite amounts of each resource available in each ecosystem
- Therefore, there is competition for these resources
- Competition may be classified as intraspecific (within a species) or interspecific (between two different species)

Intraspecific Competition

- A number of resources may be required by all of the individuals of a species
- However, there is not enough resources to ensure the survival of all of these individuals

Interspecific Competition

- Competition between species occurs when two different species occupy the same niche
- If these niches are the same, the stronger species will become dominant and eventually the weaker species will disappear (either through extinction or migration)
- If humans introduce a new species to an ecosystem, it can often disrupt the niche of another native species, often causing extinction

Predation

- Predation naturally limits the population of prey species
- The change in the numbers of prey will affect trophic levels beneath the prey species
- Predators that feed on multiple prey types will affect numerous food chain relationships

Parasitism

- Parasitism differs from predation as the parasite often does not kill its host when feeding
- If there is an increase in the density of the host population, parasites can more easily pass between those hosts
- Often parasitic infestations will limit the reproductive and survival ability of the host

Taxonomy

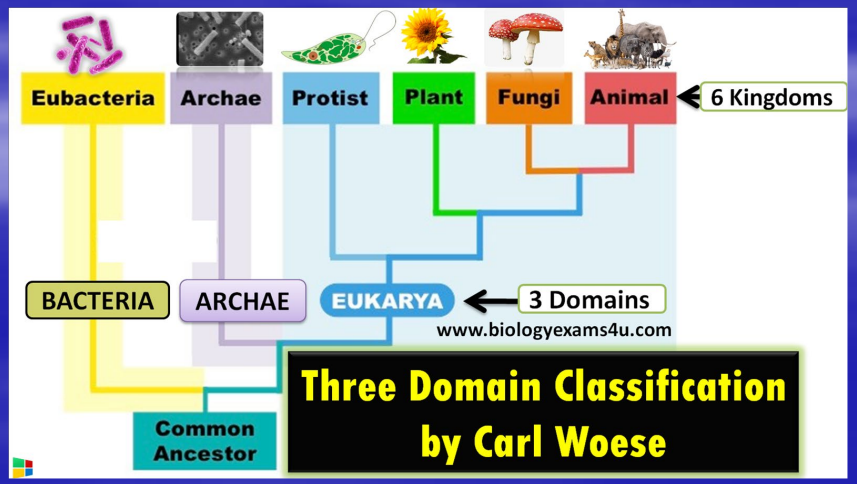
- The total number of species in the world is thought to total between 10 and 100 million.
- Taxonomy is the science of classifying living organisms.
- Classification of organisms is necessary to have consistent communication.
- Latin is used because it is not spoken by any country, which allows it to be universal, and unevolving.
  - similar to element/compound naming in chemistry, or metric units in physics and math

Early Classification

- As early as 2000 years ago, Aristotle began to classify organisms into kingdoms (plants and animals)
- Of course, when more organisms were identified using the microscope, it was acknowledged that we needed more than two divisions
  - Important definitions:
    - Prokaryote = *before nucleus*, no membrane-bound nucleus
    - Eukaryote = have a membrane-bound nucleus

Domains

- The 2-Domain system has recently been revised as we have developed a better understanding of the relationships between some organisms
- There are three major domains, which are large groups that encompass all 6 of the kingdoms



3 Domains

1. Eukarya – unicellular or multicellular organisms that have cells that contain a nucleus. Reproduce sexually.
2. Archaea – unicellular prokaryotic organisms that reproduce asexually. Often have cell walls and are autotrophic by chemosynthesis.
3. Bacteria – unicellular prokaryotic organisms that reproduce asexually. Can be autotrophic (by chemo- or photosynthesis) or heterotrophic (by absorption).

The Six Kingdoms

Archaebacteria	Single-celled prokaryotic organisms that live in extreme environments
Eubacteria	Single-celled prokaryotic organisms that live in a wide range of habitats
Protista	Consists of both single and multi-celled eukaryotic organisms
Fungi	Single and multi-celled eukaryotes that secrete enzymes to digest their food
Plantae	Eukaryotic multi-celled organisms that use photosynthesis
Animalia	Eukaryotic multi-celled organisms that are heterotrophs

The 3 Domains & 6 Kingdoms

Classification of Living Things						
DOMAIN	**Bacteria**	**Archaea**	**Eukarya**			
KINGDOM	**Eubacteria**	**Archaebacteria**	**"Protista"**	**Fungi**	**Plantae**	**Animalia**
CELL TYPE	Prokaryote	Prokaryote	Eukaryote	Eukaryote	Eukaryote	Eukaryote
CELL STRUCTURES	Cell walls with peptidoglycan	Cell walls without peptidoglycan	Cell walls of cellulose in some; some have chloroplasts	Cell walls of chitin	Cell walls of cellulose; chloroplasts	No cell walls or chloroplasts
NUMBER OF CELLS	Unicellular	Unicellular	Most unicellular; some colonial; some multicellular	Most multicellular; some unicellular	Multicellular	Multicellular
MODE OF NUTRITION	Autotroph or heterotroph	Autotroph or heterotroph	Autotroph or heterotroph	Heterotroph	Autotroph	Heterotroph
EXAMPLES	*Streptococcus, Escherichia coli*	Methanogens, halophiles	*Amoeba, Paramecium*, slime molds, giant kelp	Mushrooms, yeasts	Mosses, ferns, flowering plants	Sponges, worms, insects, fishes, mammals

The Levels of Classification

- There are 8 separate levels of classification
- These 8 levels are, from most general to most specific:
- Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species
- This system (minus the Domain classification) was developed by Carolus Linnaeus

Binomial Nomenclature

- Carolus Linnaeus suggested a **binomial nomenclature**, or two-name system based on the last two levels of classification
- The name is written *Genus species*
  - note that the genus name is capitalized and the whole name is italicized in type or underlined when written

The scientific name for lodgepole pine is Pinus contorta

genus

species

Linnaean Hierarchy

Group	Bobcat's classification	Organisms that can be included in this group
domain	Eukarya	euglena, mushroom, lodgepole pine, earthworm, starfish, bee, shark, horse, oyster, frog, dog, cougar, lynx, house cat, bobcat
kingdom	Animalia	earthworm, starfish, bee, shark, horse, oyster, frog, dog, cougar, lynx, house cat, bobcat
phylum	Chordata	shark, horse, frog, dog, cougar, lynx, house cat, bobcat
class	Mammalia	horse, dog, cougar, lynx, house cat, bobcat
order	Carnivora	dog, cougar, lynx, house cat, bobcat
family	Felidae	cougar, lynx, house cat, bobcat
genus	*Lynx*	lynx, bobcat
species	*rufus*	bobcat

Ex: Classifying the Human

- Domain: Eukarya
- Kingdom: Animalia
- Phylum: Chordata
- Class: Mammalia
- Order: Primates
- Family: Hominidae
- Genus: Homo
- Species: Sapiens

Mnemonics?

You are responsible for remembering the order

domain, kingdom, phylum, class, order, family, genus, species

How will you do this?

Dear **K**ing **P**hilip, **C**ome **O**ver **F**or **G**ood…. **S**paghetti
Does **K**illing **P**otatoes **C**ause **O**besity **F**or **G**iant **S**quid?
Do **K**eep **P**ots **C**lean **O**r **F**amily **G**ets **S**ick

Can you think of any others?

Changing Names

- With the ability to genetically sequence the DNA of any organism, we can now verify whether or not a particular organism is correctly classified
- We can compare an organisms' DNA to other organisms that we suspect are related
- For instance, skunks have recently been removed from the family that contains the weasels and have been placed in their own family

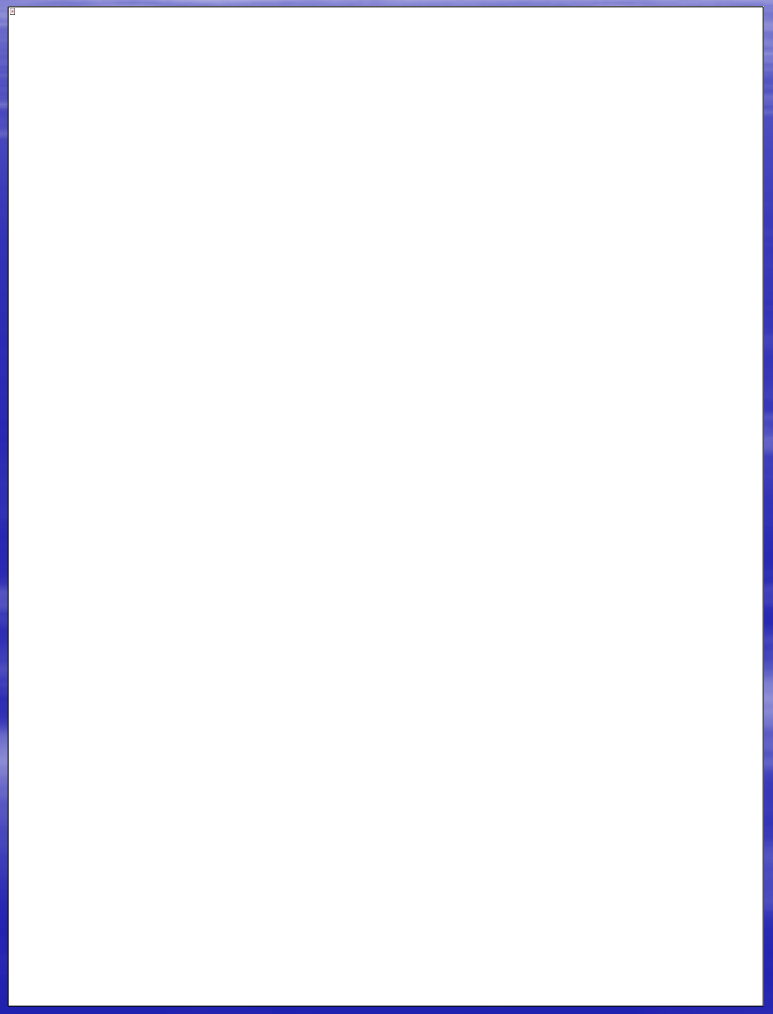
Dichotomous Key

- A dichotomous key is a branched or stepped process that can be used to identify organisms.

- The key is a series of comparisons arranged in steps, with each step having a possibility of **two** choices.

Dichotomous Key

- With each choice, the comparisons become more detailed, until the scientific name of the organism is determined.



Dichotomous Key

- When constructing keys:
  - make a flow chart that keeps separating organisms based on your criteria
  - all choices should have only two possibilities
  - keep going with this until all parts of your flow chart are down to only one organism
  - transfer this information into a key which has a series of numbered choices, each identified as a or b
  - at the end of a line for each decision there should be either the organism's identity or a "Go to..." instruction

- Do Investigation 3.B p.90
- Do Section 3.2 Review p.92 # 1, 3, 5, 6