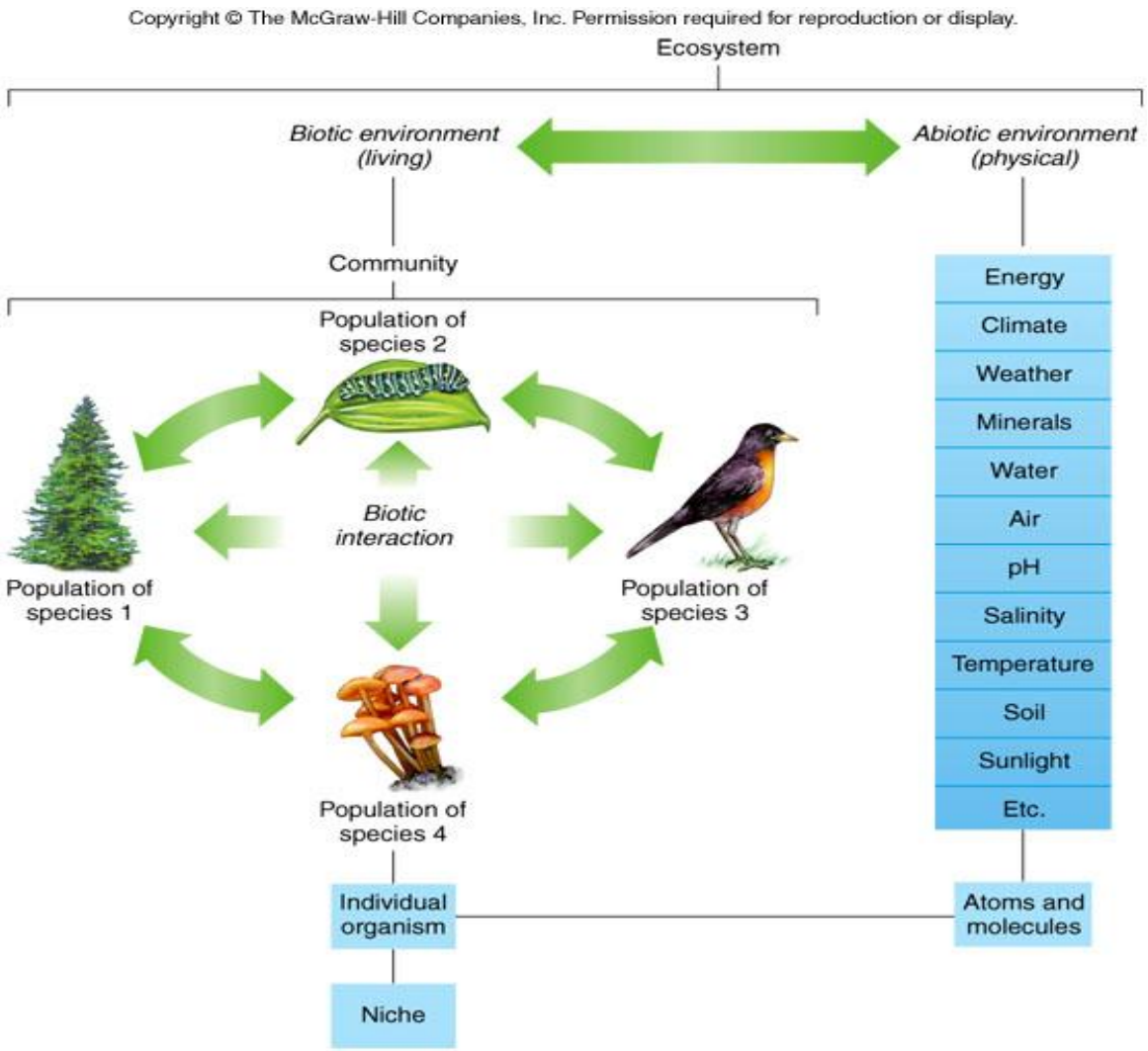
Tech Prep Biology
Ecology Unit Review
Mrs. Wood and Mr. Talbot
Spring, 2013

Ecological Concepts

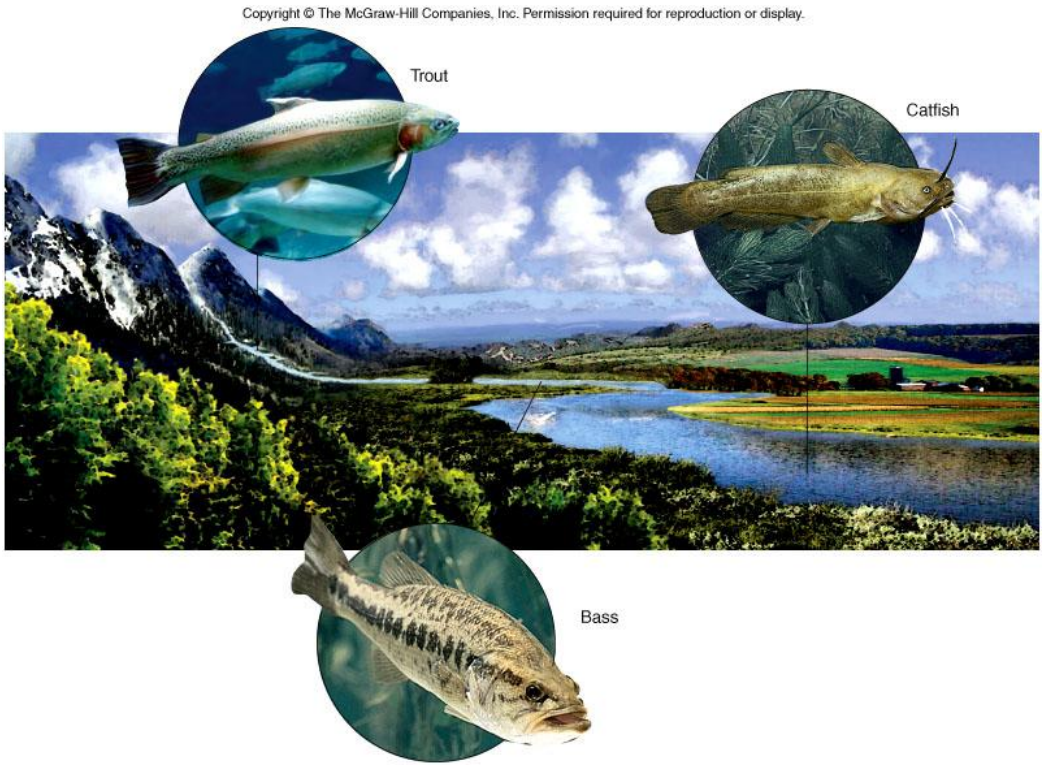
- Ecology - Study of ways organisms interact with each other and with their non-living surroundings.
- Environment - Everything that affects an organism during its lifetime.
  - Biotic - Living components
  - Abiotic - Non-living components

Levels of Organization in Ecology



Ecological Concepts

- Limiting Factors - Any factor whose shortage or absence restricts species success.
  - Range of Tolerance - Range of conditions an organism can survive in.
    - Temperature
    - pH



Habitat and Niche

- Habitat - Space an organism inhabits; defined by biological requirements of each particular organism.
  - Usually highlighted by prominent physical or biological features.
- Niche - Functional role an organism has in its surroundings.
  - Includes all ways an organism affects organisms with which it interacts as well as how it modifies its physical surroundings.

Succession

- Succession - A series of regular, predictable changes in community structure over time.
  - Activities of organisms change their surroundings and make the environment suitable for other kinds of organisms.
    - Climax community - Relatively stable, long-lasting community, primarily determined by climate.

Succession

- Primary Succession - Begins with total lack of organisms on bare mineral surfaces or water.
- Secondary Succession - Begins with disturbance of an existing ecosystem.
  - Much more commonly observed, and generally proceeds more rapidly.

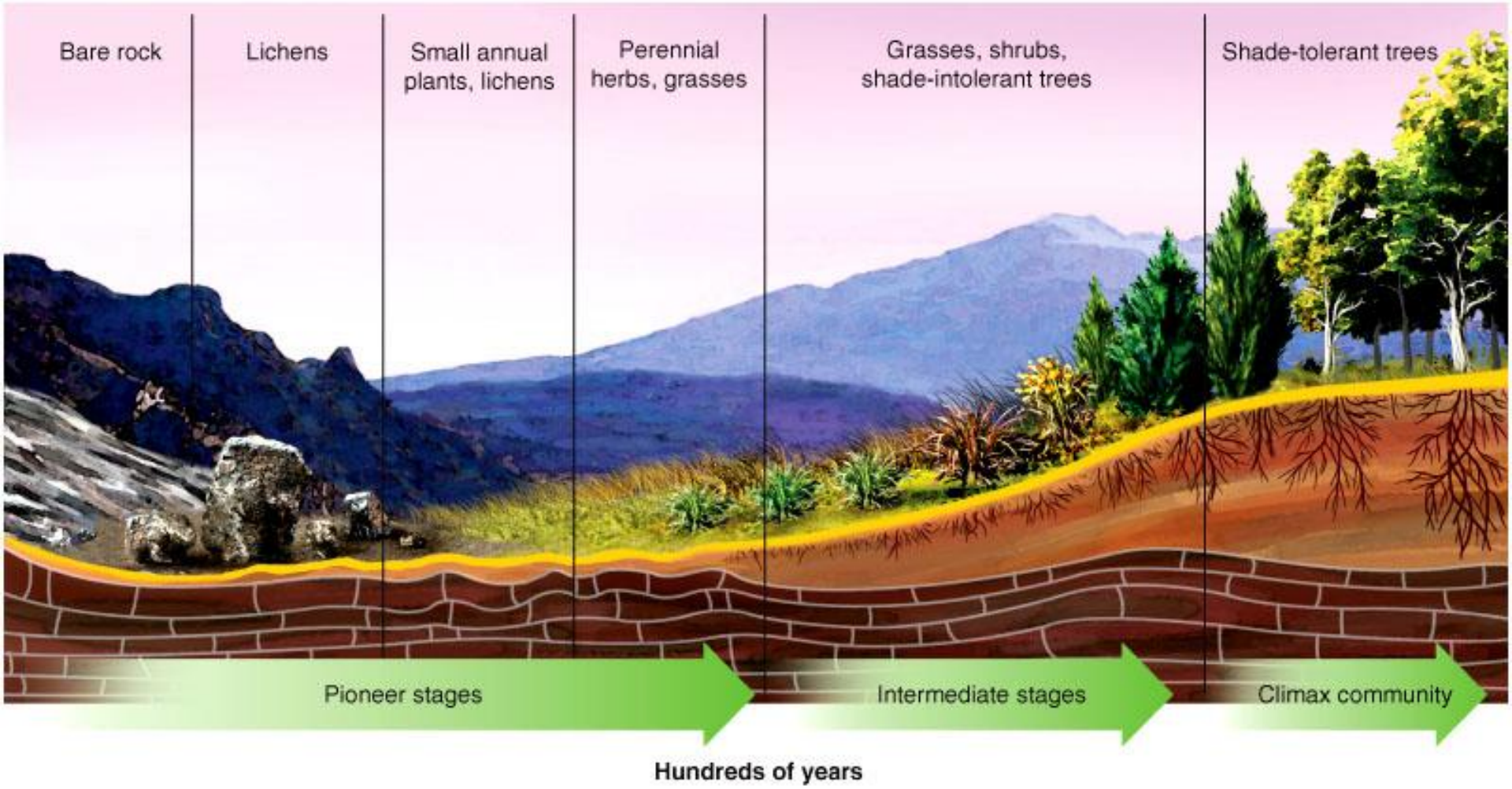
Primary Succession

- Terrestrial Primary Succession
  - Pioneer Community - Collection of organisms able to colonize bare rock (i.e., lichens).
    - Lichens help breakdown rock, and accumulate debris helping to form a thin soil layer.
      - Soil layer begins to support small forms of life.

Terrestrial Primary Succession

- Lichen community replaced by annual plants.
- Annuals replaced by perennial community.
- Perennial community replaced by shrubs.
- Shrubs replaced by shade intolerant trees.
- Shade intolerant trees replaced by shade tolerant trees.
- Stable, climax community often reached.
  - Each step in the process is known as a Successional (seral) Stage.

Primary Succession on Land



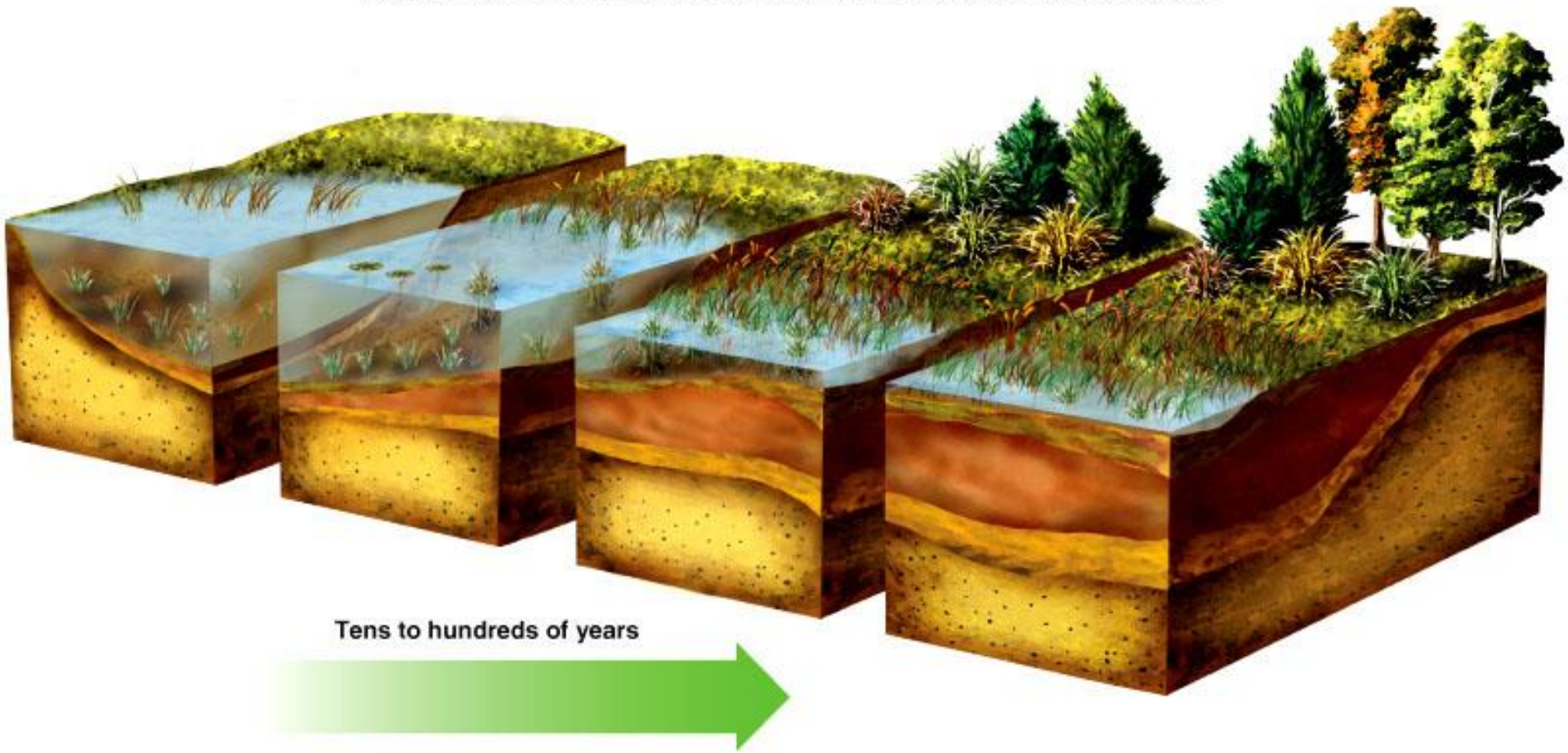
Climax Community Characteristics

- Maintain species diversity for extended period.
- Contain multiple specialized ecological niches.
- Maintain high level of organism interactions.
- Recycle nutrients while maintaining a relatively constant biomass.
  - The general trend in succession is toward increasing complexity and more efficient use of matter and energy.

Aquatic Primary Succession

- Except for oceans, most aquatic systems are considered temporary.
- All aquatic systems receive inputs of soil particles and organic matter from surrounding land.
  - Gradual filling of shallow bodies of water.
    - Roots and stems below water accumulate more material.
      - Establishment of wet soil.

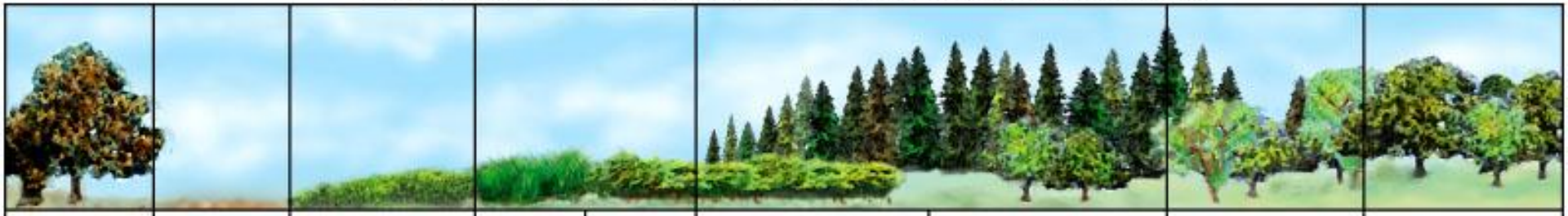
Primary Aquatic Succession



Secondary Succession

- Occurs when an existing community is disturbed or destroyed.
  - With most disturbances, most of the soil remains, and many nutrients necessary for plant growth may be available for reestablishment of previous ecosystem.
    - Nearby undamaged communities can serve as sources of seeds and animals.
      - Tends to be more rapid than primary growth.

Secondary Succession on Land



Mature oak/hickory forest destroyed	Farmland abandoned	Annual plants	Grasses and biennial herbs	Perennial herbs and shrubs begin to replace grasses and biennials	Pines begin to replace shrubs	Young oak and hickory trees begin to grow	Pines die and are replaced by mature oak and hickory trees	Mature oak/hickory forest
		1–2 years	**3–4 years**	**4–15 years**	**5-15 years**	**10–30 years**	**50–75 years**	

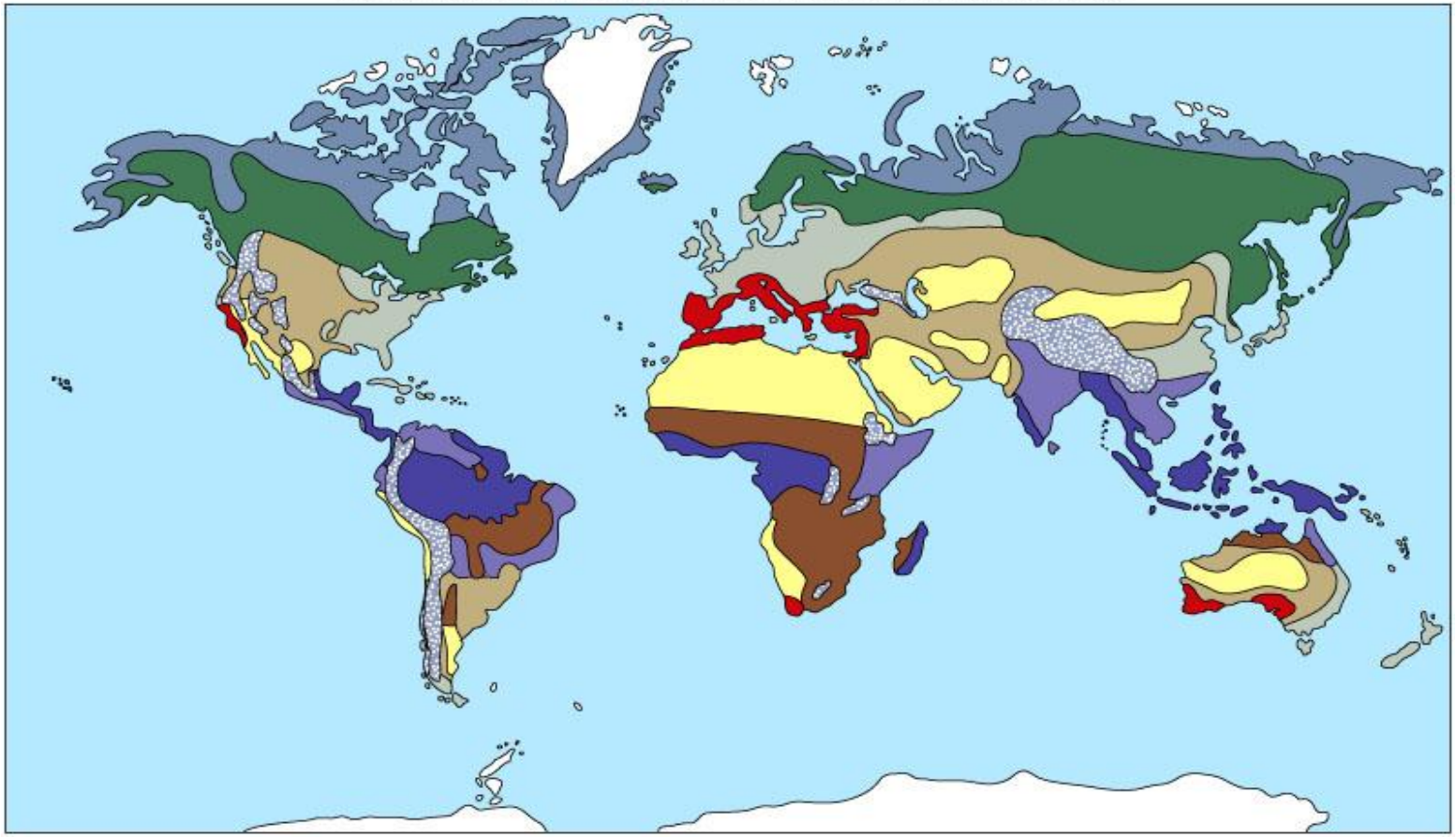
Modern Concepts of Succession and Climax

- As settlers changed “original” ecosystems to agriculture, climax communities were destroyed.
  - Many farms were abandoned, and land began to experience succession.
- Ecologists began to recognize there was not a fixed, pre-determined community.
  - Only thing differentiating a climax community from any other successional community is its time scale.

Biomes: Terrestrial Climax Communities

- Biome - Terrestrial climax communities with wide geographic distributions.
  - Usually defined by undisturbed natural plant communities.
    - Two main non-biological factors determining biomes:
      - Temperature
      - Precipitation

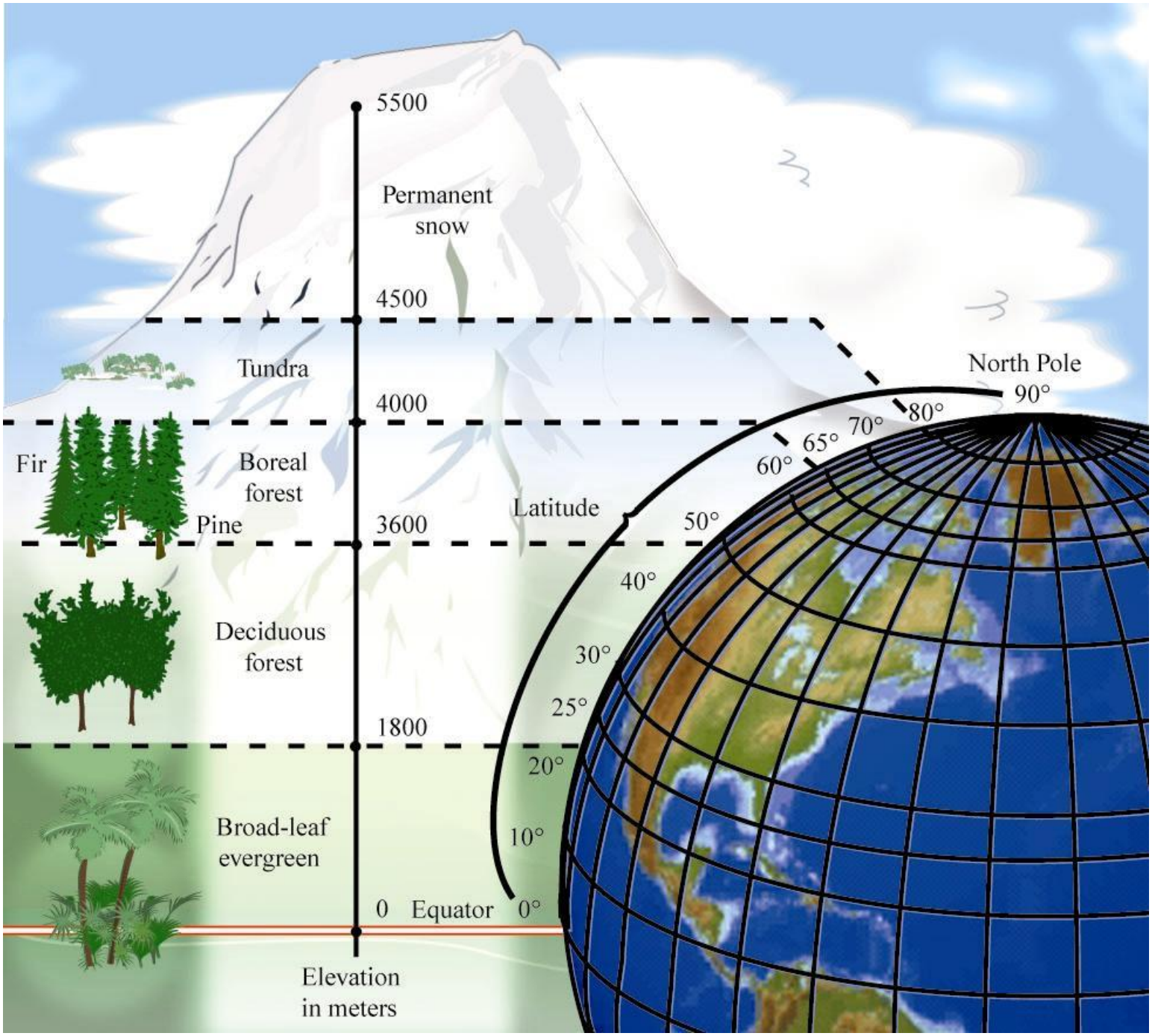
Biomes of the World



- Polar ice cap
- Tundra
- Northern coniferous forest (taiga)
- Temperate deciduous forest
- Mediterranean shrubland
- Grassland
- Desert
- Tropical rainforest
- Tropical dry forest
- Savanna
- Mountain

Elevation Effects on Climate and Vegetation

- As altitude increases, average temperature decreases.
  - Moving from sea level to mountain tops, it is possible to pass through a series of biomes similar to what would be encountered moving from the equator to the north pole.


5500
Permanent
snow
4500
Tundra
4000
Fir
Boreal
forest
Pine
3600
Deciduous
forest
1800
Broad-leaf
evergreen
0
Equator
Elevation
in meters
Latitude
North Pole
90°
80°
70°
65°
60°
50°
40°
30°
25°
20°
10°
0°

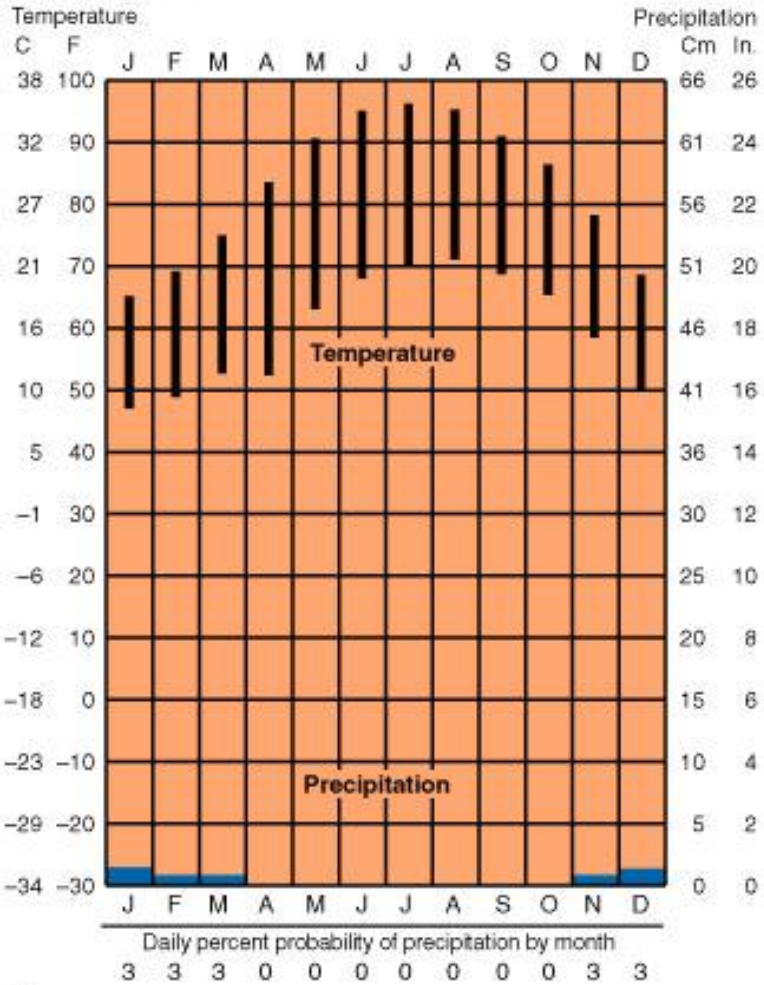
Desert

- Less than 25 cm annual precipitation.
  - Unevenly distributed throughout the year.
- Large daily temperature fluctuations.
- Likely to be windy.
- Infrequent cloud cover.
- Many species, but low numbers.
- Most species exhibit specialized adaptations to climate.
  - Water Conservation

Desert

City: Cairo, Egypt
Latitude: 29 52′N
Altitude: 116 m (381 ft.)
Yearly precipitation: 1.8 cm (0.7 in.)

Climate name: Hot desert
Other cities with similar climates:
Mecca, Karachi



(a)

(b)

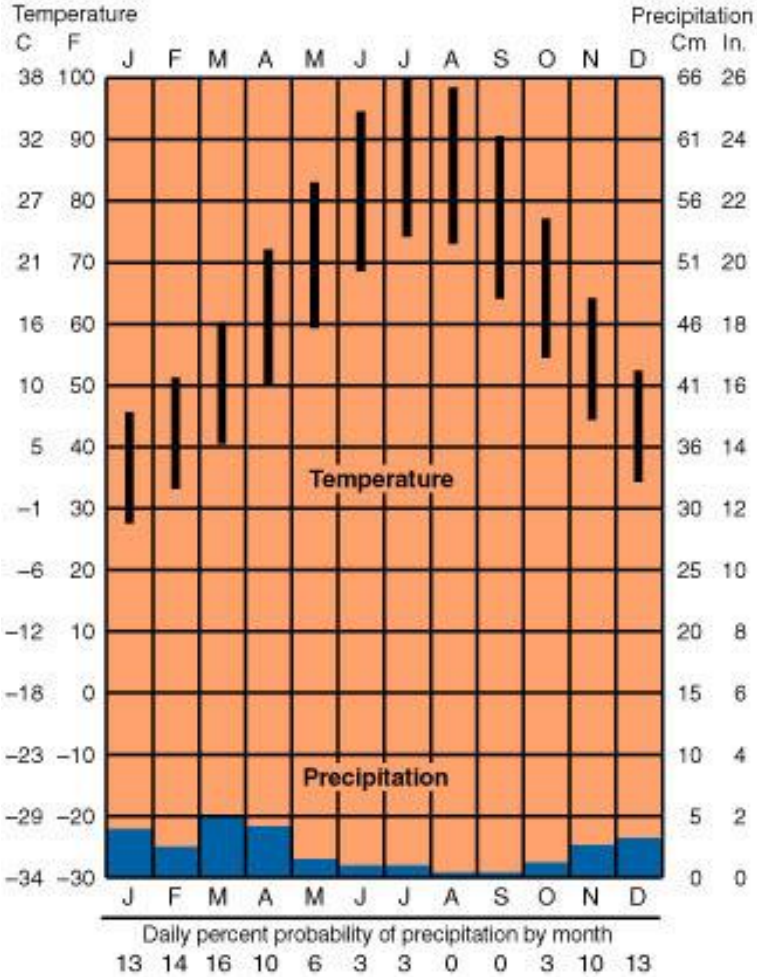
Grassland

- Also known as prairies or steppes.
- Receives 25 -75 cm of annual precipitation.
- Fire regime usually present.
  - Rainfall sporadic enough to cause droughts.
- Historically evolved with large herds of migratory grazing mammals.
  - Supply fertilizer and discourage invasion by woody species.

Grassland

City: Tehran, Iran
Latitude: 35 41′N
Altitude: 1220 m (4002 ft.)
Yearly precipitation: 26 cm (10.1 in.)

Climate name: Midaltitude dryland
Other cities with similar climates:
Salt Lake City, Ankara



(a)

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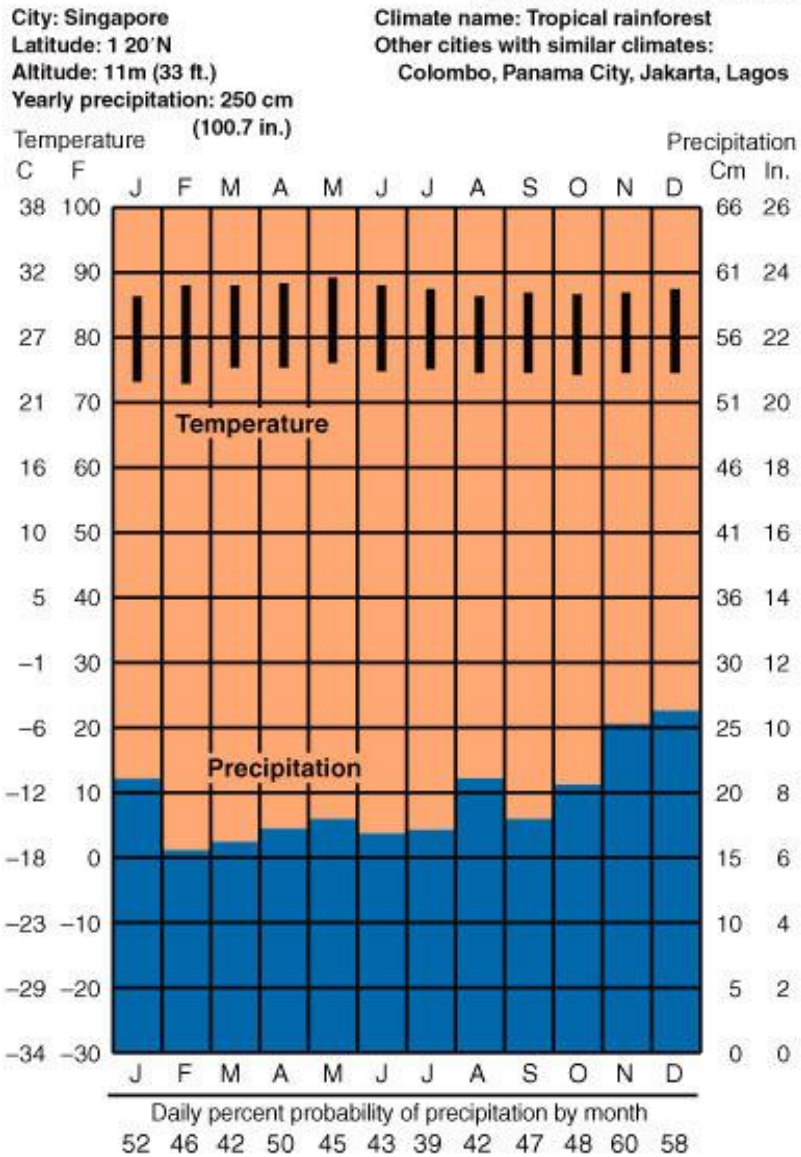
Tropical Rainforest

- Located near equator where temperature is relatively warm and constant.
- Most areas receive 200^{+} cm annual rainfall.
  - (Some in excess of 500 cm)
- Soil allows high levels of leaching, thus most nutrients are tied-up in biomass.
- Multi-layered canopy.
  - Epiphytic plants
- Very high species diversity.

Tropical Rainforest



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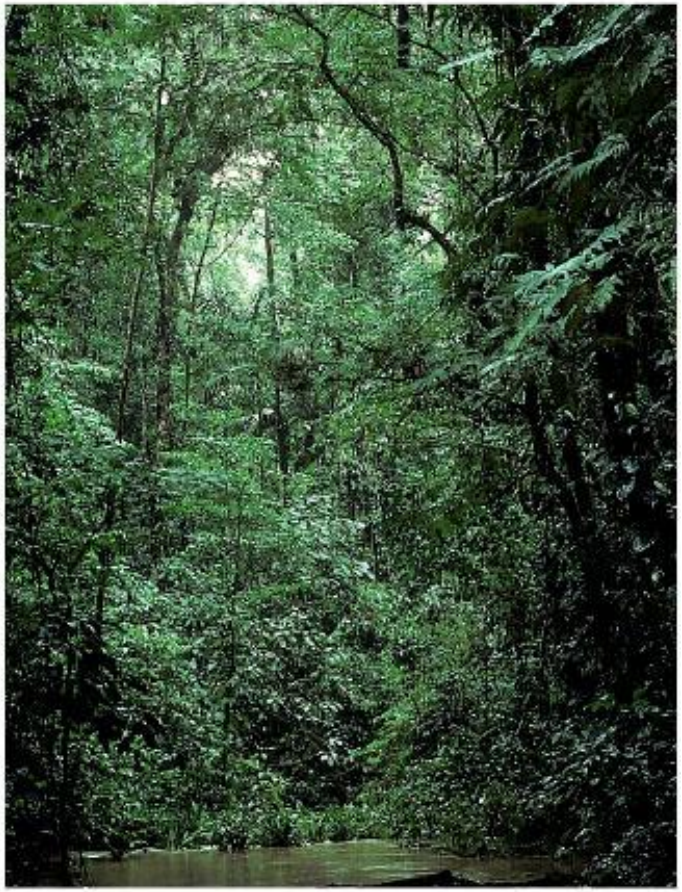


(b)

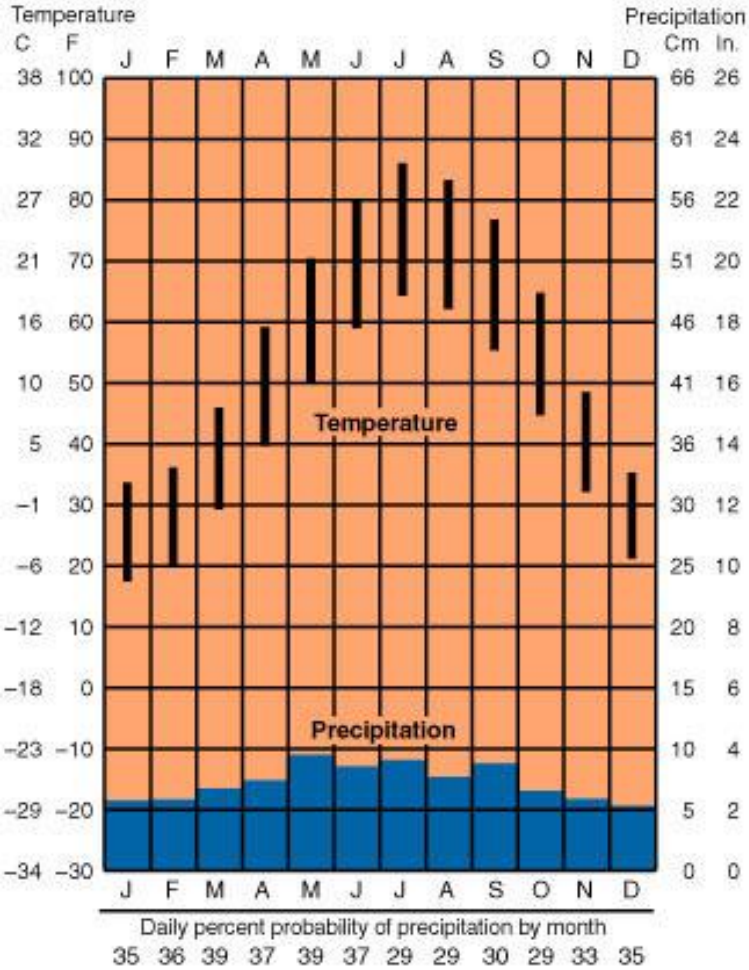
Temperate Deciduous Forest

- Receives 75-100 cm annual precipitation.
  - Evenly distributed throughout the year.
- Trees typically lose their leaves during the winter and replace them the following spring.
- Mild winters
- Long growing season (6 months).
- Relatively few species.

Temperate Deciduous Forest

City: Chicago, Illinois
Latitude: 41 52′N
Altitude: 181 m (595 ft.)
Yearly precipitation: 85 cm (33.3 in.)

Climate name: Humid continental (warm summer)
Other cities with similar climates:
New York, Berlin, Warsaw



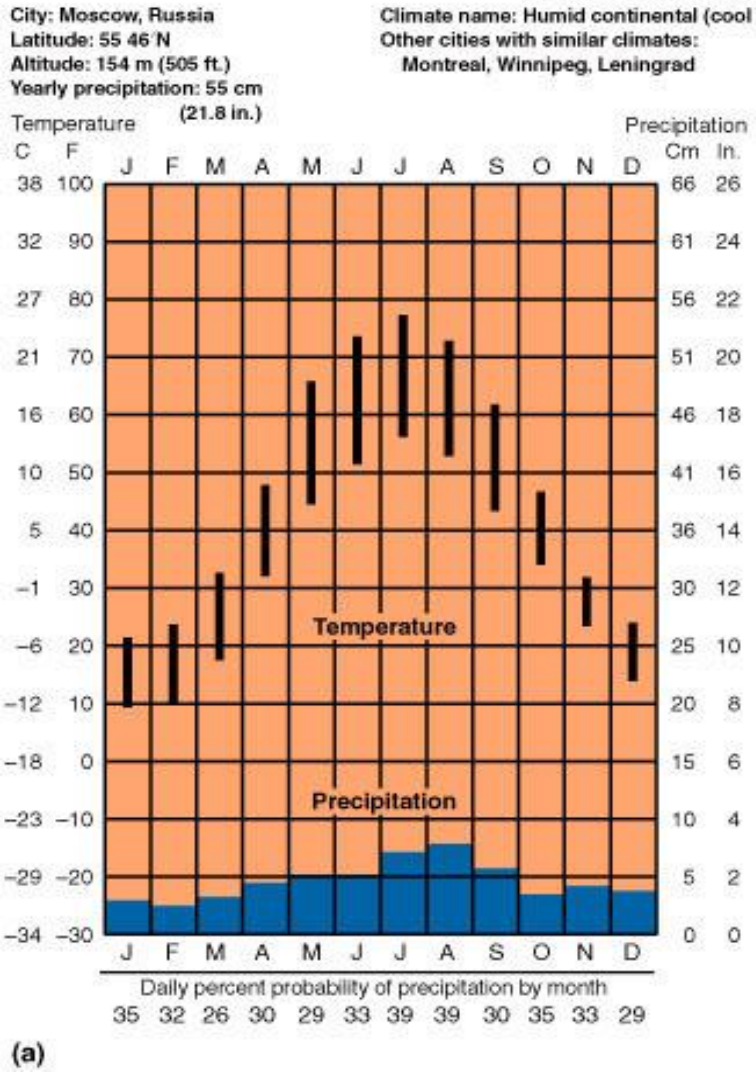
(a)

(b)

Taiga, Northern Coniferous (Boreal) Forest

- Receives 25-100 cm precipitation annually.
- Short, cool summers.
- Long winters with abundant snowfall.
- Humid climate
- Trees adapted to winter conditions:
  - Needle-shaped leaves prevent water loss.
  - Flexible branches

Taiga, Northern Coniferous (Boreal) Forest



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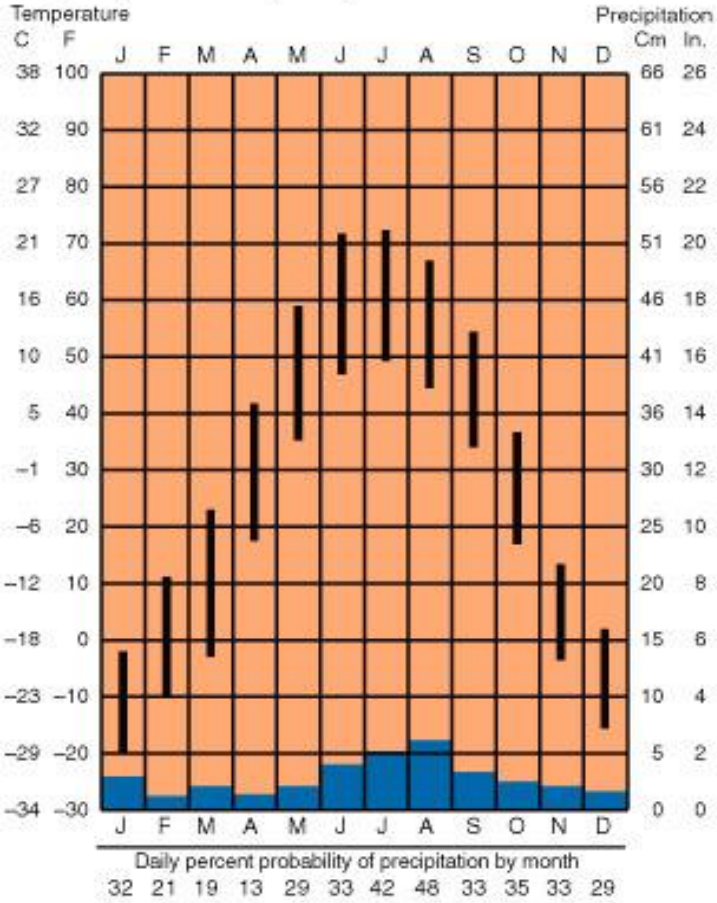
Tundra

- Less than 25 cm annual precipitation.
- Permanently frozen soil (permafrost).
- Short, wet summer.
- Waterlogged soils and shallow ponds and pools in spring and summer.
- Plants usually less than 20 cm tall.
- Alpine Tundra found on mountaintops.

Tundra

City: Fairbanks, Alaska
Latitude: 64 51′ N
Altitude: 134 m (440 ft.)
Yearly precipitation: 31.5 cm (12.4 in.)

Climate name: Subarctic tundra
Other cities with similar climates:
Yellowknife, Yakutsk



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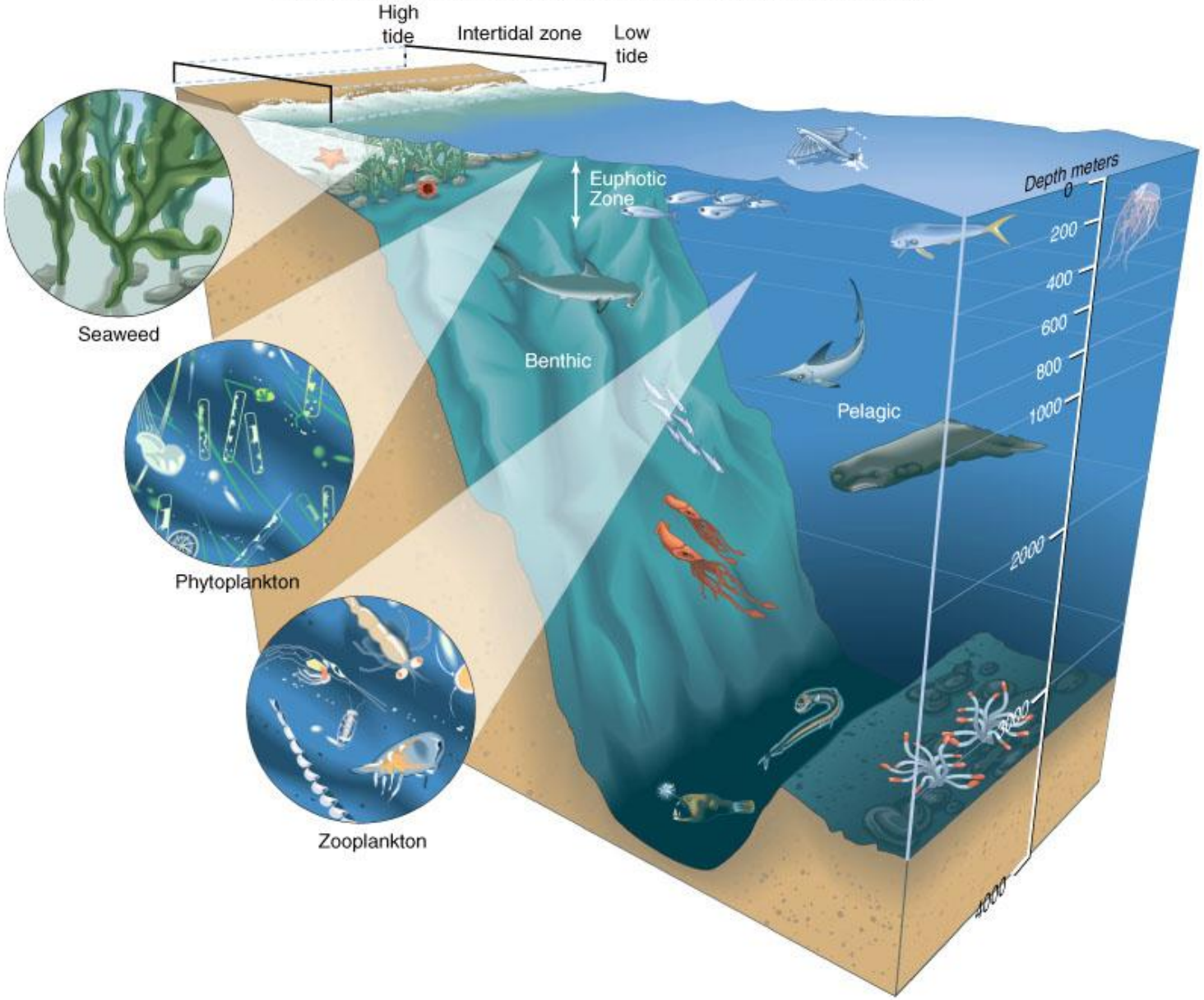
Major Aquatic Ecosystems

- Marine Ecosystems
  - Freshwater Ecosystems - Low salt content.
  - Marine Ecosystems - High salt content.
  - Estuary Brackish Water – Mixture of salt and fresh.

Pelagic Marine Ecosystems

- Pelagic Region - Open sea above sea floor.
  - Euphotic Zone - Upper layer of ocean where sun's rays penetrate.
- Phytoplankton - Microscopic plants floating in the ocean. (Perform photosynthesis)
- Zooplankton - Microscopic animals of many kinds - feed on phytoplankton.
  - Productive aquatic ecosystems contain a plentiful supply of essential nutrients.

Marine Ecosystems



Marine Ecosystems

- Benthic Marine Ecosystems
  - Benthic organisms, attached or non-attached, live on the ocean bottom.
    - Substrate and Temperature are very important characteristics in determining benthic community development.

Marine Ecosystems

- Coral Reef Ecosystems - Large number of animals that build cup-shaped external skeletons.
  - Contain single-celled algae and carry on photosynthesis.
  - Require warm water, thus are found only near the equator.
    - Most require clear, shallow water with ample sunlight penetration.

Marine Ecosystems

- Mangrove Swamp Ecosystems
  - Occupy region near shore.
  - Trees tolerate high salt content.
    - Excrete salt from leaves.
  - Extensively developed roots.
    - Can extend above water.
  - Trap sediment in shallow areas.
    - Develop terrestrial ecosystems.

Marine Ecosystems

- Estuaries
  - Shallow, partially enclosed areas where freshwater enters the ocean.
  - Extensive production because areas are shallow, warm, and nutrient-rich.
    - Nursery sites for fish and crustaceans.

Lakes and Ponds

- Littoral Zone - Region of a lake with rooted vegetation.
  - Emergent Plants - Have leaves that float on, or protrude above, water's surface.
  - Submerged Plants - Stay submerged below water's surface.
- Limnetic Zones - Region of lake with no rooted vegetation.

Lakes and Ponds

- Productivity of a lake determined by many factors.
  - Cold temperature reduces rate of photosynthesis.
  - Shallow water allows more photosynthesis.
  - Erosion from land increases nutrient levels.
  - Dissolved oxygen input via wave action and photosynthesis from aquatic plants.

Lakes and Ponds

- Oligotrophic - Deep, cold, nutrient-poor.
- Eutrophic - Shallow, warm, nutrient-rich.
- Biochemical Oxygen Demand (BOD)
  - Amount of oxygen used by decomposers to break down specific amount of organic matter.

Streams and Rivers

- Swamps - Wetlands containing trees able to live in environments permanently flooded, or flooded most of the year.
- Marshes - Wetlands dominated by grasses and reeds.

Kinds of Organism Interactions

- Predation - One animal kills/eats another.
  - Predator benefits from food.
    - Prey adaptation is manifested in a higher reproduction rate.

Kinds of Organism Interactions

- Prey species benefits by eliminating non-adaptive genes from the gene pool.
  - Poorly adapted predators are less likely to obtain food and thus pass on non-adaptive genes.

Competition

- Competition - Two organisms strive to obtain the same limited resource, and both are harmed to some extinct.
  - Intraspecific - Members of same species competing for resources.
  - Interspecific - Members of different species competing for resources.
- The more similar the competing species, the more intense the competition.

Competition

- Competitive Exclusion Principle - No two species can occupy the same ecological niche in the same place at the same time.
  - Less fit species must evolve into a slightly different niche.

Symbiotic Relationships

- Symbiosis - Close, physical relationship between two different species. At least one species derives benefit from the interaction.
  - Parasitism - One organism (parasite) lives in or on another organism (host), from which it derives nourishment.
    - Ectoparasites - Live on host's surface.
      - Fleas
    - Endoparasites - Live inside host.
      - Tapeworms

Symbiotic Relationships

- Commensalism - One organism benefits while the other is not affected.
  - Remoras and Sharks
- Mutualism - Both species benefit. Obligatory in many cases as neither can exist without the other.
  - E. coli in intestinal tract
  - Lichens

Community and Ecosystem Interactions

- Community - Assemblage of all interacting species of organisms in an area.
- Ecosystem - Defined space in which interactions take place between a community, with all its complex interrelationships, and the physical environment.

Major Roles of Organisms in Ecosystems

- Producers - Organisms able to use sources of energy to make complex organic molecules from simple inorganic molecules in the environment.

Roles of Organisms

- Consumers - Consume organic matter to provide themselves with energy and organic matter necessary for growth and survival.
  - Primary Consumers
    - Herbivores (plants)
  - Secondary Consumers
    - Carnivores (animals)
    - Omnivores (plants and animals)

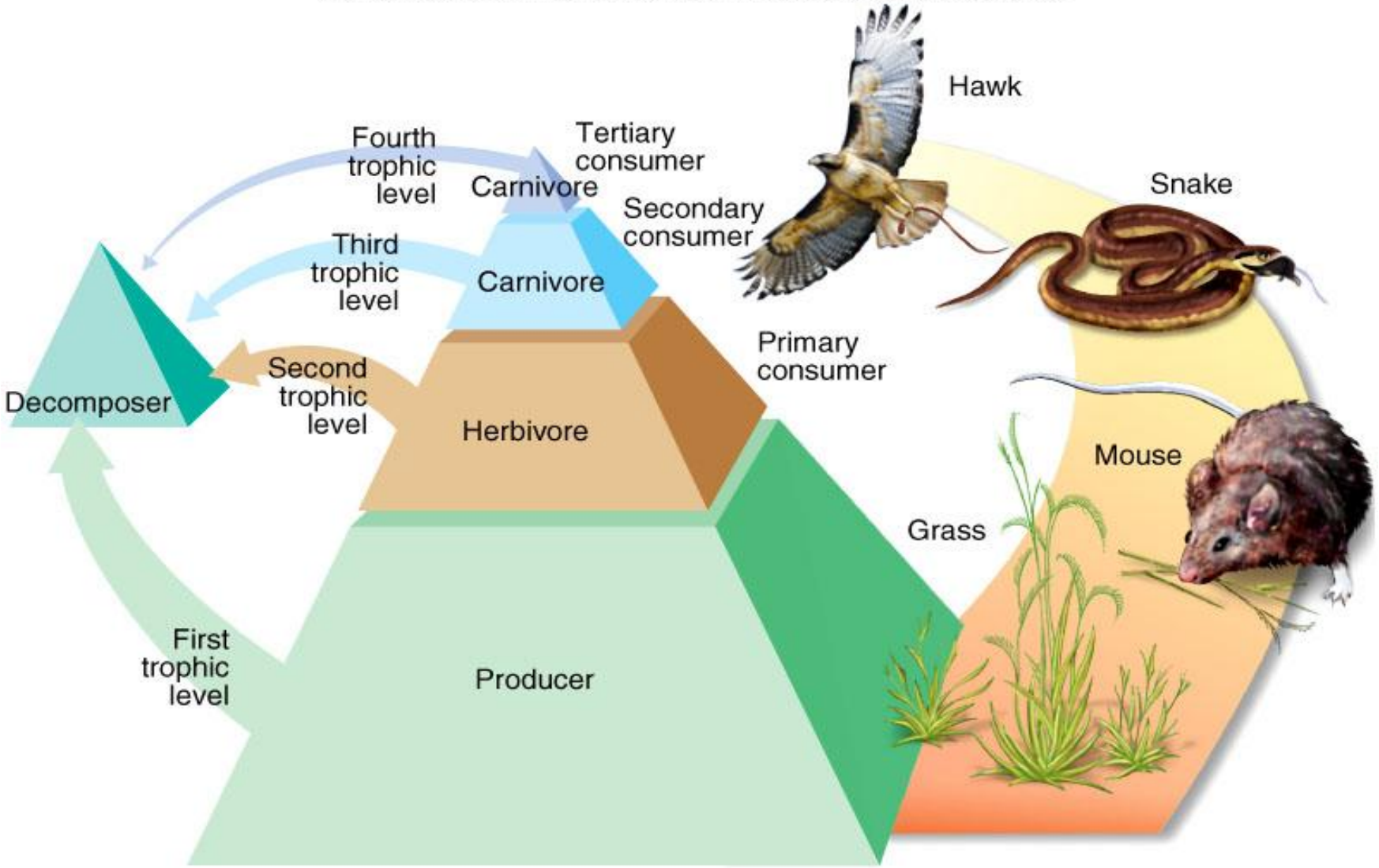
Roles of Organisms

- Decomposers
  - Digest organic molecules in detritus into simpler organic compounds, and absorb soluble nutrients. (Bacteria and Fungi)
    - Use non-living organic matter as source of energy.
- Keystone Species
  - Play critical role in maintenance of specific ecosystems.
    - Bison in American Tall Grass Prairie

Energy Flow Through Ecosystems

- Each step in the flow of energy through an ecosystem is known as a trophic level.
  - As energy moves from one trophic level to the next, most of the useful energy (90%) is lost as heat (2nd Law of Thermodynamics).
    - Because energy is difficult to track, biomass (weight of living material) is often used as a proxy.

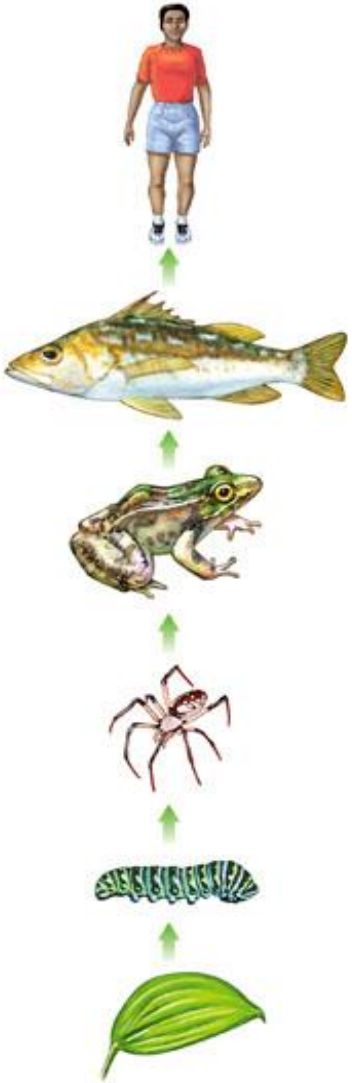
Energy Flow Through an Ecosystem



Food Chains and Food Webs

- Food Chain - Passage of energy from one trophic level to the next due to one organism consuming another.
  - Some chains rely on detritus.
- Food Web - Series of multiple, overlapping food chains.
  - A single predator can have multiple prey species at the same time.

Food Chain



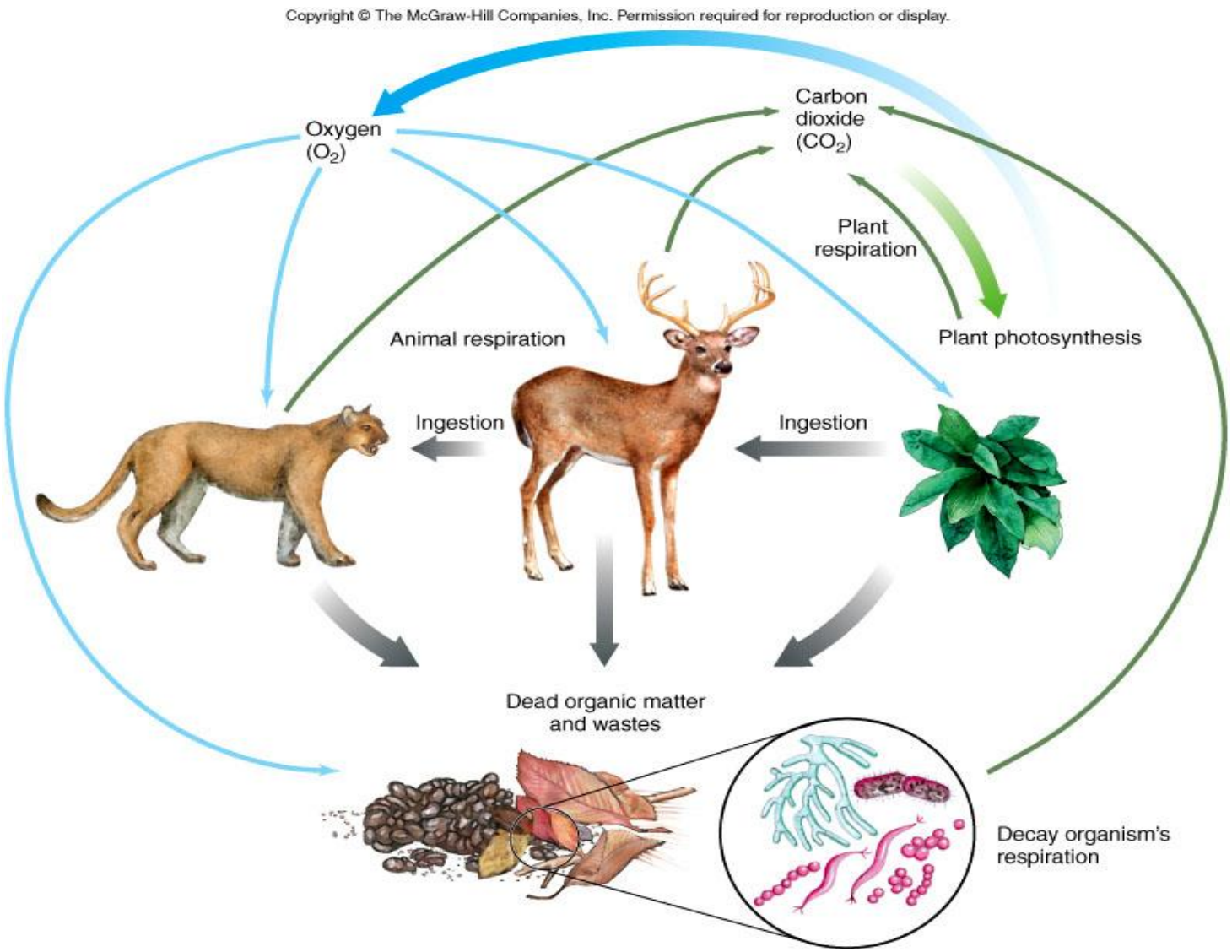
Nutrient Cycles in Ecosystems

- Organisms are composed of molecules and atoms that are cycled between living and non-living portions of an ecosystem.
  - Biogeochemical Cycles

Carbon Cycle

- Carbon and oxygen combine to form carbon dioxide.
  - Plants use carbon dioxide during photosynthesis to produce sugars.
    - Plants use sugars for plant growth.
      - Herbivores eat plants, and incorporate molecules into their structure.
        - » Respiration breaks down sugars releasing CO_2 and water back into the atmosphere.

Carbon Cycle



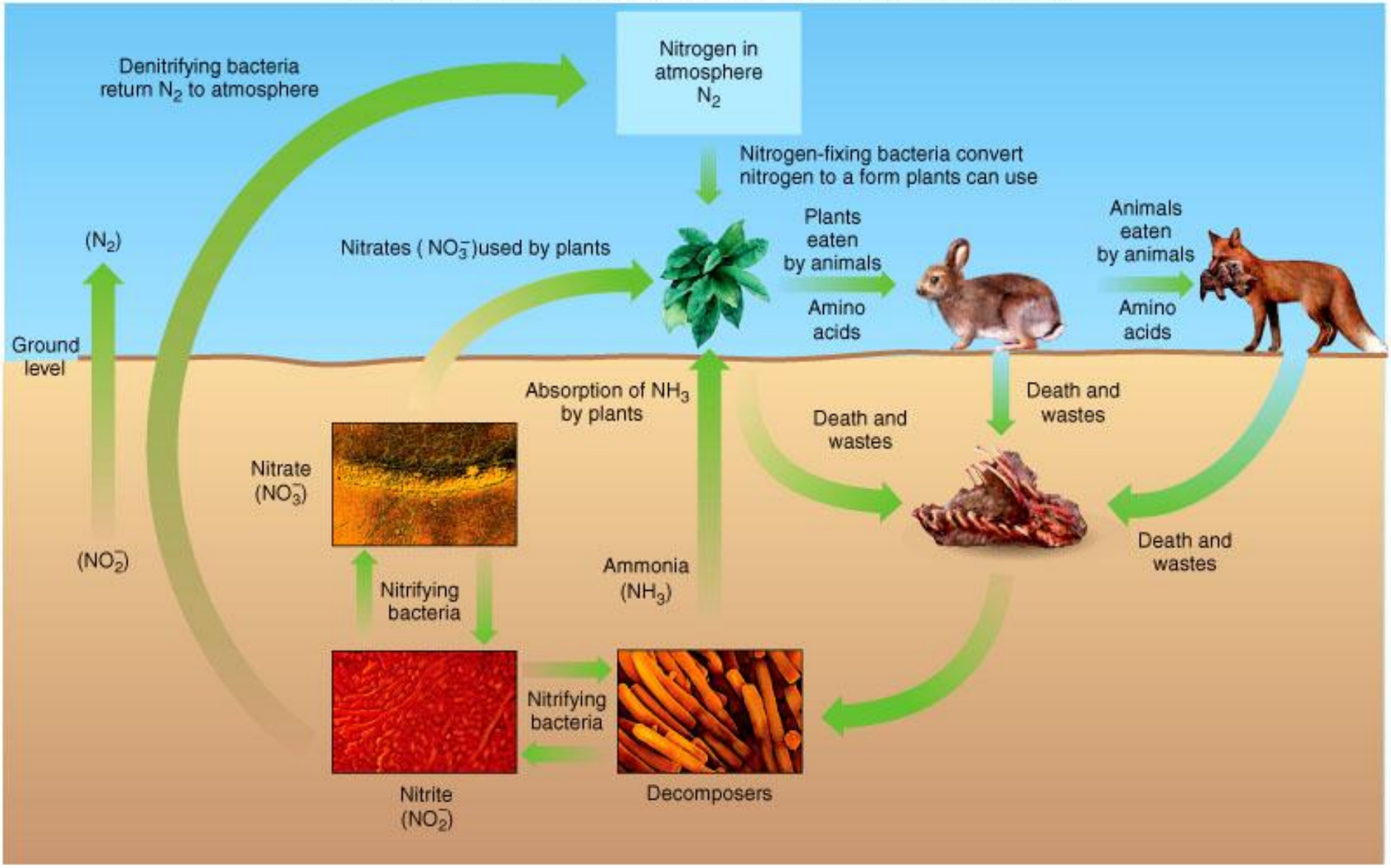
Nitrogen Cycle

- Cycling of nitrogen atoms between abiotic and biotic ecosystem components.
  - Producers unable to use atmospheric N.
    - Must get nitrate NO_3 or ammonia NH_3.
  - Nitrogen-fixing bacteria converts nitrogen gas N_2 into ammonia.
    - Plants construct organic molecules.
      - Eaten by animals.
  - Decomposers also break down nitrogen-containing molecules releasing ammonia.

Nitrogen Cycle

- Nitrifying bacteria are able to convert ammonia to nitrite, which can be converted to nitrate.
- Denitrifying bacteria are able to (under anaerobic conditions) covert nitrite to nitrogen gas (N_2) which is ultimately released into the atmosphere.

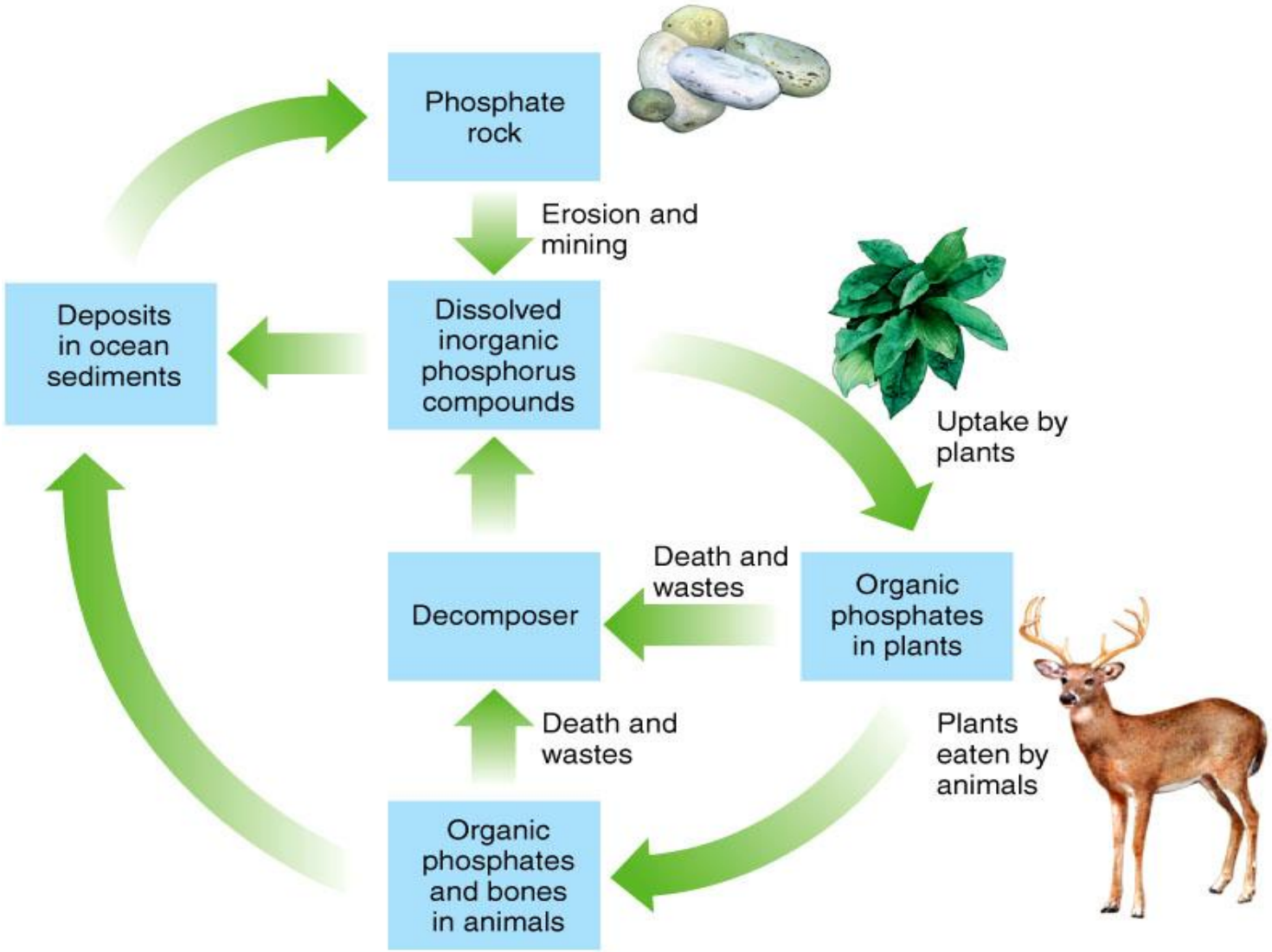
Nitrogen Cycle



Phosphorus Cycle

- Phosphorus is not present in the atmosphere as a gas.
  - Phosphorus compounds released by erosion and become dissolved in water.
    - Plants use phosphorus to construct necessary molecules.
      - Animals gain necessary phosphorus via herbivory.
        - » Decomposers recycle into soil.

Phosphorus Cycle



Human Impact on Nutrient Cycles

- Two activities caused significant changes in carbon cycle:
  - Burning of fossil fuels.
  - Converting forests to agricultural land.
- Fossil fuel burning also increased amount of nitrogen available to plants.
- Fertilizer carried into aquatic ecosystems.
    - Increase aquatic plant growth rate.
      - Lowered oxygen concentrations.