

Chapter 20 Ecosystems

Ecosystem: most complex level of biological organization

Biosphere: all earth's ecosystems

Energy Flows Through Ecosystems

- ❖ Trophic Levels

- ❖ **Ecology**: study of the interactions of living organisms with one another and with their physical environment

- ❖ **Community**: the collection of organisms that live in a particular place

- ❖ the place where a community lives is called the habitat

- ❖ community + habitat = the ecosystem

- ❖ closed system with respect to chemicals

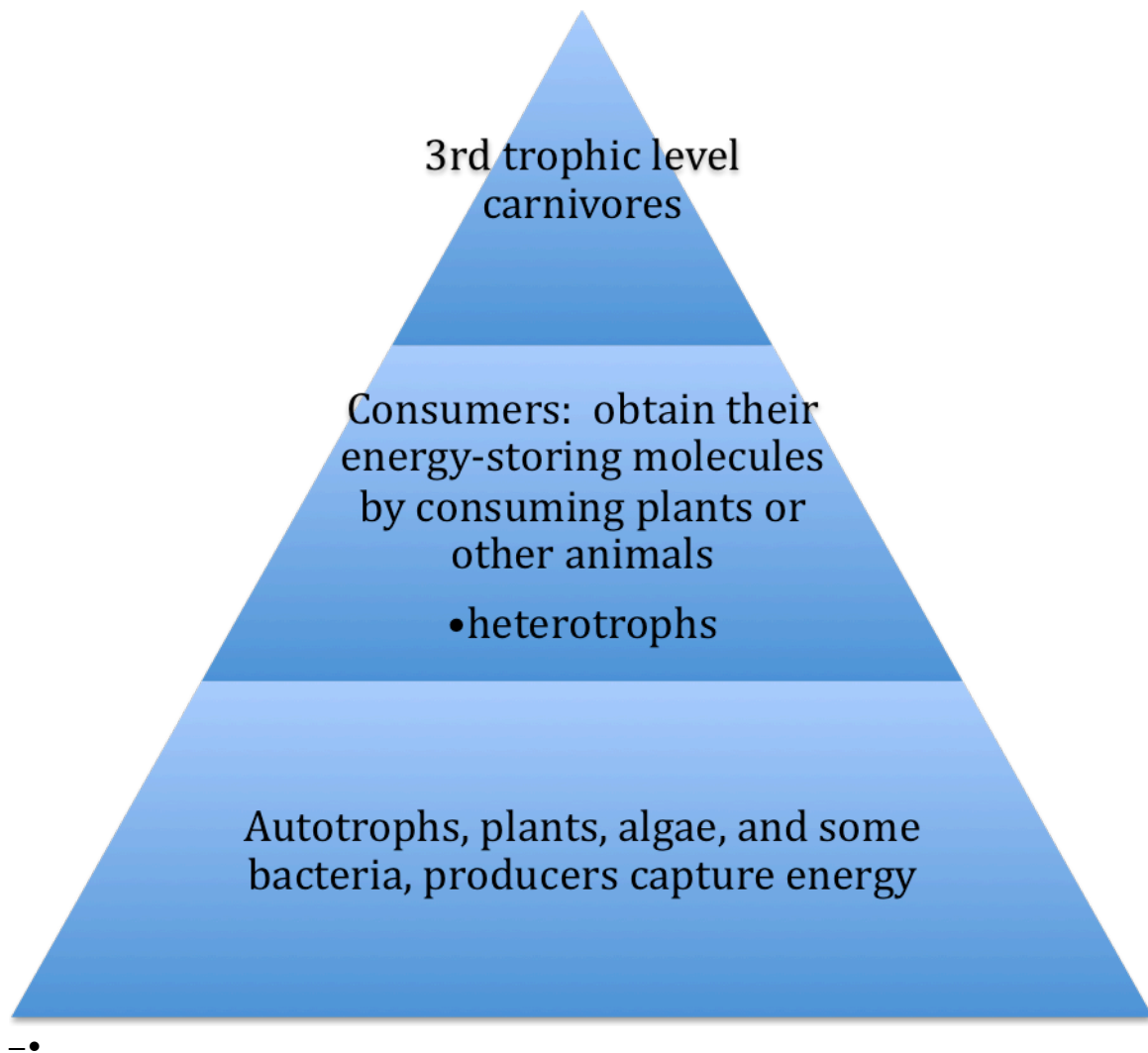
- ❖ an open system in terms of energy

- ❖ organisms in ecosystems regulate the capture and expenditure of energy and the cycling of chemicals

organisms in an ecosystem

Every organism has a trophic level: feeding level composed of those organisms whose source of energy is the same number of consumption "steps" away from the sun

- food energy passes through ecosystem from one trophic level to another
- if path is a simple linear progression = food chain
- chain ends with decomposers that break down dead organisms



In most ecosystems, the path of energy is not linear because *individuals often feed at several trophic levels*

a food web describes this more complex path of energy flow

<u>Producers</u>	lowest trophic level of any ecosystem <u>green plants</u> in most terrestrial ecosystems <u>algae</u> in most aquatic systems
<u>Primary Consumers</u>	occupy the second trophic level and eat producers heterotrophs
Carnivores	3rd trophic level eat producers secondary consumers some carnivores also eat plants, and are called omnivores
Detrivores	are special consumers that eat dead organisms also known as <u>scavengers</u>
Decomposers	organisms that break down organic substances, making them available to other organisms bacteria and fungi are the principal decomposers in land ecosystems

Primary productivity: total amt of light energy converted by producers into organic compounds in a given area per unit of time

Net primary productivity: total amt of energy fixed by photosynthesis per unit time minus that expended by photosynthetic organisms to fuel metabolic activities

Biomass: total wt of all ecosystem organisms
–increases as a result of the ecosystems net primary productivity

Much of the energy captured by the plant is lost as energy passes through the ecosystem

- ❖ 80% to 95% of the energy available at one trophic level is not transferred to the next
- ❖ Food chains consist of only 3-4 steps
- ❖ so much energy is lost at each step that very little remains in system once it is in the bodies of organisms at four successive trophic levels

Ecological Pyramids

- more individuals at the lower trophic levels than at the higher levels
- plants fix about 1% of the sun's energy into their green parts
- consumers get only 10% of this by eating autotrophs
- the biomass of primary producers is greater than that of higher trophic levels
- Some aquatic ecosystems have inverted pyramids because the turnover of phytoplankton producers being consumed by zooplankton is very high
- the phytoplankton can never build a large biomass
- they still produce the largest amount of energy
- Energy loss at each trophic level limits # of top-level carnivores a community can support
- top-level predators tend to be relatively large animals
- only 1/1000th of the original energy captured by photosynthesis is available to a tertiary consumer

- top-level predators have no predators that subsist exclusively on them

Biogeochemical cycle

- is a circuit or pathway by which a chemical element or molecule moves through both biotic ("bio-") and abiotic ("geo-") compartments of an ecosystem.
- the element is recycled
- element may accumulate for a long period of time. (sinks or reservoirs)
- All the chemicals, nutrients, or elements (C,N,O₂, Ph) used in ecosystems by living organisms operate on a closed system,
- recycled instead of being lost and replenished constantly such as in an open system.

ENERGY occurs on an open system;

- the sun constantly gives the planet energy in the form of light
- Light is used and lost in the form of heat throughout trophic levels of food web.

4 Cycles

1. Water
2. Carbon
3. Nitrogen
4. Phosphorus

The Water Cycle

Of all abiotic components of ecosystem, water has the greatest influence on the living portion

water cycles within an ecosystem in 2 ways

- •environmental water cycle
 - water vapor in atmosphere condenses and falls to earth as precipitation
 - reenters the atmosphere by evaporation from lakes, rivers, and oceans

- organismic water cycle
 - surface water is taken up by plant roots
 - after passing through the plant, it evaporates from a plant leaf via transpiration

Deforestation breaks the water cycle

- in especially dense forest ecosystems, such as tropical rain forests, 90% of the moisture in the atmosphere is taken up by plants and returned by transpiration

- the vegetation is actually the primary source of local rainfall

- when forests are cut down the moisture is not returned to the atmosphere

- In the US more than 96% of the freshwater is in the form of groundwater

- groundwater occurs in permeable, saturated, underground layers of rock, sand, and gravel called aquifers

- the increasing chemical pollution and use of groundwater is becoming a very serious problem

CARBON CYCLE

Processes:

1. Diffusion: water to air
2. Respiration:
3. Photosynthesis
4. Combustion:
5. Erosion:

The earth's atmosphere contains plentiful carbon, present as CO₂
C cycles between atmosphere & living organisms

- ❖ plants trap C by photosynthesis
- ❖ C returns to atmosphere by respiration, combustion, and erosion
- ❖ some C is locked up as fossils
- ❖ the burning of fossil fuels leads to some of this carbon being released back to the atmosphere
- ❖ 3 large Reservoirs where C is found in the biosphere
 - as dissolved CO₂ in water
 - as CO₂ gas in atmosphere
 - as coal, petroleum, calcium carbonate in rock

NITROGEN CYCLE

•Atmosphere:

- 78% N, 20% O₂, .04% CO₂
- N: N inert gas (triple bond/ stable)
- Needed for AA (proteins) and nucleotides (DNA/RNA)

<u>ATMOSPHERE:</u>	<u>EARTH</u>
abiotic	Biotic
stable/inert	soil/ organisms, H ₂ O

•Processes in N Cycle

- 1. Nitrogen Fixation
- 2. Decay
- 3. Nitrification
- 4. DeNitrification

1. N Fixation: removes N₂ from atmosphere

- most living organisms cannot use N₂ gas (Atmospheric form)
- the two nitrogen atoms of N₂ are bound by a triple bond that is hard to break
- some bacteria can break this bond, and add the N to H atoms, forming ammonium (NH₄⁺)
- nitrogen fixation

N fixation can only take place if O₂ is absent

- ✓ N-fixing bacteria are found in cysts that admit no oxygen or within airtight nodules of certain plants, such as beans
- ✓ the availability of fixed nitrogen in fields is very limited
- ✓ farmers supplement their fields through adding fertilizers

2. Decay:

- ❖ Partially decomposed organic matter becomes part of the soil carbon storage pool.
- ❖ Eventually, the organic material in the soil is decomposed to its constituents, water and [carbon dioxide](#), which return to the atmosphere

3. Nitrification: ammonia → nitrates

- ❖ Ammonia in soil becomes nitrates by action of soil bacteria (NO₃)
- ❖ These nitrates in the soil are taken up by the roots of plants in a process called assimilation

4. DeNitrification

- Process conducted by soil bacteria where soil nitrates become N₂

PHOSPHORUS CYCLE

- Ph does not form a gas and is not available in the atmosphere
- Phosphorous: a soil nutrient, a key part of both ATP and DNA
- most Ph in ecosystems taken up by organisms
- Ph level of freshwater lake ecosystems is usually very low, (limits the growth of photosynthetic algae)
- If P-containing fertilizers or detergents pollute a lake, rapid uncontrolled blooms of algae result in a process called eutrophication
- algae die. Bacteria decompose the algae using up lake's dissolved O₂, killing other organisms

The Sun and Atmospheric Circulation

world climate determined by earth's annual orbit around sun and its daily rotation on its axis

- tropics warmer than temperate regions because sun's rays are perpendicular at the equator
- all parts away from the equator experience a progression of seasons

Latitude affects climate

In this view of earth, the Southern Hemisphere is tilted more towards the sun and is experiencing summer.

- interactions between 6 large air masses produce atmospheric circulation patterns
- these air masses affect climate because the rising and falling of an air mass influence its temperature,
- Air temp influences its moisture-holding capacity
- Air rises at the equator and then falls
- Temperature varies with elevation,
 - Cooler at higher elevations

at any given latitude, air temperature falls about 6°C for every 1,000-meter increase in elevation

RAIN SHADOW

- Mountain forces air upward,
- air is cooled at higher elevation,
- produces rain on the windward side of a mountain
- as air passes the peak and descends on the far side of the mountains, its moisture-holding capacity increases

Ocean Ecosystems

- photosynthetic organisms are confined to the upper few hundred meters because light does not penetrate any deeper
- almost all organisms that live below this level feed on organic debris from above

3 main types of ocean ecosystems

- **shallow water:** along the shoreline/ contains the most species
 - consists of the intertidal zone, which is periodically exposed to air
 - Estuaries: partly enclosed bodies of water, (river mouths and coastal bays) have intermediate salinities
- **open-sea surface**
 - contains lots of phytoplankton that drift with the current and perform 40% of all the photosynthesis that takes place on earth
- **deep-sea water**
 - Very few organisms live below 300 meters and are often bizarre

In the deep-sea ecosystem

- many inhabitants are bioluminescent for the purpose of communication or predation
- many are specialized to a local area (i.e., endemic)
- while some utilize energy falling to the ocean floor as debris from above, some deep-sea inhabitants are autotrophic
- they derive energy from hydrothermal vent systems

Freshwater Ecosystems

- lakes, ponds, rivers, and wetlands
- they are limited in area
- all freshwater habitats are strongly connected to land habitats with wetlands (i.e., marshes and swamps) constituting intermediate habitats
- a large amount of organic and inorganic material continually enters bodies of freshwater from nearby land communities

- Ponds and lakes have 3 zones in which organisms live
- Littoral (shallow “edge”)
- Limnetic (open-water surface)
- Profundal (deep-water)
 - no light penetrates here

In temperate regions, large lakes undergo thermal stratification, a process in which water at 4°C sinks below water that is either cooler or warmer

- this is because 4°C is when water is most dense
- overturns, when the deeper waters of the lake come to the surface as the denser surface waters sink, occur in the spring and fall
- this brings up fresh supplies of nutrients to the surface waters

2 categories of Lakes based on their production of organic materials

- eutrophic lakes have an abundant supply of minerals and organic matter
 - they have little oxygen at deep depths but are reinfused at overturns
- oligotrophic lakes have little scarce minerals and organic matter
 - because they are deeper, they always have deep waters rich in oxygen

Land Ecosystems

biome: a terrestrial ecosystem characterized by a particular climate and a defined group of organisms

there are seven major and seven minor biomes distributed throughout the earth

Tropical rain forests

- are the richest ecosystems on earth
- Communities in these forests are very diverse

Savannahs

Deserts

- dry places with sparse vegetation
- Plants and animals may restrict their activity to favorable times of the year, when water is present

Grasslands

- (also called prairies) grow in temperate areas
- have widely spaced trees and seasonal rainfall
- This biome is a transition between tropical rain forest and desert
- Most of the original grasslands have been converted to use by agriculture

Deciduous Forests

- forests of trees that drop their leaves in the winter

The Taiga

- a great ring of coniferous trees that extends across vast areas of North America and Asia
- Most of the trees occur in dense stands of one or two species

Tundra

- open, often boggy, grassland that occurs in the far north beyond the taiga
- Permafrost, or permanent ice, usually exists within 1 meter of the surface

Chapparal

- consists of evergreen, often spiny shrubs and low trees
- These communities occur a dry summer climate, also known as Mediterranean

Polar Ice caps

- lie over the Arctic Ocean in the north and the Antarctica in the south
- This region receives almost no precipitation and freshwater is scarce

Tropical upland forests occur at slightly higher altitudes than rainforest or where local climates are drier

Rainfall is seasonal

- monsoon season brings rainfall from the oceans into the interior

Semidesert areas

- occur in regions with less rain than monsoon forests but more rain than savannas
- Vegetation is dominated by bushes and trees with thorns and this biome is also known as thornwood forest
- The biome is found on the edges of desert biomes

There are three additional minor biomes

- mountain (alpine) zone
 - similar to tundra but at high altitude
- temperate evergreen forest
 - occurs in regions where winters are cold and there is a strong, seasonal dry period
- warm, moist evergreen forest
 - occur in regions where winters are mild and moisture is plentiful