Communities Structure and Dynamics
(Outline)

1. Community & niche.
2. Inter-specific interactions with examples.
3. The trophic structure of a community
5. Biomass, food web, and biological magnification.
6. Energy flow and nutrient cycling in ecosystems
The Hierarchical Structural Organization of Life

Anatomy & Physiology

Ecology
Interactions of living organisms with their surrounding environment

Atom
Molecules
Organelle
Cell
Tissue
Organ
Organ system
Organism
Population
Community
Ecosystems (Biomes)
Biosphere
The Hierarchical Structural Organization of Life

Anatomy & Physiology

Structure & Dynamics

Ecology

Interactions of living organisms with their surrounding environment

Atom
Molecules
Organelle
Cell
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Organ system
Organism
Population
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Ecosystem
Biosphere
Check your knowledge....

1. Niche
2. Competition
3. Mutualism
4. Predation
5. Herbivory
6. Parasitism
7. Detritivores
8. Food Chain/Food web
9. Biological magnification
10. Biomass
Ted Talk

A Plant’s Eye View

http://www.ted.com/talks/michael_pollan_gives_a_plant_s_eye_view

https://www.youtube.com/watch?v=bK0vErB4X9U
(17:30 mins)

Start From 6:30 mins
• A Biological **community** is populations of organisms belonging to different species living close together

• An **ecological niche** is the sum of an organism’s use of biotic and abiotic resources

• Inter-specific Interactions
  • **Without** competition
  • **With competition** for a limited shared resource when the niches of two different populations overlap
Community structure is affected by Inter-specific Interactions

1. Competition
2. Mutualism
3. Predation
4. Herbivory
5. Parasitism


• **Competition** happens when the niches of two different populations overlap
  
  o Squirrels and black bears competing for acorns

• **Mutualism** benefits both partners
  
  o Coral reef built by corals and photosynthetic protists
Predation benefits the predator but kills the prey. Prey adapts using protective strategies:

- Camouflage
- Mechanical defenses
- Chemical defenses
• **Herbivory:**
  – the consumption of plant tissues by herbivores
  – leads to diverse defensive adaptations in plants

Herbivory and Plant Defenses

• Herbivores and plants undergo coevolution
  – A change in one species acts as a new selective force on the other
Parasites and pathogens live on or in a host from which they obtain nourishment
- Internal (nematodes and tapeworms)
- External parasites (mosquitoes and ticks)

Pathogens are disease-causing parasites
- Pathogens can be bacteria, viruses, fungi, or protists
<table>
<thead>
<tr>
<th>Interspecific Interaction</th>
<th>Effect on Species 1</th>
<th>Effect on Species 2</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>−</td>
<td>−</td>
<td>Squirrels/black bears</td>
</tr>
<tr>
<td>Mutualism</td>
<td>+</td>
<td>+</td>
<td>Hippo/microbes in hippo stomach</td>
</tr>
<tr>
<td>Predation</td>
<td>+</td>
<td>−</td>
<td>Crocodile/fish</td>
</tr>
<tr>
<td>Herbivory</td>
<td>+</td>
<td>−</td>
<td>Hippo/grasses</td>
</tr>
<tr>
<td>Parasites and pathogens</td>
<td>+</td>
<td>−</td>
<td>Heartworm/dog; Salmonella/humans</td>
</tr>
</tbody>
</table>
Trophic structure

- A pattern of **feeding relationships** consisting of several different levels
- A key factor in community dynamics
- **Food chain** is a sequence of food transfer up the trophic levels
• **Producers*/autotrophs
  Photosynthetic; support all other trophic levels
  – Plants on land
  – Cyanobacteria and algae in water

• **Consumers*/Heterotrophs
  – Primary consumers
  – Secondary consumers
  – Tertiary consumers
  – Quaternary consumers

• **Detritivores and decomposers**
  Derive energy from dead matter and wastes
A terrestrial food chain

Plant

Producers

Phytoplankton

Primary consumers

Grasshopper

Secondary consumers

Mouse

Tertiary consumers

Snake

Quaternary consumers

Hawk

Killer whale

Tuna

Herring

Zooplankton

An aquatic food chain

Phytoplankton

Primary consumers

Zooplankton

Secondary consumers

Herring

Tertiary consumers

Snake

Quaternary consumers

Hawk
A Food web is a network of interconnecting food chains.
Biological Magnification: PCB’s

“PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don’t burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.”

a) https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=140&tid=26

b) "Polychlorinated biphenyl structure" by D.328 07:28, 13 August 2006 (UTC) - drawn by D.328. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Polychlorinated_biphenyl_structure.svg#/media/File:Polychlorinated_biphenyl_structure.svg
- Pollutants in a food chain can lead to biological magnification

- DDT bioaccumulation and Biomagnification

- Concentration of PCBs
  - Herring gull eggs 124 ppm
  - Lake trout 4.83 ppm
  - Smelt 1.04 ppm
  - Zooplankton 0.123 ppm
  - Phytoplankton 0.025 ppm

[Link to video](https://www.youtube.com/watch?v=J9i6a_NRahg)
Energy flows and chemicals are recycled in the ecosystem through the living communities and the abiotic environment.

A terrarium as an ecosystem
Energy budget of ecosystems

Primary production

– The amount of solar energy converted to chemical energy by producers generating **biomass** (the amount of living organic material)
• Primary production of biomass of different ecosystems
• Energy supply limits the length of food chains
• A pyramid of production shows the cumulative loss of energy transfer in a food chain

1,000,000 kcal of sunlight

10,000 kcal

1,000 kcal

100 kcal

10 kcal

Producers

Primary consumers

Secondary consumers

Tertiary consumers
• The dynamics of energy flow apply to the human population “meat is a luxury for humans”
The Hierarchical Structural Organization of Life

Chemical cycling between organic matter and abiotic reservoirs
Chemical cycling between organic matter and abiotic reservoirs

- Life also depends on the recycling of chemicals
- **Biogeochemical cycles** between organisms and the Earth, can be local or global
- Decomposers play a central role in biogeochemical cycles
The Carbon Cycle

- Depends on photosynthesis and respiration
- Carbon is the major ingredient of all organic molecules
- The return of CO$_2$ to the atmosphere by respiration closely balances its removal by photosynthesis
- The carbon cycle is affected by burning wood and fossil fuels
Photosynthesis

Decomposers (soil microbes)

Cellular respiration

CO₂ in atmosphere

Primary consumers

Higher-level consumers

Plants, algae, cyanobacteria

Detritus

Wastes; death

Wood and fossil fuels

Burning

Decomposition

Plant litter; death
The Nitrogen Cycle

• Depends on bacteria
• Nitrogen is an essential component of proteins and nucleic acids
• Nitrogen has two abiotic reservoirs: air & soil
• **Nitrogen fixation** converts $N_2$ to nitrogen used by plants
  – carried out by some bacteria and cyanobacteria
Nitrogen (N₂) in atmosphere

Plant

Assimilation by plants

Organic compounds

Organic compounds

Death; wastes

Animal

Denitrifiers

Nitrates in soil (NO₃⁻)

Nitrifying bacteria

Nitrogen-fixing bacteria in root nodules

Free-living nitrogen-fixing bacteria and cyanobacteria

Ammonium (NH₄⁺) in soil

Decomposers

Detritus

Decomposition

Nitrogen fixation

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The Phosphorus Cycle

- Depends on the weathering of rock
- Organisms require phosphorus for nucleic acids, phospholipids, and ATP
  - Plants absorb phosphate ions in the soil and build them into organic compounds
  - Phosphates are returned to the soil by decomposers
  - Phosphate levels in aquatic ecosystems are typically low enough to be a limiting factor