Agenda

• 1:30 – 2:50:
  – Lecture Slides: Energy and Nutrient flow in Ecosystems
  – Activities 1, 2 and 3 during slide presentation
    • No handout
    • Write out the questions along with the answers
    • Handwriting must be legible

• 2:50 – 3:20: Activity 4
  – Mid-term Presentation Meeting 1: Choose one Aquatic System or Biome
  – Due from each team: Presentation Topic, Team and member names
  – Due from each student:
    1. Preliminary List of sub-topics
    2. Sources
    3. Half page write up on sub-topics
Ecosystems – Function

Energy & Nutrient Flow in Ecosystems
Ecosystems Structure
Ecological Hierarchy

• How is an ecosystem sustained?

• How do individual organisms survive and thrive within the limits set by the Fundamental Biological Principle?

• They need Nutrients and Energy
Matter and Energy

**Matter:** All substances made up of elements (atoms) and compounds (molecules)

**Energy:** The capacity to do work

- Potential (stored)
- Kinetic (from movement)

Matter and Energy obey **UNIVERSAL LAWS**

- The Law of Conservation of Matter (see A)

(The First and Second Laws of Thermodynamics) (see B & C)

- The Law of Conservation of Energy
- The Law of Increasing Entropy
Law of Increasing Entropy

The Total Entropy of a system and its surroundings can never decrease over time

Entropy:
1. It represents how uniformly energy is distributed in the system.
2. The more uniform it is, higher the entropy.

- A system can work only if energy is non-uniformly distributed within it.
- Doing work means conversion of any form of energy to kinetic energy.
  - During this process, some of the energy is lost to the surroundings where it gets evenly distributed – Irretrievable, heat loss!

Consequence:
1. Energy cannot be converted with 100% efficiency
2. Energy must be supplied continuously for a system to do work
Scientific Fact:

The Matter Conservation Law
The First and Second Laws of Thermodynamics

Govern all the Earth’s Systems and their interactions
  • Including the Biosphere
  • At all levels of the Ecological Hierarchy

Q: Where is the energy source and how is matter used?
Life on Earth Sustained by...

Energy from Sun

Absorbed energy used to power / sustain Earth’s systems through geological, biological, bio-geo-logical processes, and ...

Cycling of Nutrients

Earth is a “Closed System” for matter
No new matter entering or leaving

Reflected back to space by
- Atmosphere
- Snow and icy surfaces

Nutrients
Chemical Matter used in BioGeological Processes
How do Matter (nutrients) and Energy Flow in Ecosystems?
Life sustained by
One way flow of Energy from the Sun
Cycling of Nutrients (Chemical Matter)

- How do Energy and Nutrients enter the Ecosystem?
- How do they move through the Ecosystem?
- How are those first chemicals that store energy formed?
Producers: Energy and Nutrients

Photosynthesis: A Chemical reaction that occurs in Producers
Uses solar radiation and abiotic resources to make Glucose

\[
6 \text{ CO}_2 + 6 \text{ H}_2\text{O} \quad \text{Input } \Delta E \text{ (Solar Radiation)} \quad \rightarrow \quad \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2
\]

Glucose
\[
\text{C}_6\text{H}_{12}\text{O}_6
\]

Chemical Energy (Carbohydrate)

Producers:
Organisms that contain chlorophyll (causes green color)
E.g. Phytoplankton, Algae, Plants

Photosynthesis

Carbon dioxide
6 CO₂
Water
6 H₂O

Oxygen
6O₂

Oxygen
Atmosphere
Photosynthesis Questions:

1. Where is the energy for photosynthesis coming from?
2. Write and label the chemical reaction for photosynthesis.
   \[
   6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{Solar Energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2
   \]
3. Where does it occur?
4. Is life sustainable? Why?
5. Why is it important to you? List at least 3 reasons...

"Using sunlight to make carbohydrates"
Photosynthesis Questions:

1. Where is the energy coming from?  **The SUN**

2. Write and label the chemical reaction for photosynthesis.

   \[6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{Solar Energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2\]

3. Where does it occur? **In green life forms such as plants, algae, phytoplankton**

4. Is life sustainable? **Yes! The sun shines! Matter is cycled! It’s been around for 3.5 BillionYrs.**

5. Why is it important to you? List at least 3 reasons...

"Using sunlight to make carbohydrates"
Here are some ways plants benefit us!

• Produce oxygen
• Take up carbon dioxide
• Convert radiant energy into chemical energy
  ➢ Produce food (carbohydrates)
• Aesthetics!
  ➢ Shade
  ➢ Gives us beauty!
Consumers: Energy and Nutrients

Cell Respiration: Chemical Reaction that depends on producers for nutrients
Releases Energy that sustains consumers

\[
6 \text{ O}_2 + \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{Energy}
\]

Growth increases Body Mass of prey animals, a type of Potential Energy available for predators

Digestion produces Glucose (\(\text{C}_6\text{H}_{12}\text{O}_6\))
Food Chain

- **Sequence of organisms** in the flow of energy and nutrients, each of which is a source of nutrients for the organism that *consumes* it

- **Trophic levels**
- **Trophic categories**
- **“Troph” = “nutrition”**

- **Producers (auto-trophs)**
- **Consumers (hetero-trophs)**
- **Primary Consumers (prey)**
- **Secondary and above (predators)**
Food Web

• Most prey species have multiple predators, and many predators have multiple prey species, leading to a web!

• A web is a complex network of many interconnected food chains
Sustainability and Trophic Categories

**Consumers (heterotrophs)**
- Herbivores, carnivores, omnivores
- Animals, zooplankton, some bacteria, some protists, fungi

**Producers (autotrophs)**
- Plants, phytoplankton, some bacteria and protists

**Detritivores (heterotrophs)**
- Eats detritus (dead biotic material – dead plant matter, fecal wastes of animals & dead animals)
- Animals, birds, insects, worms, fungi, bacteria

**Decomposers (heterotrophs)**
- Break down detritus - Secrete enzymes that “decays” or “rots” detritus
- Fungi, bacteria
Activity 2: Food Web

1. Write down at least 2 food chains in the terrestrial ecosystem
2. Write down at least 2 food chains in the aquatic ecosystem
3. Identify and write down the longest food chain in the aquatic ecosystem
How many trophic levels do you see? 3 – 4

How many trophic levels do you see? 5 – 6

Arrow points to the direction of flow of nutrients and energy

Predator

Prey
Intake Energy of Elk

Energy in all the grass Elk eats

Why so few Trophic Levels?

The remaining energy stored in the body mass, aka BIOMASS, available to the Next Trophic Level

Food

Cell respiration

\[ \text{Glucose: } 6 \text{ C}_6\text{H}_12\text{O}_6 \]

Energy

\[ 6 \text{ O}_2 + 6 \text{ C}_6\text{H}_12\text{O}_6 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} \]

Used for growth, maintenance repair, lost as heat

Released as waste

Undigested

Passes through

Minus energy used for maintenance, repair, heat loss

The remaining energy stored in the body mass, aka BIOMASS, available to the Next Trophic Level
Biomass Distribution

Trophic Categories

Prosducers

Plants

Lot of Biomass at the Producer level

Primary Consumers

Herbivores/Prey

Secondary Consumers

Carnivores/Predators

Much less biomass at the Secondary and higher Consumer levels
How much Biomass is Transferred between Trophic Levels?  $\frac{1}{10}$

<table>
<thead>
<tr>
<th>Trophic Level</th>
<th>Biomass Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third level</td>
<td>Total combined mass of tertiary consumers = Biomass of third level consumers</td>
</tr>
<tr>
<td>Second level</td>
<td>Total combined mass of all secondary consumers = Biomass of second level consumers</td>
</tr>
<tr>
<td>First level</td>
<td>Total combined mass of all primary consumers = Biomass of first level consumer</td>
</tr>
<tr>
<td>Producer</td>
<td>Total combined mass of all producers = Biomass of producers</td>
</tr>
</tbody>
</table>
Activity 3: Biomass Distribution

1. Scientists say that eating like a vegetarian is the most ecologically sustainable way to feed ourselves. Explain why that might be.
Trophic Cascade

How Wolves Change Rivers
Activity 4

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  – Choose one Aquatic or Terrestrial Biome

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