3 Nutritional Patterns in Biosphere

- The production of food in an ecosystem begins with autotrophic organisms **(producers)**, followed by heterotrophic organisms (**consumers and decomposers**.

FIRST : AUTOTROPHIC ORGANISMS

Autotrophic organisms

Living organisms that produce their own food as they are capable of converting inorganic substances into energy-stored organic compounds, such as green plants and algae, as well as some specialized bacteria.

- Plants use light energy, carbon dioxide, and water to synthesize sugars and organic food through photosynthesis, as illustrated in the following equation:

$$6CO_2 + 12H_2O \xrightarrow[\text{Chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Note

Producers form the **base of the energy pyramid** GR ? Because all the energy available to the higher trophic levels originates primarily from their conversion of light energy into usable chemical energy.

SECOND : HETEROTROPHIC ORGANISMS

Heterotrophic organisms

Living organisms that can't produce their own food and instead obtain energy by consuming producers or other consumers.

▶ **Consumers can be classified into trophic levels according to their food source:**

1 ▶▶ **Primary consumers (herbivores):**

- Feed directly on plants.

2 ▶▶ **Secondary consumers.**

- Feed on herbivores and may extend to higher-level predators.

Examples of Trophic Levels

EX.1 **In river ecosystems:** microscopic algae (producers) feed small fish (primary consumers), which in turn feed larger predatory fish (secondary or tertiary consumers).

EX.2 **In terrestrial ecosystems:** trees and plants form the base of the food chain and are consumed by rabbits and gazelles, which are then preyed upon by wolves or eagles as higher-level consumers.

THIRD : DECOMPOSERS

- Decomposers as **Bacteria** and **Fungi** play a fundamental role in recycling matter within the ecosystem.
- Decomposers decompose the remains of dead plants and animals, converting them into **simple mineral elements** that return to soil and water.
- **In the absence of decomposers**, organic matter and dead organisms would accumulate, and the cycling of nutrients would cease, negatively affecting all levels of ecological organization.

Note

Any food chain start with a producer ,then the consumers and ends with a decomposer

Illustrative example **In Nile Delta and Associated Lakes**

Algea and Phytoplankton
Producers

Zooplankton
Primary consumers

Small Fish
Secondary consumers

Predetory fish and Water Birds
Top-level consumers

Note : During the energy transfer from a trophic level to another level, a large amount of energy is lost.

Think With Mr. Meligy

1) Which of the following types of organisms can exist at more than one level in a food chain?

a) Autotrophs **b) Herbivores** **c) Carnivores** **d) Decomposers**

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2) All of the following living organisms are autotrophs except ……

a) Green plants **b) Algae** **c) Phytoplankton** **d) Fungi**

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3) Which organism in the food chain represents a primary consumer?

a) Grasshopper **b) Frog** **c) Snake** **d) Eagle**

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4) In the process of photosynthesis, green plants use ……

a) Carbon dioxide and water to produce energy

b) Oxygen and water to produce energy

c) Energy to produce carbon dioxide and water

d) Energy to produce oxygen, water, and glucose

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5) Decomposers in food chains carry out the process of ……

a) Producing food by photosynthesis

b) Recycling nutrients back to the ecosystem

c) Absorbing light energy from the sun

d) Producing new food substances

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6) What type of organisms represents the end of any food chain?

a) Autotrophs **b) Primary consumers** **c) Secondary consumers** **d) Decomposers**

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7) Which of the following can represent primary consumers in an aquatic ecosystem?

a) Phytoplankton and algae **b) Aquatic plants and water birds**

c) Zooplankton and small fish **d) Large fish and water birds**

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8) Which of the following represents predators in a food chain?

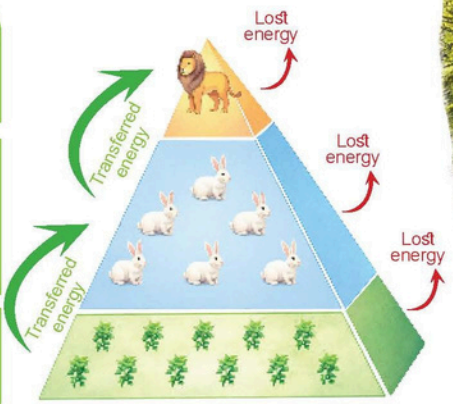
a) Primary consumers only **b) Secondary consumers only**

c) Secondary and tertiary consumers **d) Primary and secondary consumers**

Energy Flow in the Ecosystem

Direction of Energy transfer

3. When a carnivore feed on the herbivore, only 10 % of energy stored in the herbivore is transferred to it.
2. When a herbivore consumes a plant, 10% of energy stored in plant is transferred to it , a portion of this transferred energy is stored in the animal's cells and tissues and the rest is used in vital processes.
1. Plant receive light energy from Sun and convert it into chemical energy stored in food through photosynthesis process.



- **From the previous we notice that, About 90% of energy is not passed on to the next trophic level, as it is distributed through several pathways.**

The untransferred energy

1. **Energy used in vital processes:**
   Animals use part of the energy obtained from plants to carry out metabolic and life activities such as digestion, respiration, and movement which consume large amounts of energy.
2. **Energy lost as heat:**
   During metabolic activities, thermal energy is produced and released into the environment, and it is not transferred to organisms that feed on that animal.
3. **Energy stored in undigested materials:**
   Some plant components consumed by animals, such as tough fibers, are not fully digested. Consequently, part of the energy is excreted and remains stored in waste materials.

Therefore, the amount of energy transferred from one trophic level to the next **decreases progressively** as we move from producers to consumers.

Note

- The energy transferred from one level to another is equal to **10%** of the energy.
- **90%** of the energy is lost (untransffered) when moving from any level to the next level.

EX

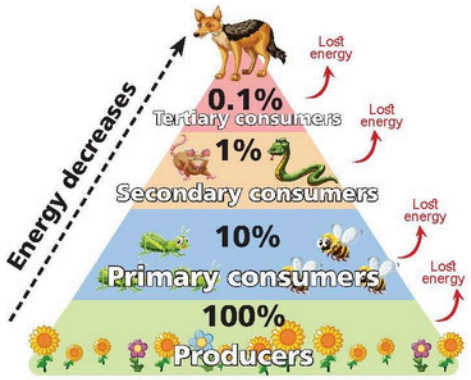
Suppose that the amount of energy stored in a given number of plants (producers) is 10,000 units ...

1. Only 1,000 units **(10%)** are transferred to the herbivores that feed on the plants **(primary consumers).**
2. Only 100 units **(10%)** are transferred to carnivores that feed on herbivores **(secondary consumers).**
3. Only 10 units **(10%)** are transferred to the predator that feeds on carnivores **(tertiary consumers).**

Ecological (trophic) Pyramids

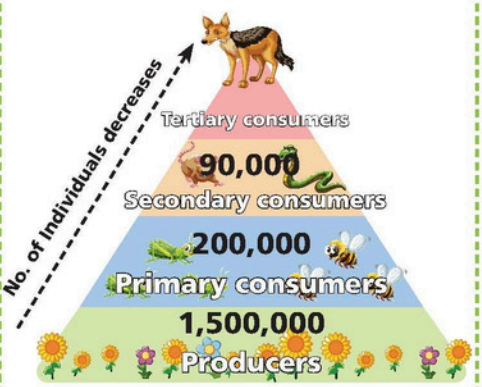
- Ecological pyramid are **graphical models** used to represent the amount of energy, the number of organisms, or the biomass at different trophic levels.

Pyramid of energy



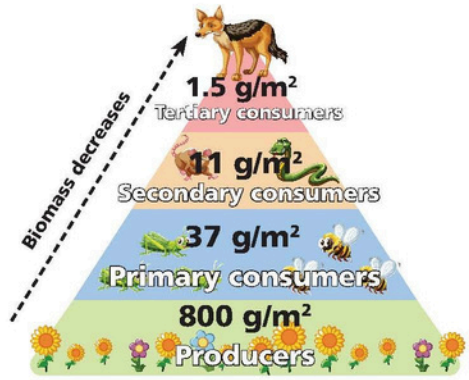
Represents flow of energy and its amount between different trophic levels

Pyramid of numbers



Represents number of organisms in each trophic levels

Pyramid of biomass



Represents the total mass of organisms at each trophic level.

Note

1) Producers form the base and the largest level of the pyramid GR, as they are the most numerous and possess the greatest amount of energy.
2) The quantity of energy, the number of organisms, or the biomass **gradually decreases** with each successive trophic level GR, as available energy decreases as we move toward the top of the pyramid.
3) Large predators are far fewer in number compared to plants and herbivores GR As the number of organisms at the highest trophic level is relatively small because the available energy can support only a limited number of individuals.

Food Webs in Deserts

- In desert regions, producers are limited GR **due to** water scarcity and extreme temperatures.
- As a result, animals adapt to use energy more efficiently, and food webs tend to be **simpler** and more **dependent on intermittent food sources**.

Note

There are also complex food webs that are composed of multiple interconnected food chains, in which consumers do not rely on a single food source but on multiple sources.

Interconnected food chains have both positive and negative impacts :

Positive Impact :
The interconnection makes the biological community more resilient to the loss of a single species.

Negative impact :
It expands the effects of environmental changes such as removal of plant cover or water pollution, , as their influence spreads throughout the entire food web.

Technological Application

Smart collars

Scientists have developed smart collars equipped with precise sensors, which are placed around the necks of wild animals in nature reserves in Kenya.

Idea of Working :

1) Sensors monitor movement rate, heart rate, and body temperature of the animal during its activities and while searching for food.
2) Sensors measure the amount of energy consumed by the animal consumes.
3) Collected data are analyzed using artificial intelligence, to determine the amount of energy lost by the animals.

Importance :
It helped save herds of the endangered Iberian lynx, after discovering that a decline in prey populations had dangerously reduced the amount of available energy for them.

Think With Mr. Meligy

9) The base of the energy pyramid is occupied by .....

a) Producers b) Primary consumers c) Secondary consumers d) Decomposers

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10) What happens to the amount of energy transferred from one trophic level to the level above it in the energy pyramid?

a) It increases b) It decreases

c) It decreases then increases d) It remains nearly constant

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11) Two food chains (S) and (Ṣ): (S) contains 4 trophic levels, while (Ṣ) contains 3 trophic levels. If the amount of energy at the last level in both is equal, which of the following can explain this?

a) The amount of energy in the producer in chain (S) is greater than in chain (Ṣ).

b) The amount of energy in the producer in chain (Ṣ) is greater than in chain (S).

c) The amount of energy in the producer is equal in both chains (S) and (Ṣ).

d) The percentage of energy transferred from one level to another differs between the two chains.

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12) What happens to the numbers of living organisms when moving from the base of the pyramid of numbers to its top?

a) Increase b) Remain constant

c) Decrease d) Differ according to the ecosystem

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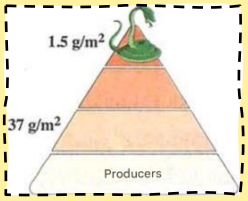
13) The adjacent figure represents a biomass pyramid in an aquatic ecosystem. Which of the following can represent the biomass of the secondary consumers?

a) 809 g b) 50 g c) 11 g d) 1 g



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14) If the amount of energy transferred to the second consumer in a food chain equals 2 J, what is the amount of energy in the producer?

a) 0.2 J b) 20 J c) 200 J d) 2000 J

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15) Suppose the amount of energy transferred from plants to a rabbit is 100 J. How much energy can reach the fox that feeds on this rabbit?

a) 10 J b) 50 J c) 90 J d) 100 J

Think With Mr. Meligy

16) The percentage of energy lost when transferring from one trophic level to the level above it in the energy pyramid equals ……

a) 1% b) 10% c) 90% d) 100%

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17) In a food chain that contains 4 trophic levels, if the amount of energy reaching the first consumer is 100 J, how much energy is lost when transferring from the producer to the third consumer?

a) 9 J b) 90 J c) 990 J d) 999 J

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18) If consumer (X) feeds on consumer (Y), which of the following represents all the energy transferred from (Y) to (X)?

a) The energy used in movement of (X)

b) The energy stored in the tissues of (X)

c) The energy used in digestion of (Y)

d) The energy stored in the tissues of (Y)

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19) Which of the following statements about food chains is incorrect?

a) Organisms in the food chain store chemical energy and lose heat energy.

b) Light energy is the source of all forms of energy in the food chain.

c) Predators benefit from the heat energy produced by the respiration of organisms at the next trophic level.

d) Nutrient elements return to the soil through decomposers.

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20) Smart collars aim to measure the following factors except ……

a) Animal movement rate

b) Pulse rate

c) Body temperature

d) Biomass