Principles of Ecology

BSc. Course 2024 – 2025

Lecture – 10

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Food Chains, Food Webs & the Laws of Matter and Energy

- **Food Chains/Webs** shows how matter and energy move from one organism to another an ecosystem.
- Each trophic level contains a certain amount of biomass (dry weight of all organic matter).

* Chemical energy stored in biomass is transferred from one trophic level to the next.

* With each trophic transfer, some usable energy is degraded and lost to the environment as low quality heat.

* Thus, only a small portion of what is eaten and digested is actually converted into an organisms' bodily material or biomass.

Food Chains, Food Webs & the Laws of Matter and Energy

- **Ecological Efficiency:**

  * The % of usable energy transferred as biomass from one trophic level to the next 10% (ranges from 5-20% in most ecosystems).

  * Thus, the more trophic levels or steps in a food chain, the greater the cumulative loss of useable energy…

- **Most energy organisms use is lost as waste heat through respiration.**

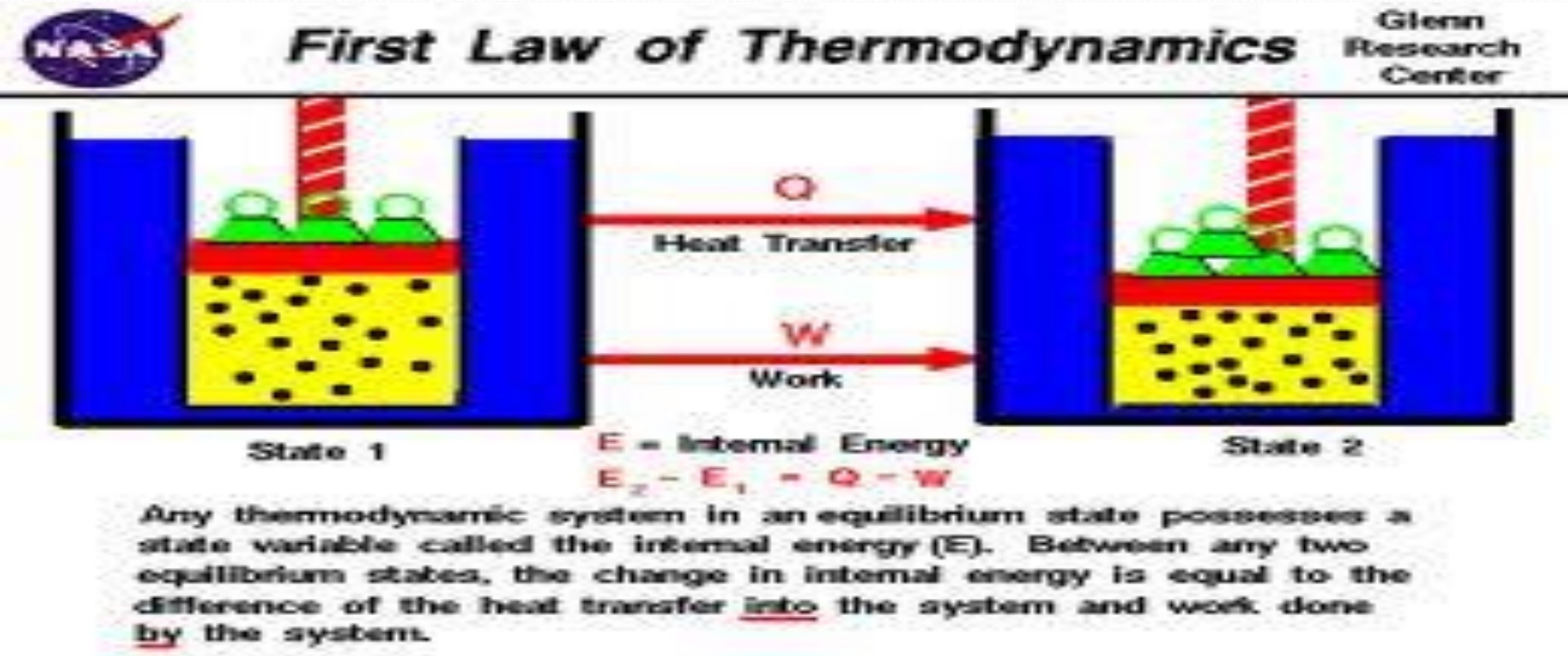
  * Less and less energy is available in each successive trophic level.

  * Each level contain only 10% of the energy or the trophic level below it.

- There are far fewer organisms at the highest trophic levels, with less energy available.

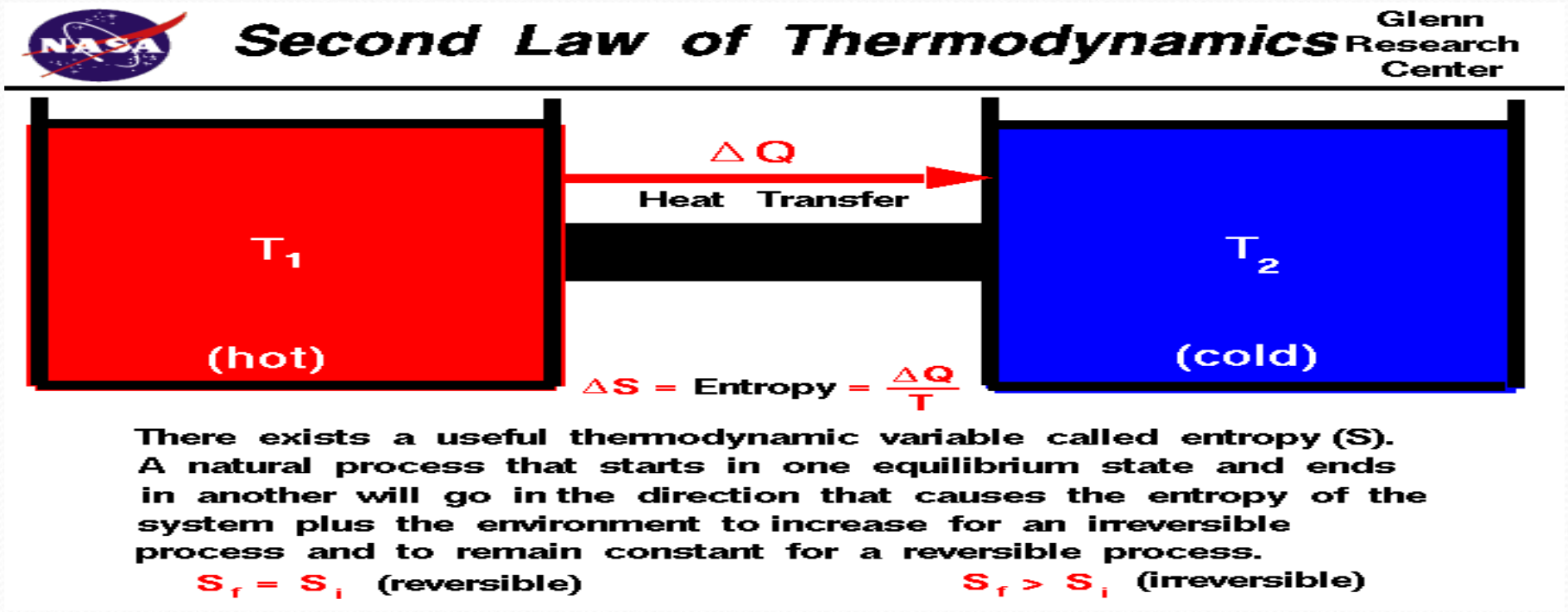
First law of Thermodynamics

- **Energy can neither be created nor destroyed, but it can be transformed from one form to another, such as the transformation of light energy into heat energy, or the transformation of heat into kinetic energy, and so on.**



Second law of Thermodynamics

- This law states that when energy is converted from one form to another, the conversion process is **not complete**.
- There is a dispersion of energy in the medium, meaning that some energy is lost in the medium by spreading in the form of lost thermal energy, so there is no 100% complete conversion.
- This disturbance in the conversion of energy is called **Entropy**, which is a measure of the amount of energy lost or not used.



The basic units for measuring energy

1- Calories Per Gram (gcal.) 15 – 16 C°

2- Calories Per Kilogram (Kcal. = 1000 cal.)

3- British Thermal Unit (B.T.U.) : BTU= 252 cal.

4- Joule, Langley, Watt.

Energy content in the bodies of living organisms

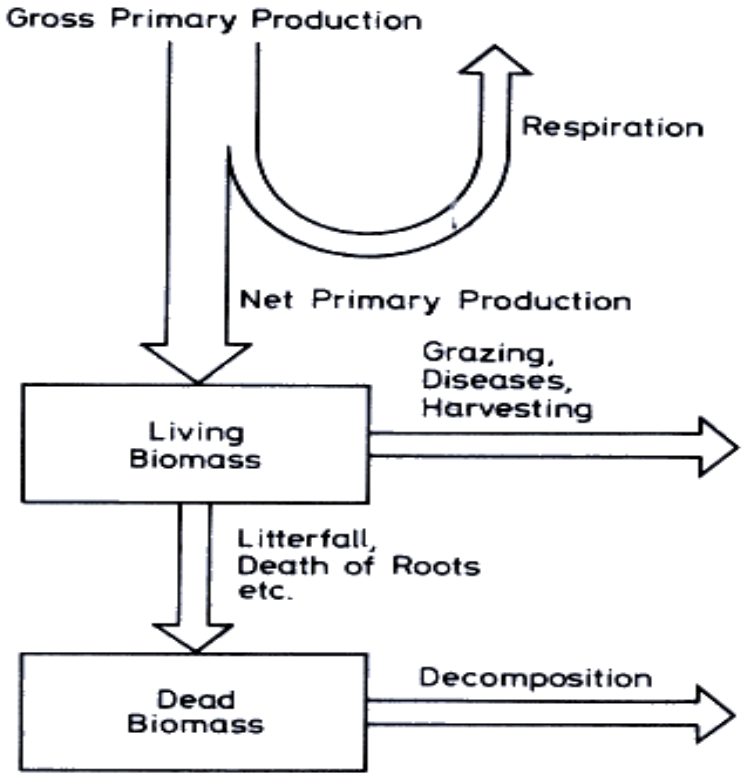
Living Organisms	Kcal. = g of dry weight	Kcal. = g of OM
Aquatic Plants	4.5	4.6
Seeds (only)	5.2	5.3
Algae	4.9	5.1
Invertebrates (except Insects)	3	5.5
Insects	5.4	5.7
vertebrates	5.6	6.3

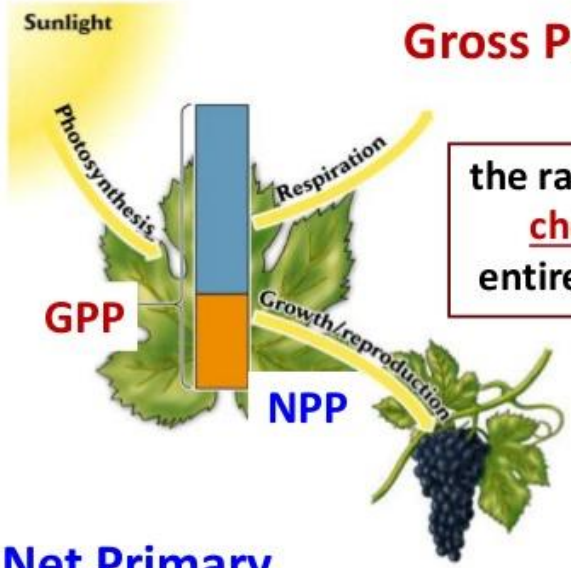
Concepts of Productivity

Photosynthesis & Chemosynthesis

1- Gross Primary Productivity (GPP)

It is the total amount of organic matter formed by the process of photosynthesis, including the energy used in the plant's respiration process.





Gross Primary Production (GPP): the rate at which plants store chemical energy and is entirely available for growth

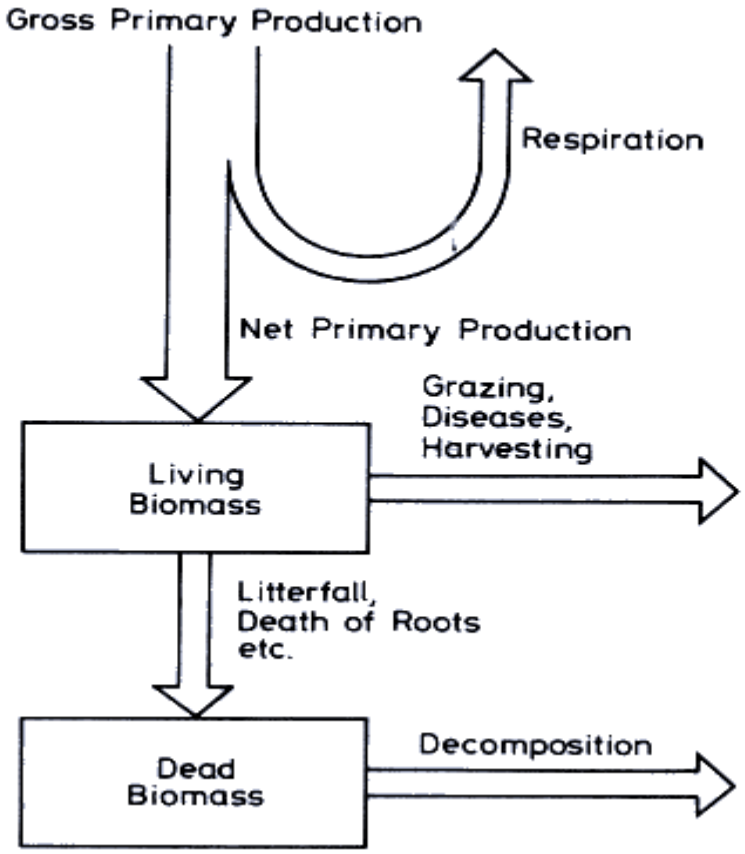
NPP = GPP - R

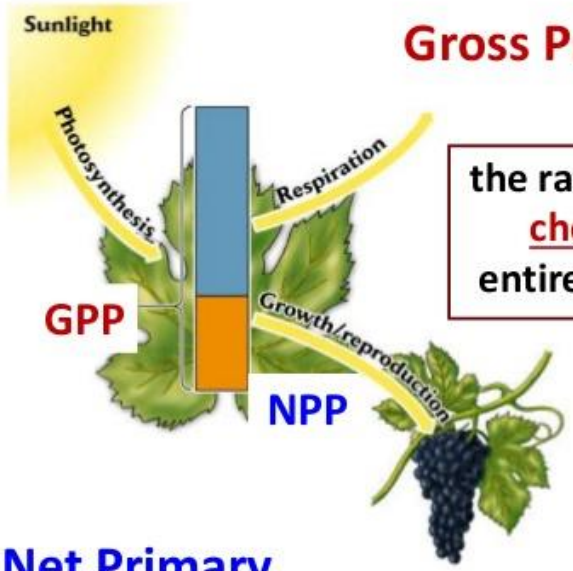
Net Primary Production (NPP): the energy potentially available to the next trophic level

Concepts of Productivity

2- Net Primary Productivity (NPP)

It is the total amount of organic matter stored in the plant after expending the necessary amount of energy for the plant's respiration.





Gross Primary Production (GPP):

the rate at which plants store chemical energy and is entirely available for growth

NPP = GPP - R

Net Primary Production (NPP): the energy potentially available to the next trophic level

Concepts of Productivity

3- Net Community Productivity (NCP)

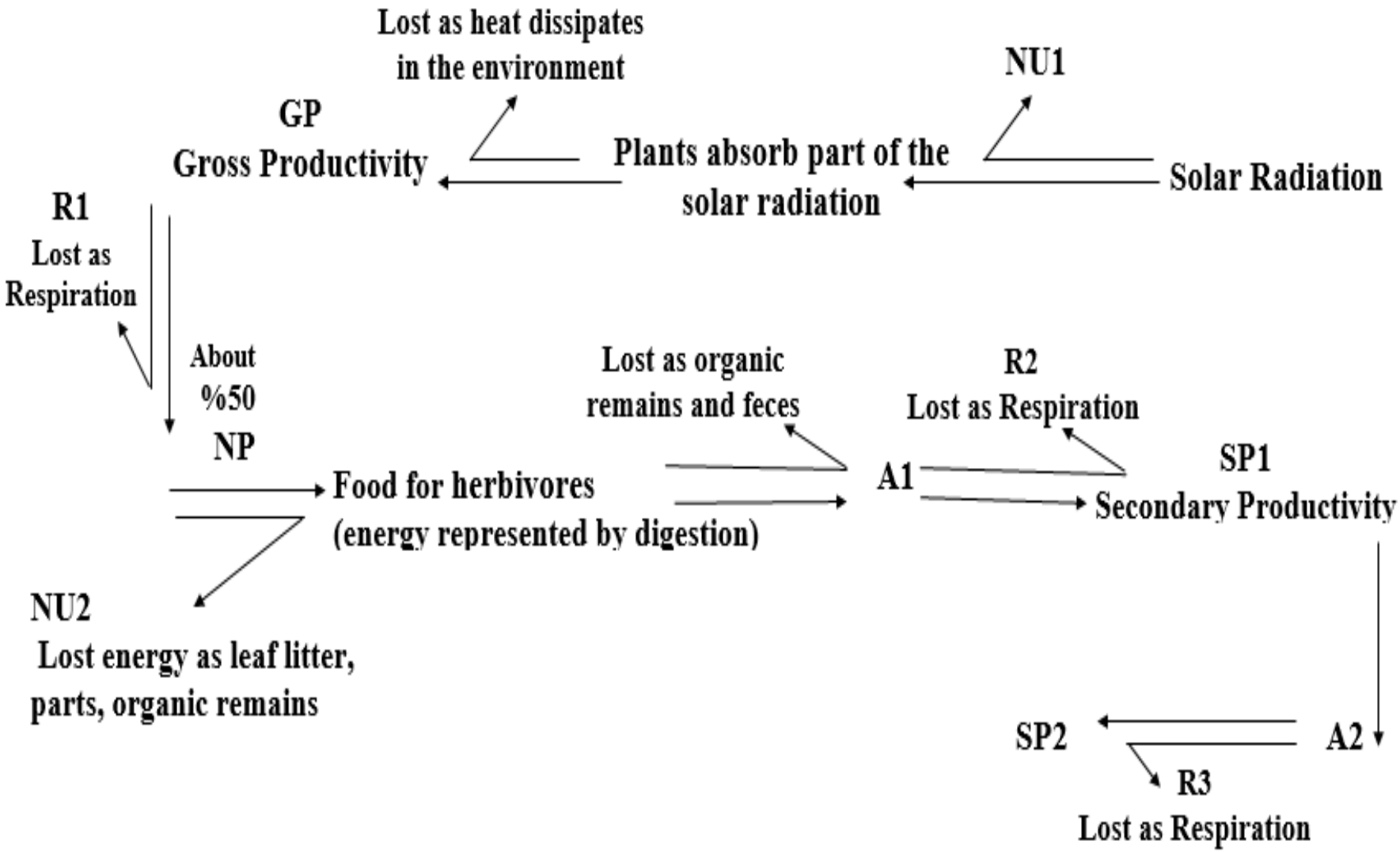
It is the total amount of organic matter stored in the plant that has not been used by heterotrophs, i.e. it is more than their needs. This amount is usually measured for a specific period.

Consumption NCP = NPP – Heterotrophs

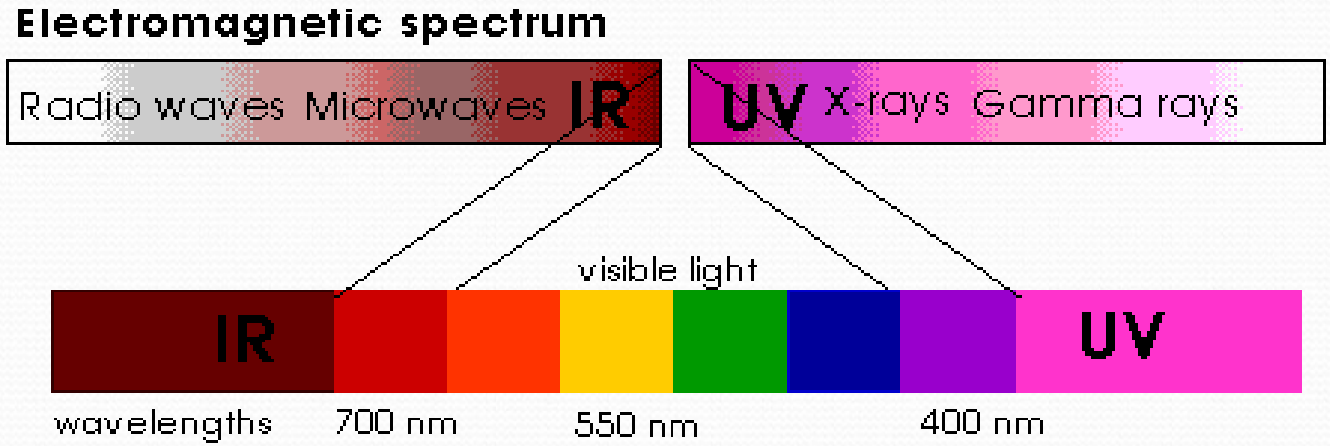
4- Secondary Productivity (SP)

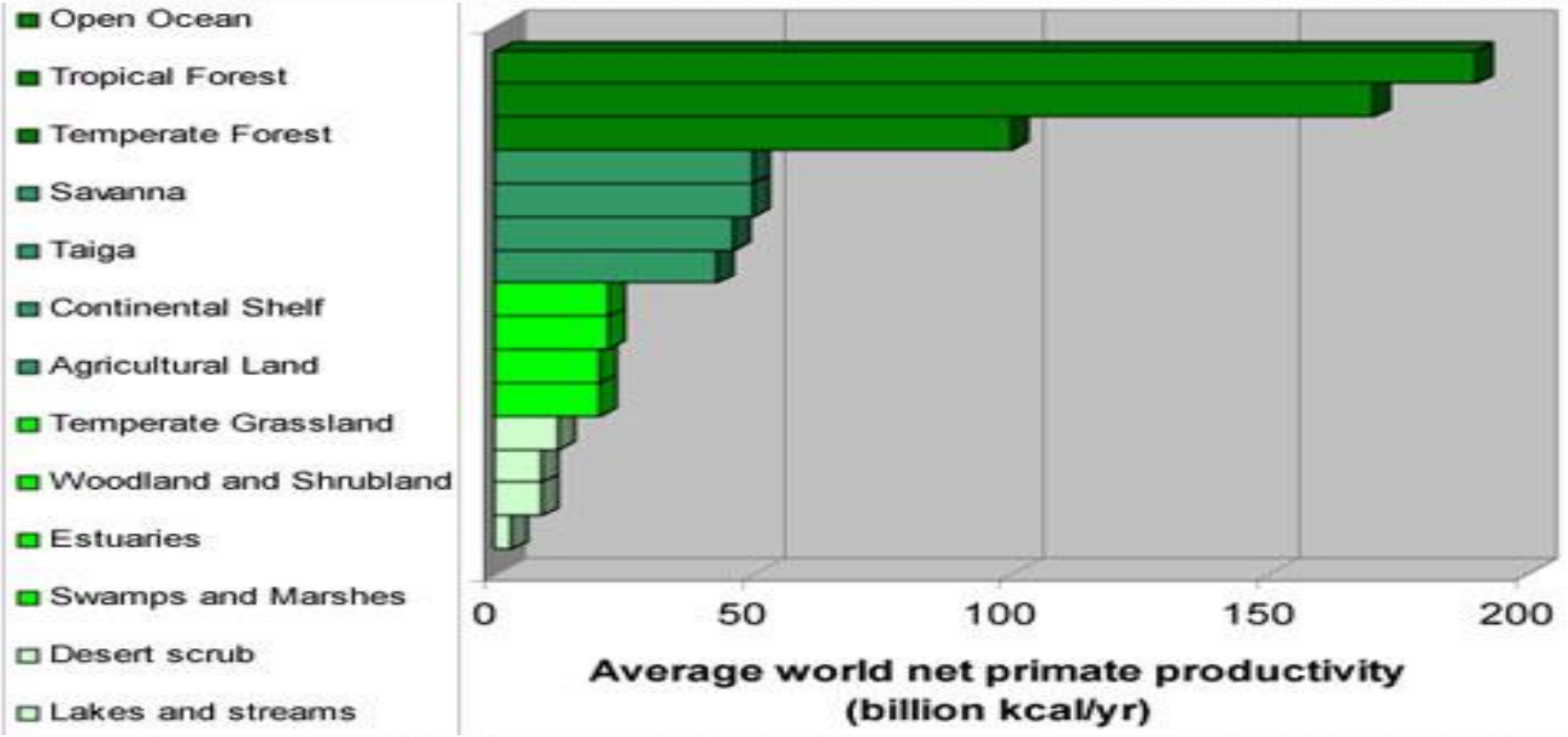
It is the total amount of organic matter stored in the bodies of consumers. In fact, animals are not true producers, and they obtain energy as a result of eating ready-made food. Therefore, the total amount of energy stored in consumers is called assimilation energy and not production.

Concepts of Productivity

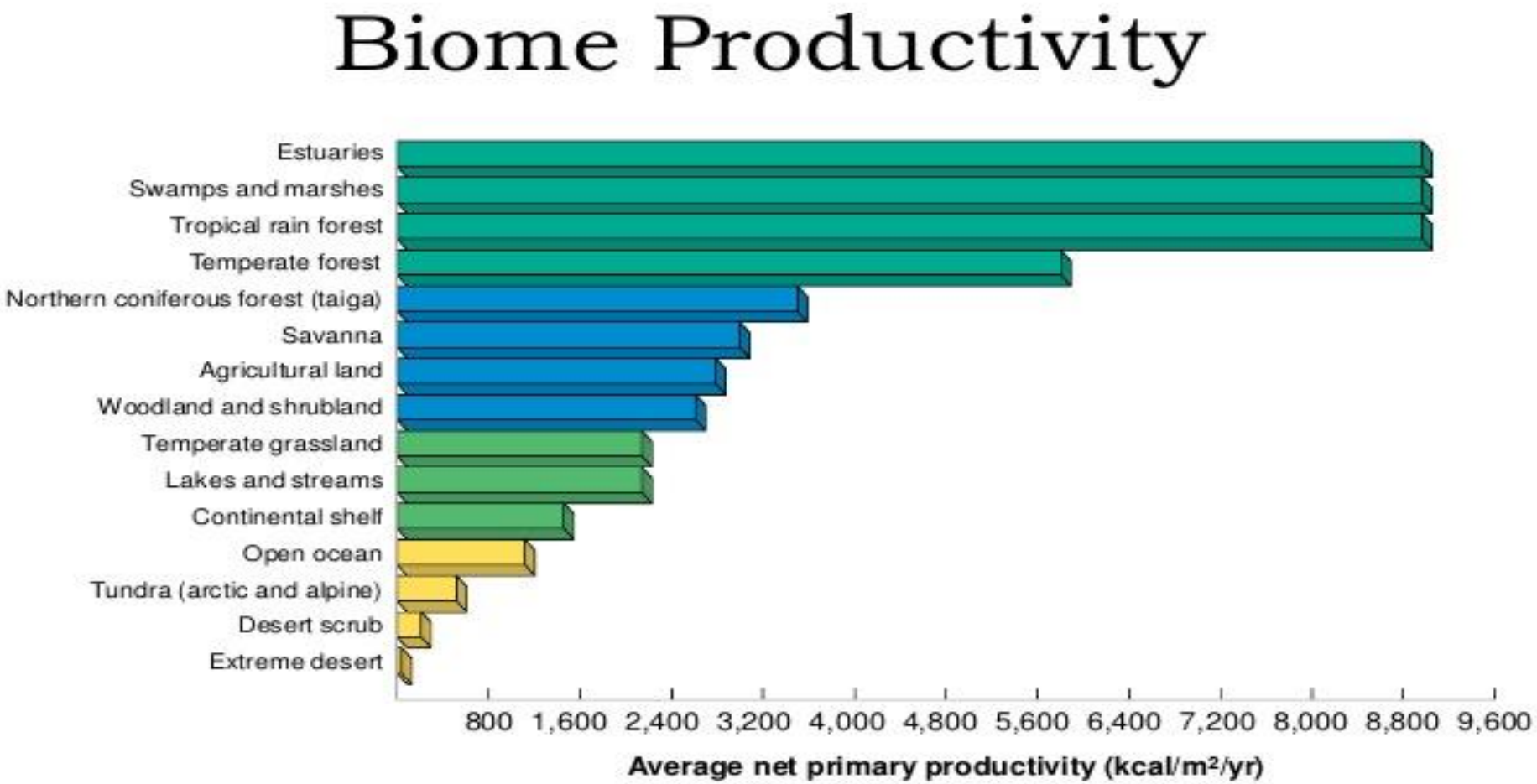


Productivity of Ecosystem





Productivity of Ecosystem



Methods of Productivity Measurement

1- The Harvest Method

2- Oxygen Measurement

3- Carbon Dioxide Method

Measuring Primary Productivity

1. **Harvest method** - measure biomass and express as biomass per unit area per unit time.

2. **CO_2 assimilation** - measure CO_2 uptake in photosynthesis and release by respiration.

3. **O_2 production** - Measure O_2 production and consumption.

Methods of Productivity Measurement

1- The Harvest Method

2- Oxygen Measurement

3- Carbon Dioxide Method

4- pH Method

Methods of Productivity Measurement

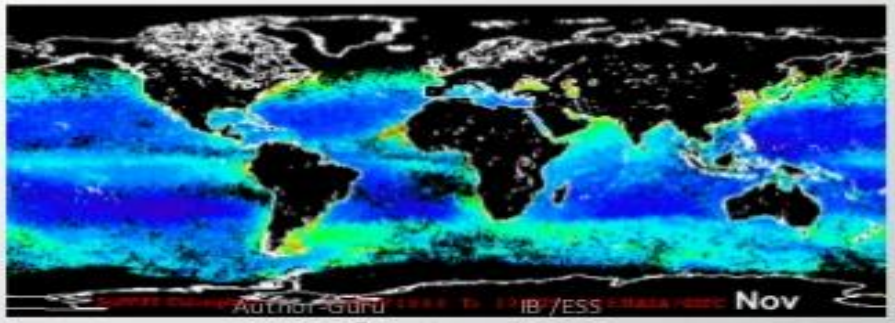
5- The Chlorophyll Method

6- Radioactive Materials (C^{14}, P^{32})

Measuring Primary Productivity

4. **Radioisotope method** - use C^{14} tracer in photosynthesis.

5. **Chlorophyll measurement** - assumes a correlation between amount of chlorophyll and rate of photosynthesis.



Food chains, Food webs and Trophic levels

Types of food webs

Two Types of Food Chain:

1. grazing food chains

grass → rabbit → fox → eagle

2. detritus food chains

leaf litter → earthworm → blackbird

dead animal → blowfly maggots → frog

(detritus → detritivore → carnivore)

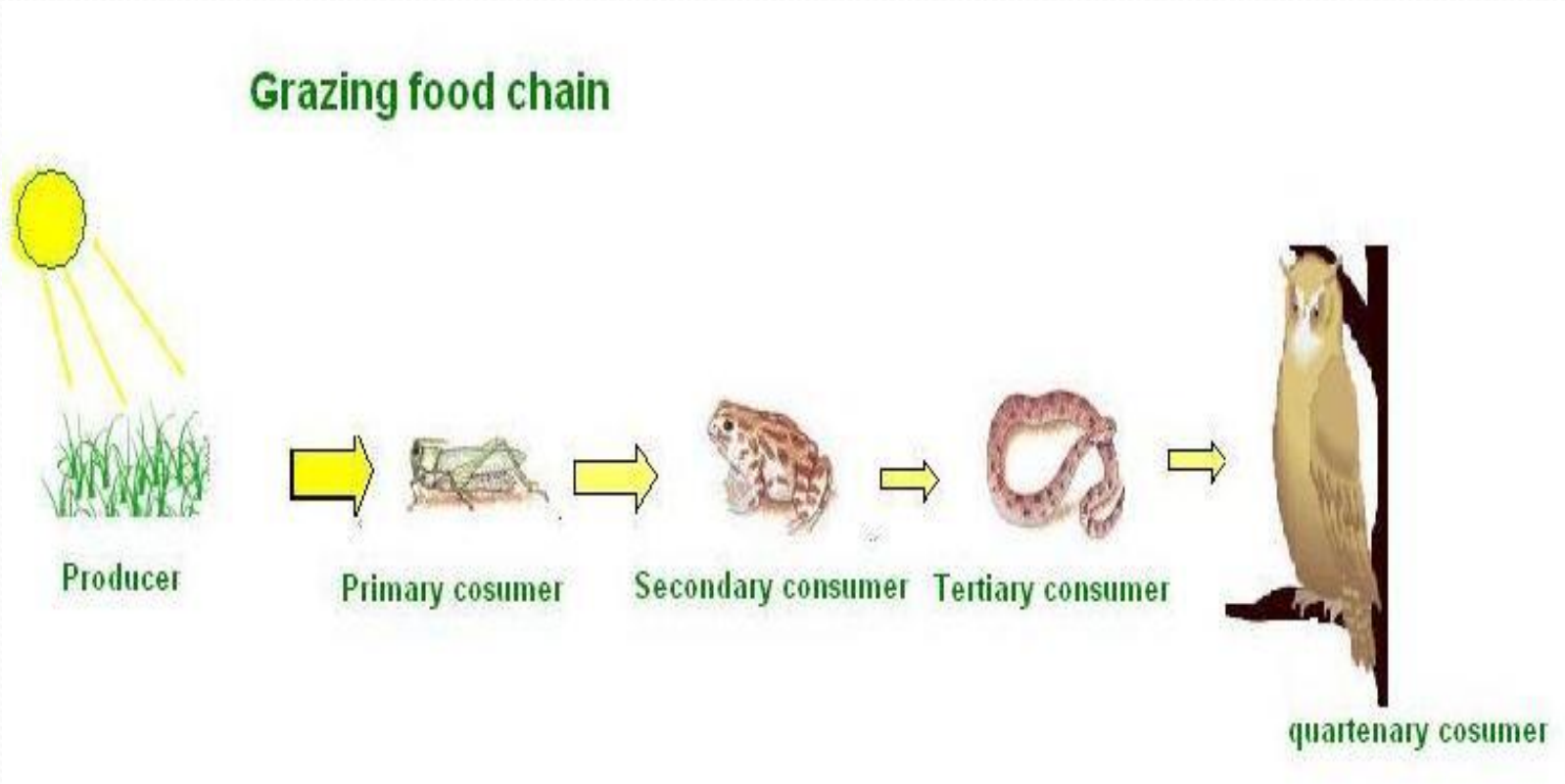
blowfly maggot

Food chains, Food webs and Trophic levels

Types of food webs

1. Grazing food chain

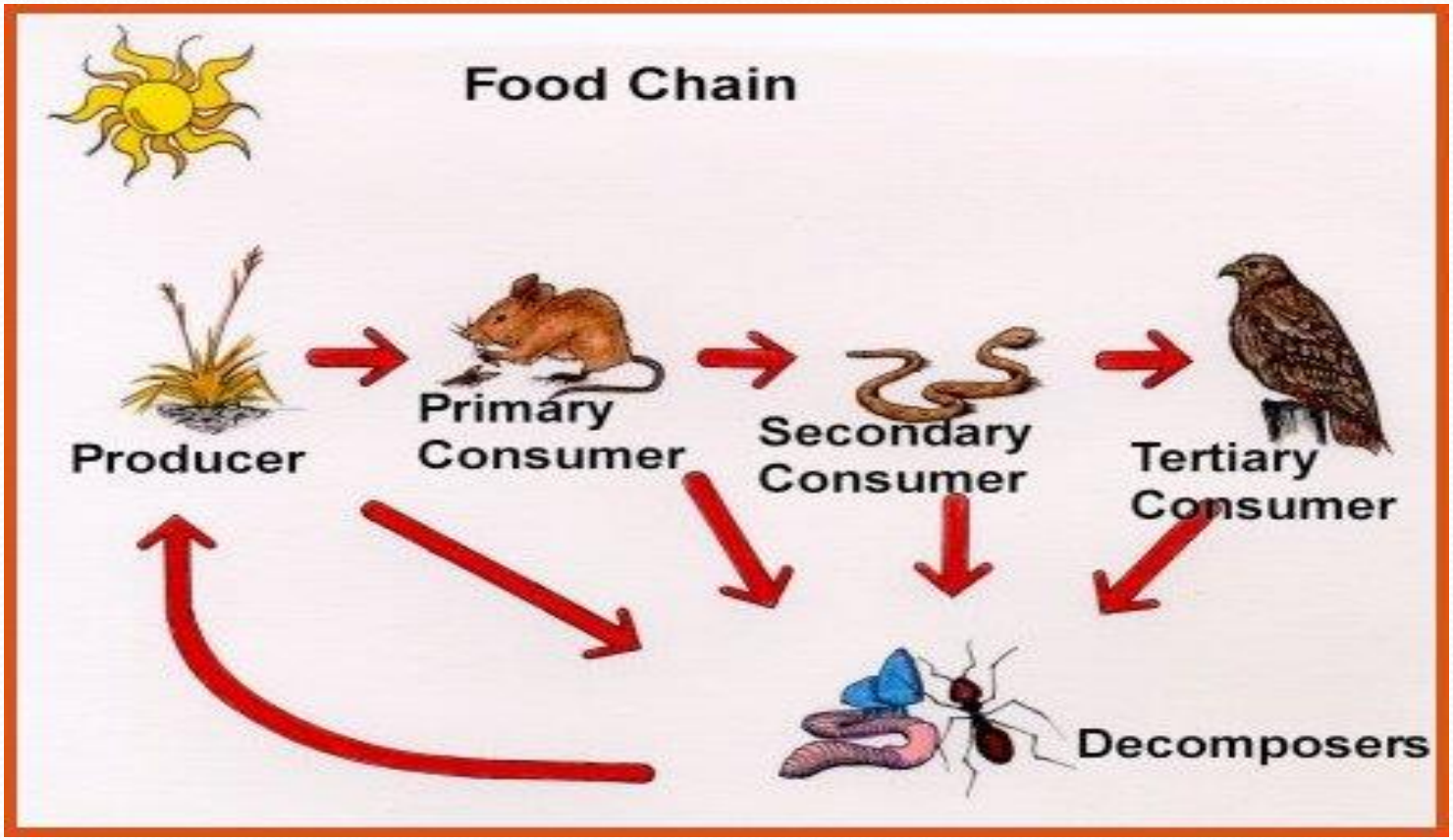
Plants → Herbivores → Carnivores



Food chains, Food webs and Trophic levels

Types of food webs

2. Detritus food chain

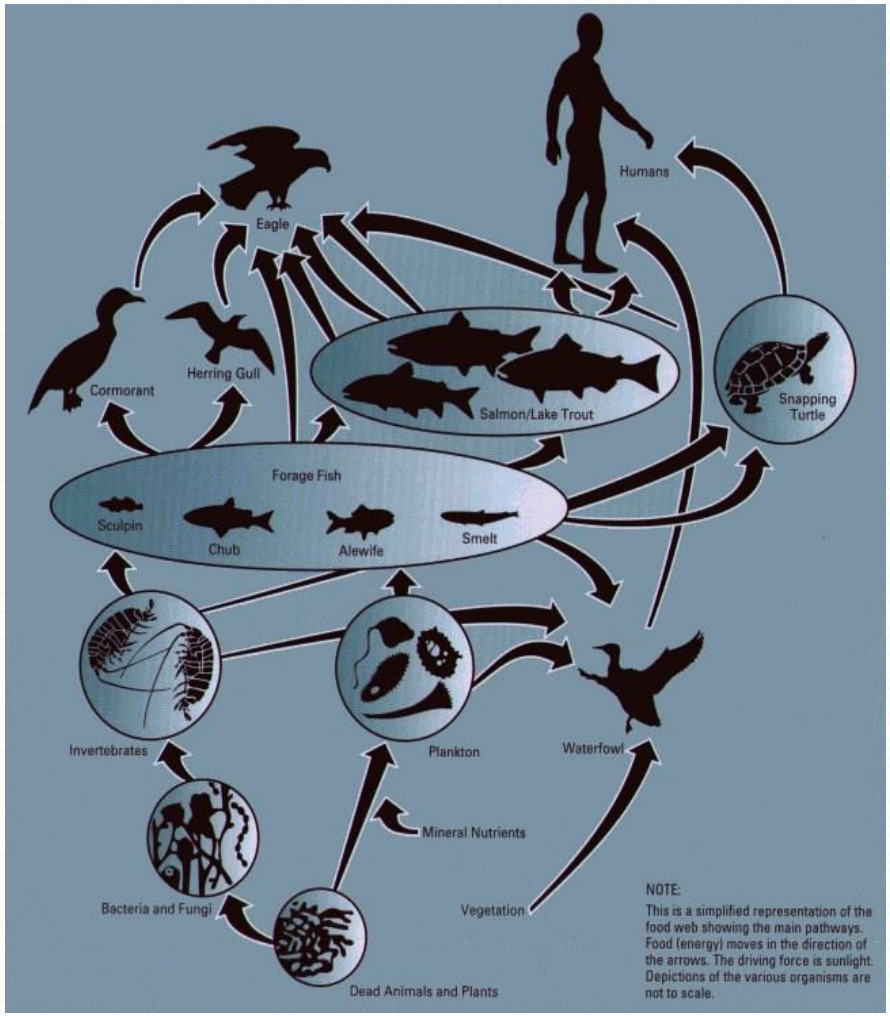


Food chains, Food webs and Trophic levels

1- long food chain

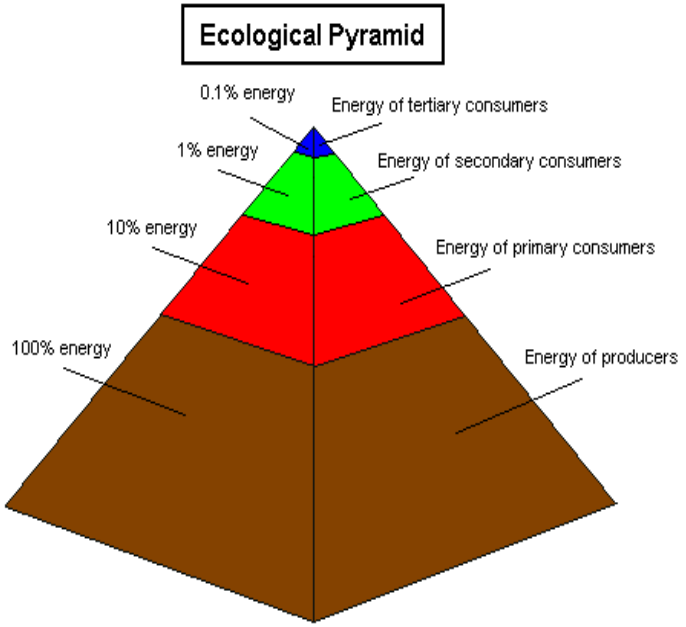
2- Short food chain

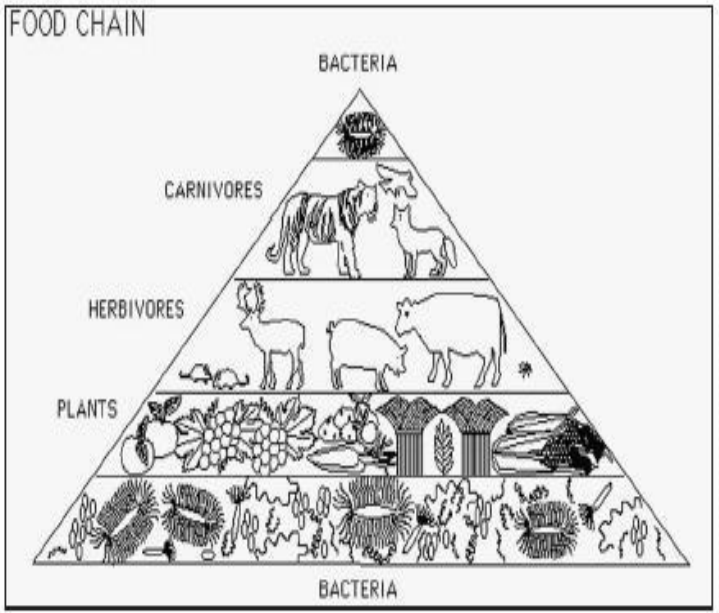
3- Very short food chain



Trophic structure and Ecological Pyramids

- Communities have clear nutritional structures as a result of the **Energy Flow** through them, the formation of **Biomass**, and the loss of energy at each step.
- The nutritional structure can be expressed or described as the amount of **Biomass** per unit area per unit time (**calories/unit area/unit time**).
- The nutritional structure can be expressed in the form of a diagram called the **Ecological Pyramid** in which the producing levels are the base of the pyramid, and the rest of the levels are the other layers of the pyramid up to the **apex**.



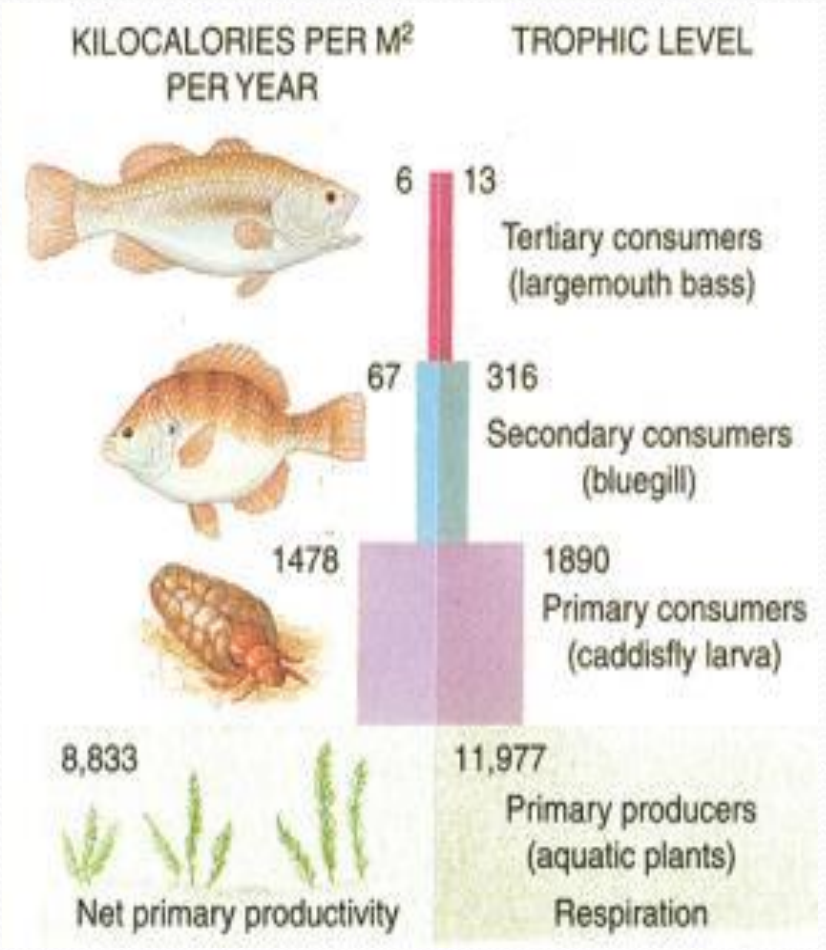


Trophic structure and Ecological Pyramids

Three types of Ecological Pyramids:

1. Pyramid of Numbers

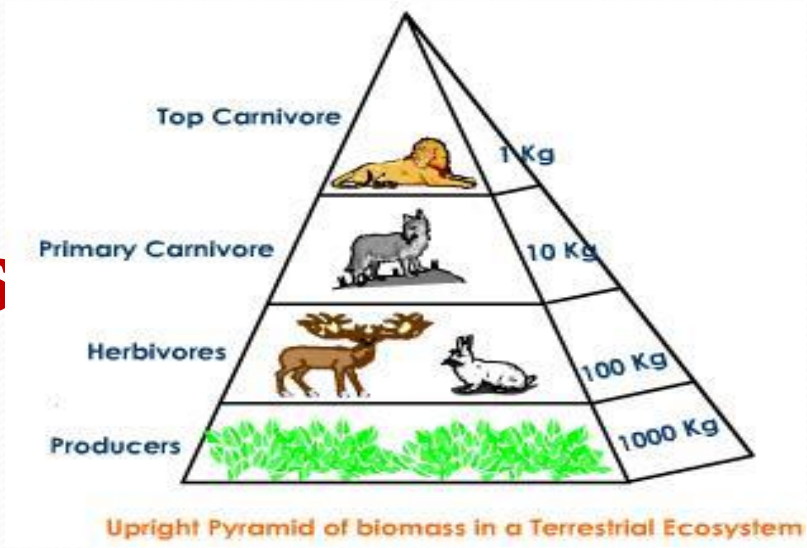
- **The number of each type of living organisms present in the community is used to build the pyramid.**



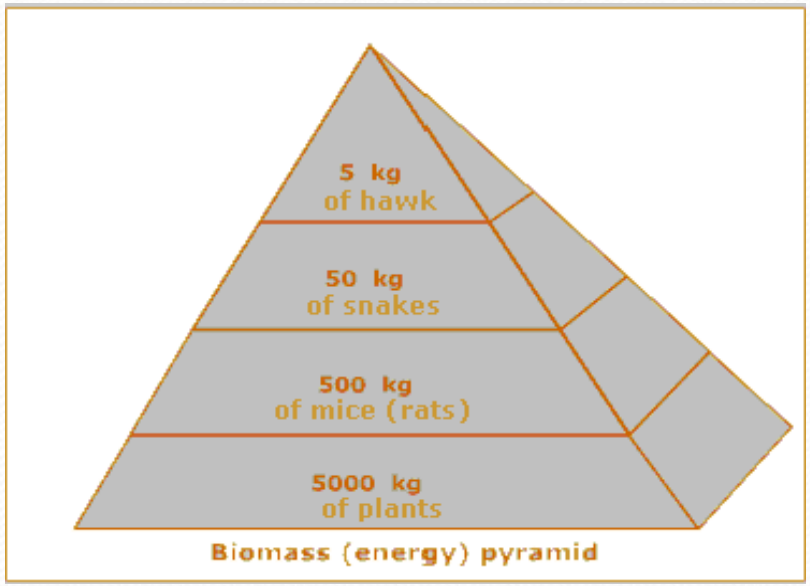
Trophic structure and Ecological Pyramids

2. Pyramid of Biomass

- **This type of pyramid depends on the total dry weight of living organisms in building the pyramid.**

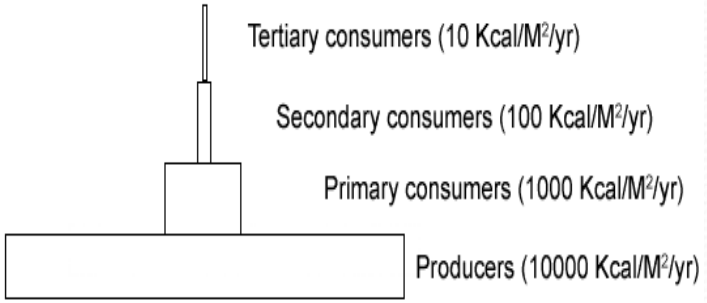


Upright Pyramid of biomass in a Terrestrial Ecosystem



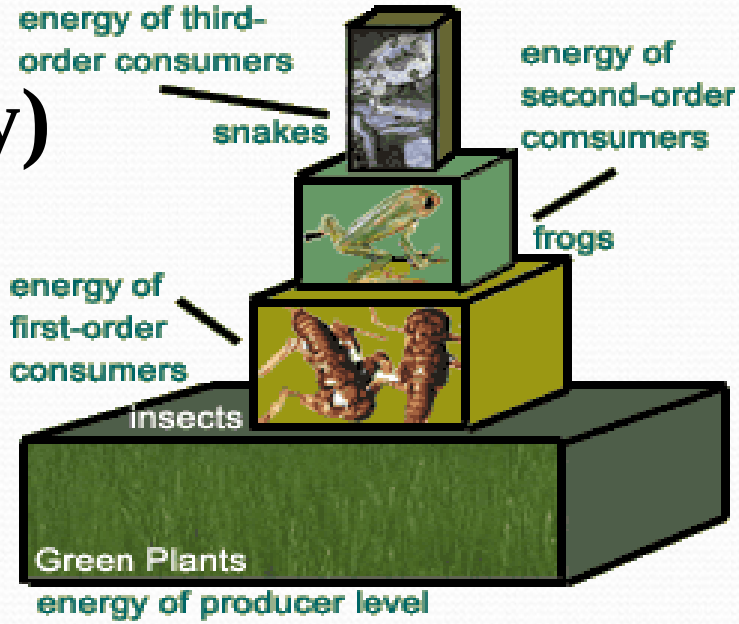
Biomass (energy) pyramid

Trophic structure and Ecological Pyramids



3. Pyramid of Energy

The energy flow (productivity) ratio at each trophic level is used to build the pyramid.



Trophic structure and Ecological Pyramids

- **The first and second types can be inverted pyramids (base up and top down), for example, and the base may be smaller than the top.**
- **As for the energy pyramid, it cannot be like that, but it is always in the form of a wide base down and a small top up.**