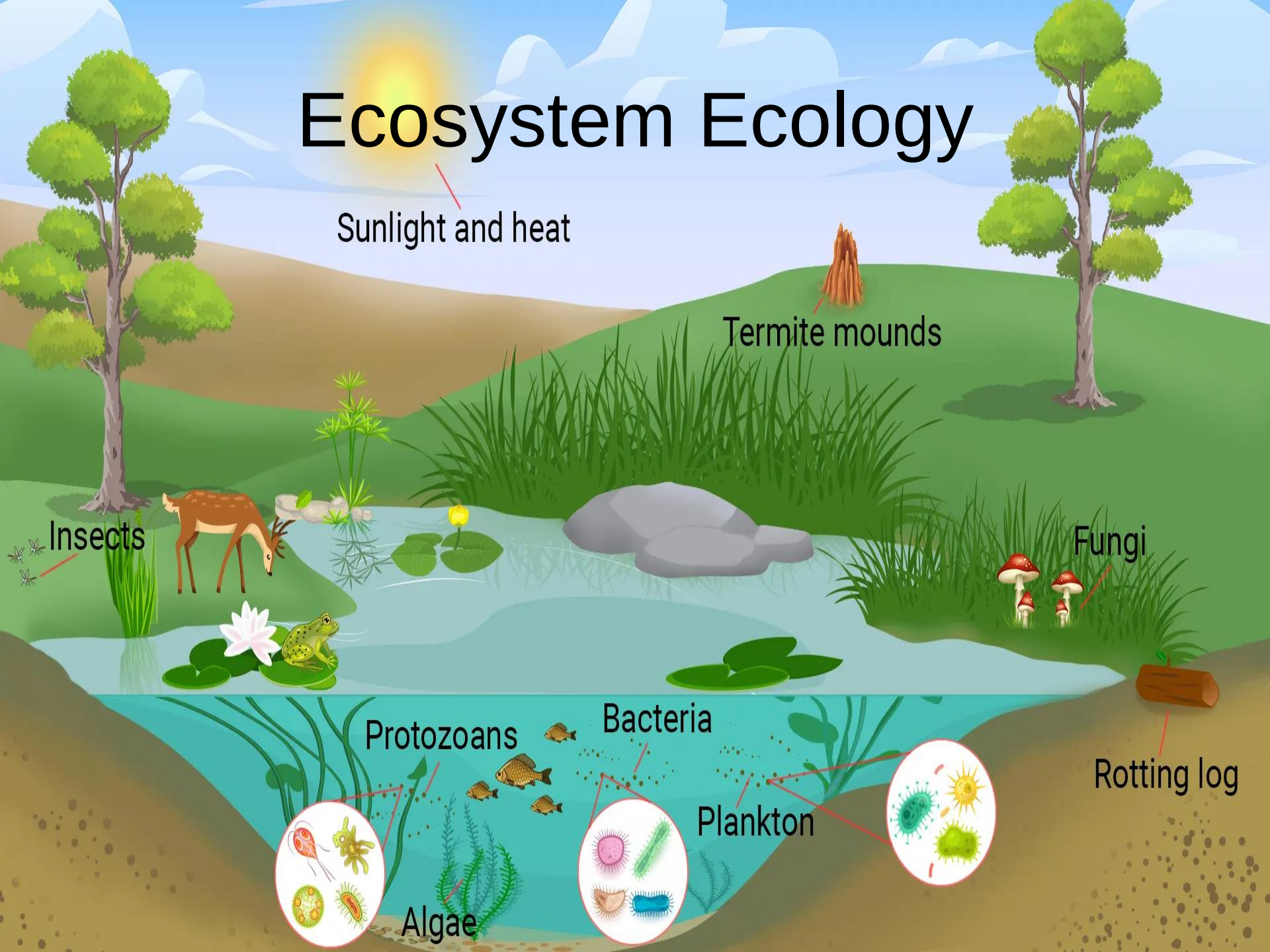

Ecosystem Ecology
Sunlight and heat
Termite mounds
Insects
Fungi
Protozoans
Bacteria
Plankton
Rotting log
Algae

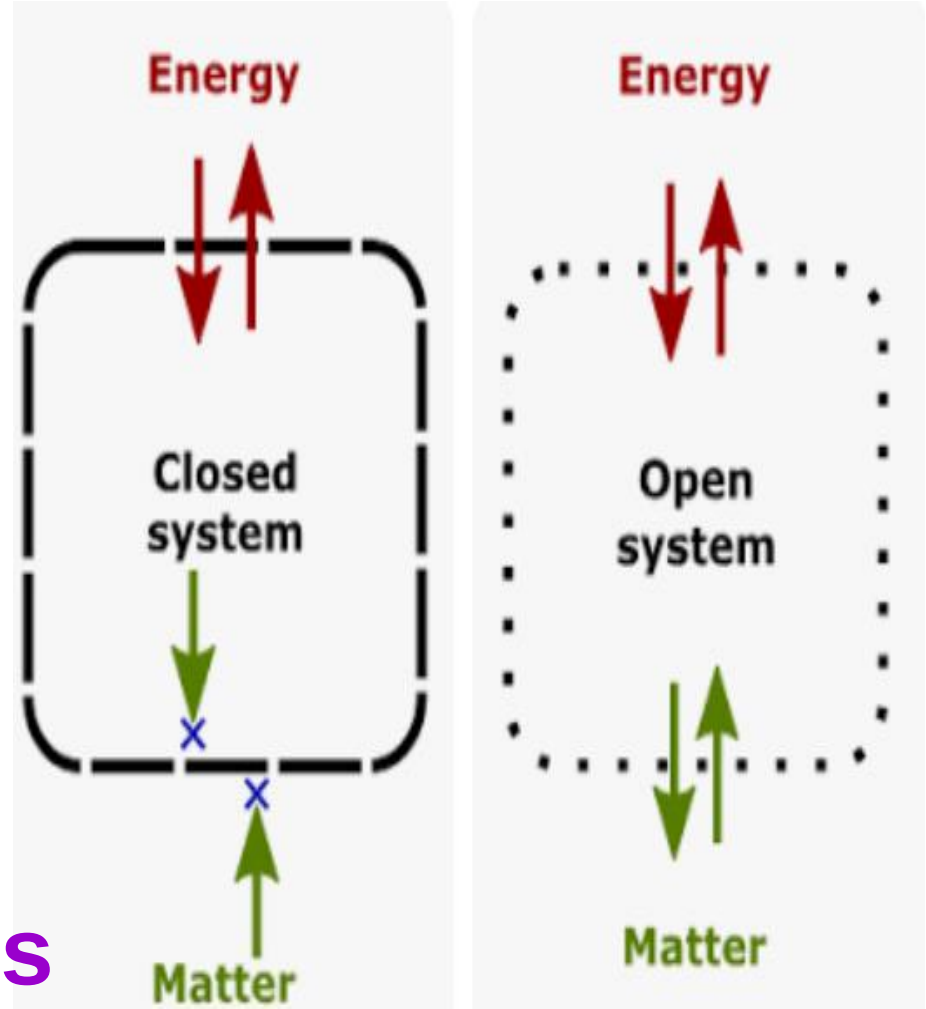
THE ECOSYSTEM DEFINITION

An ecosystem is "any spatial or organizational unit made of living organisms and nonliving substances or conditions that interact to produce an exchange of materials and energy"

***AG Tansley* (1935) … we cannot separate living organisms with abiotic factors with which they form one physical unit…the ECOSYSTEM.**

Types of System

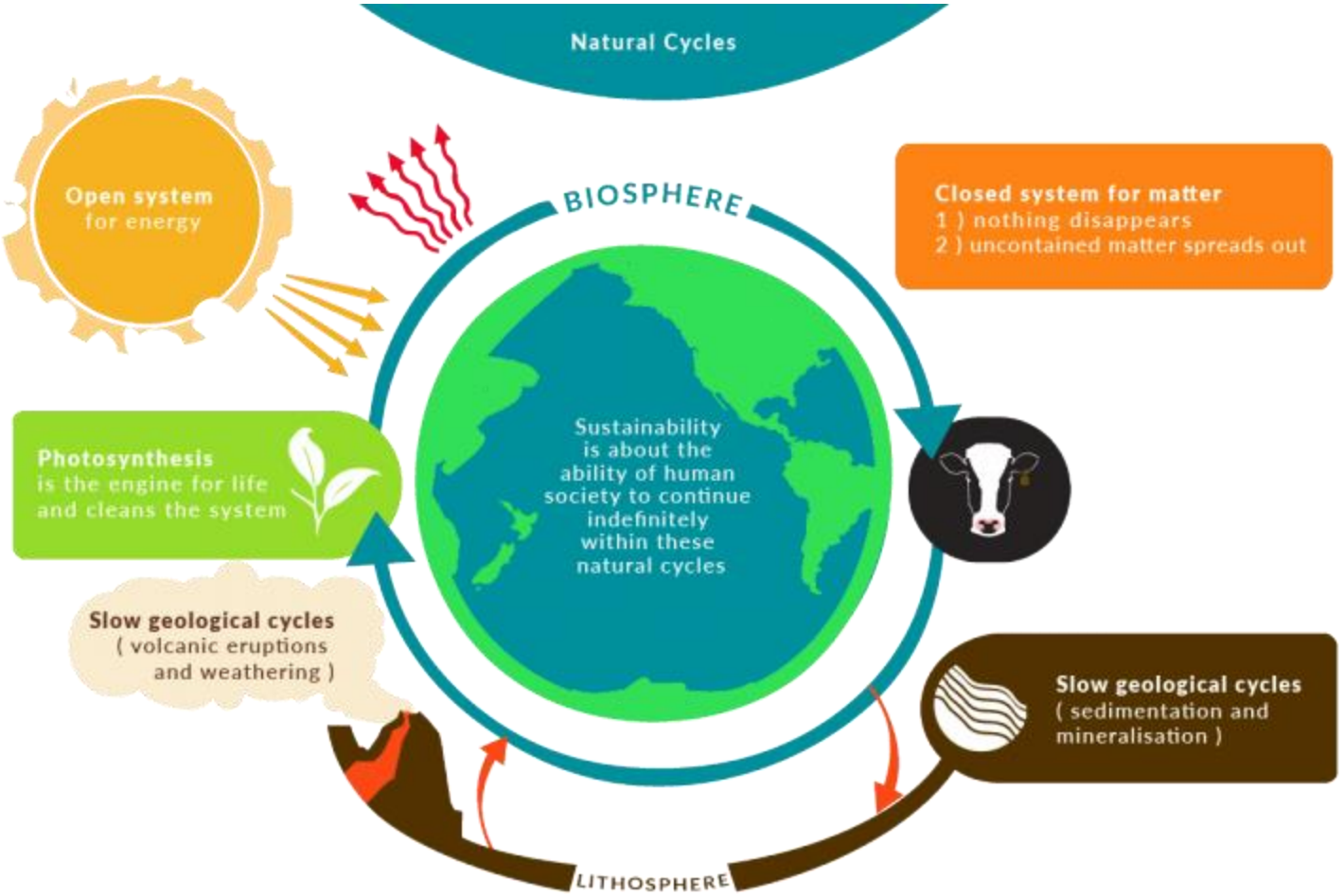
- Closed System- no exchange of matter and energy
- Open System- presence of inputs and outputs (matter and energy)



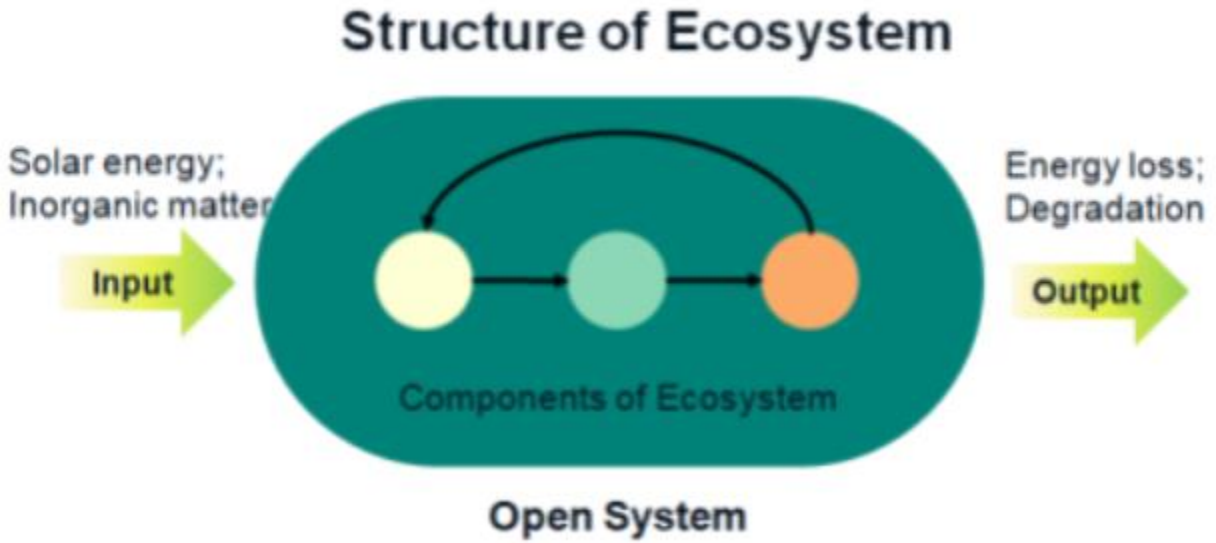
Closed vs open

All natural systems are OPEN!

The Earth is a closed system for MATTER and an open system for ENERGY

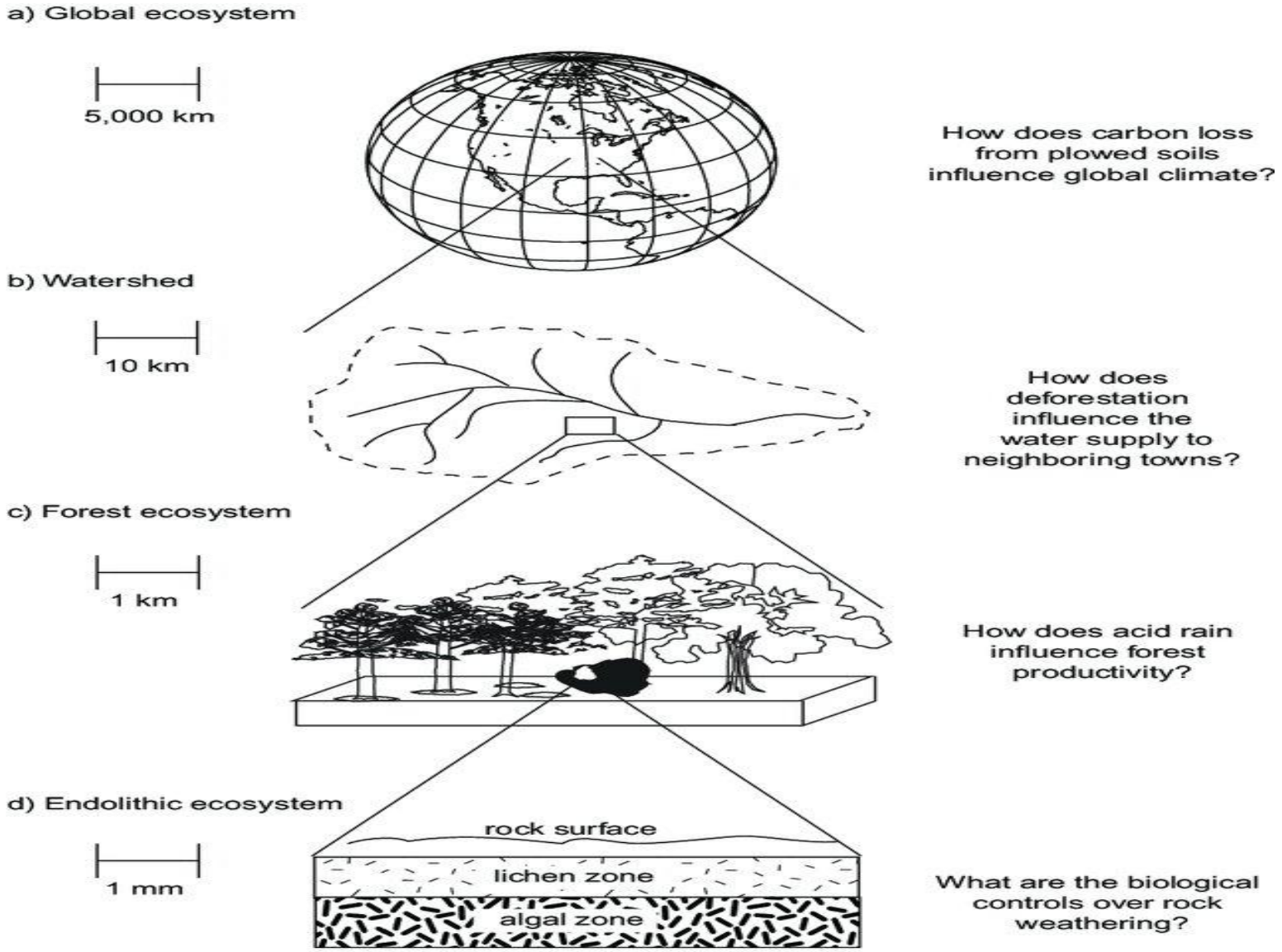


The Ecological System

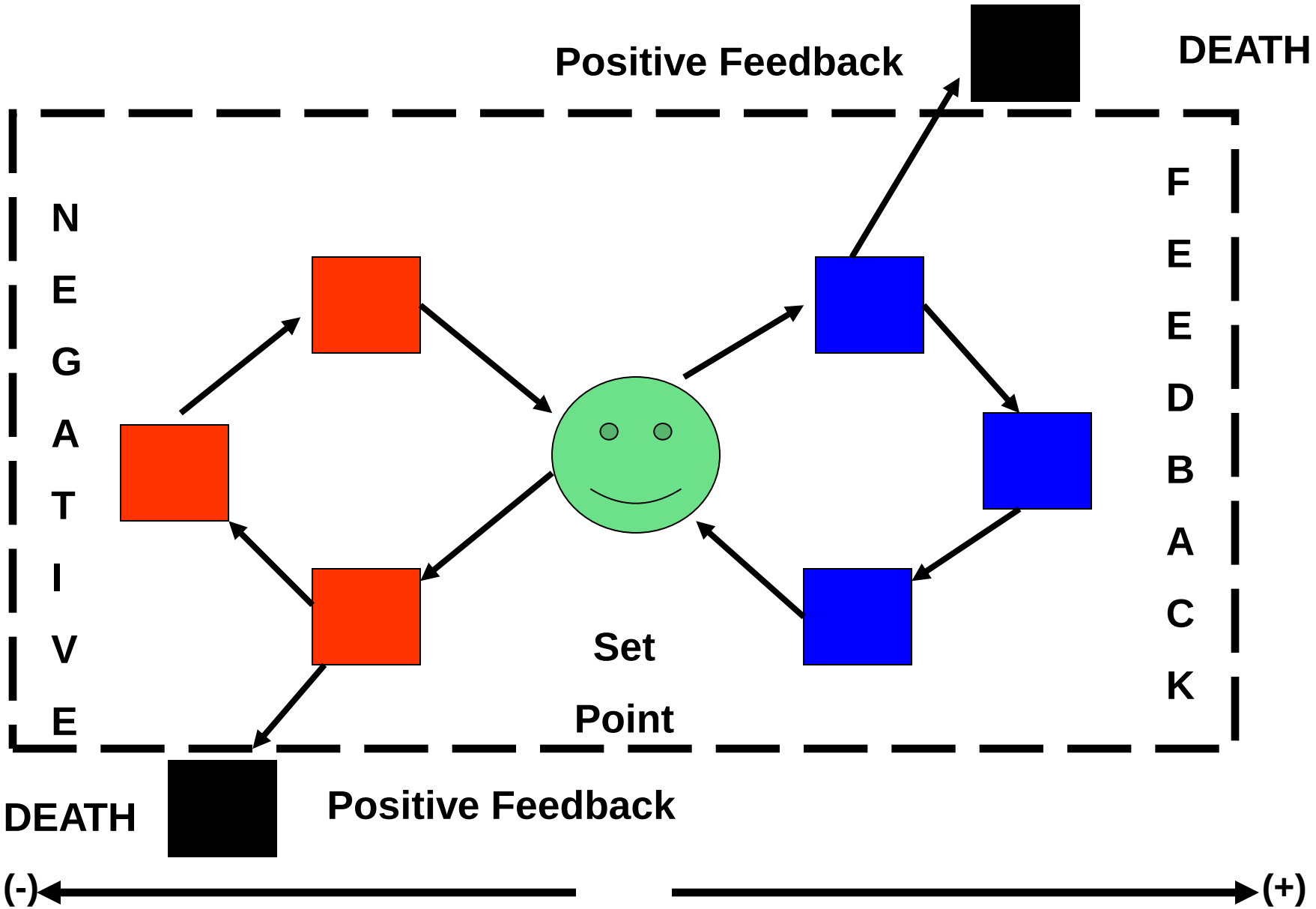


1. OPEN SYSTEM
   a) Size
   b) Degree of openness

2. CYBERNETIC SYSTEM
   a) Self- regulating
   b) Setpoint

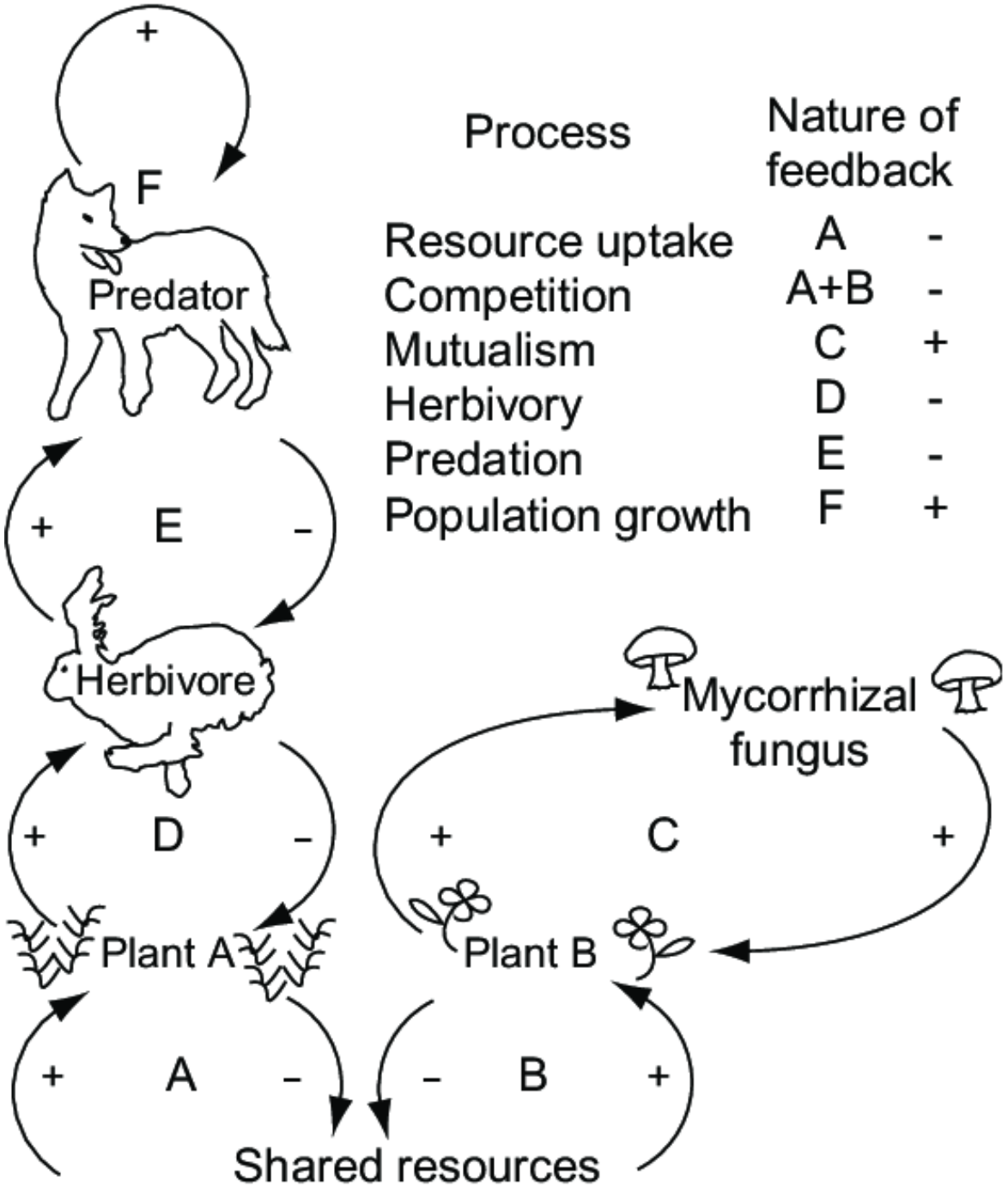

a) Global ecosystem
5,000 km
How does carbon loss from plowed soils influence global climate?
b) Watershed
10 km
How does deforestation influence the water supply to neighboring towns?
c) Forest ecosystem
1 km
How does acid rain influence forest productivity?
d) Endolithic ecosystem
1 mm
rock surface
lichen zone
algal zone
What are the biological controls over rock weathering?

HOMEOSTATIC PLATEAU



Feedback System

1. Negative Feedback- occur when two components of a system have opposite effects on one another.
2. Positive Feedback-components of a system have a positive effect on the other, or both have a negative effect on one another.



Process	Nature of feedback	
Resource uptake	A	-
Competition	A+B	-
Mutualism	C	+
Herbivory	D	-
Predation	E	-
Population growth	F	+

Is this an ecosystem?

ECOSYSTEM STRUCTURE

- **BIOTIC COMPONENTS**

A. Producers
- Green Plants
- Algae (Phytoplankton)

B. Consumers
- Herbivores
- Carnivores
- Omnivores

C. Decomposers
- Detritivores
- True decomposers
- Bacteria and fungi

- **ABIOTIC COMPONENTS**

A. Climatic Factors
- Light
- Temperature
- Precipitation
- Wind
- Humidity

B. Edaphic Factors
- Soil Nutrients
- Soil Moisture
- Soil pH

C. Hydrological Factors
- Physicochemical factors

ENERGY FLOW IN THE ECOSYSTEM

(1)The Flow of Energy & Material Cycling

- Two great processes in nature
- Principles that apply equally to all environments and all organisms including man.

ENERGY FLOW IN THE ECOSYSTEM

(2) Energy is the capacity to perform anything. (*e.g. growth, maintenance, reproduction, locomotion*).

(3) There must be a mechanism through which energy be made available to all components of the ecosystem → PROCESS OF ENERGY FLOW!

ENERGY FLOW IN THE ECOSYSTEM

(4) Flow of Energy – ***unidirectional or non-cyclic.*** **Energy is used metabolically by a given organism or population, is converted to HEAT and soon lost from the ecosystem.**

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ENERGY FLOW IN THE ECOSYSTEM

(5) Energy ultimately comes from the sun and transferred from producers (plants) to consumers and most is utilized and converted and lost as heat. Energy (*never or always?*) goes back to the Sun.

A simple cataphrase: (Odum,1959)

"Matter circulates, energy flows."

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ENERGY FLOW IN THE ECOSYSTEM

(6) On the other hand, *cycling of nutrients* (matter) is where chemicals and nutrients circulate from living components to the non-living components and back to living components of the ecosystem.

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ENERGY FLOW IN THE ECOSYSTEM

(7) The one-way flow of energy, as a universal phenomenon in nature, is the result of the operation of two laws of thermodynamics.

- **First Law of Thermodynamics**

  (Law of Conservation of Energy)

- **Second Law of Thermodynamics**

  (Law of Entropy)

First Law of Thermodynamics

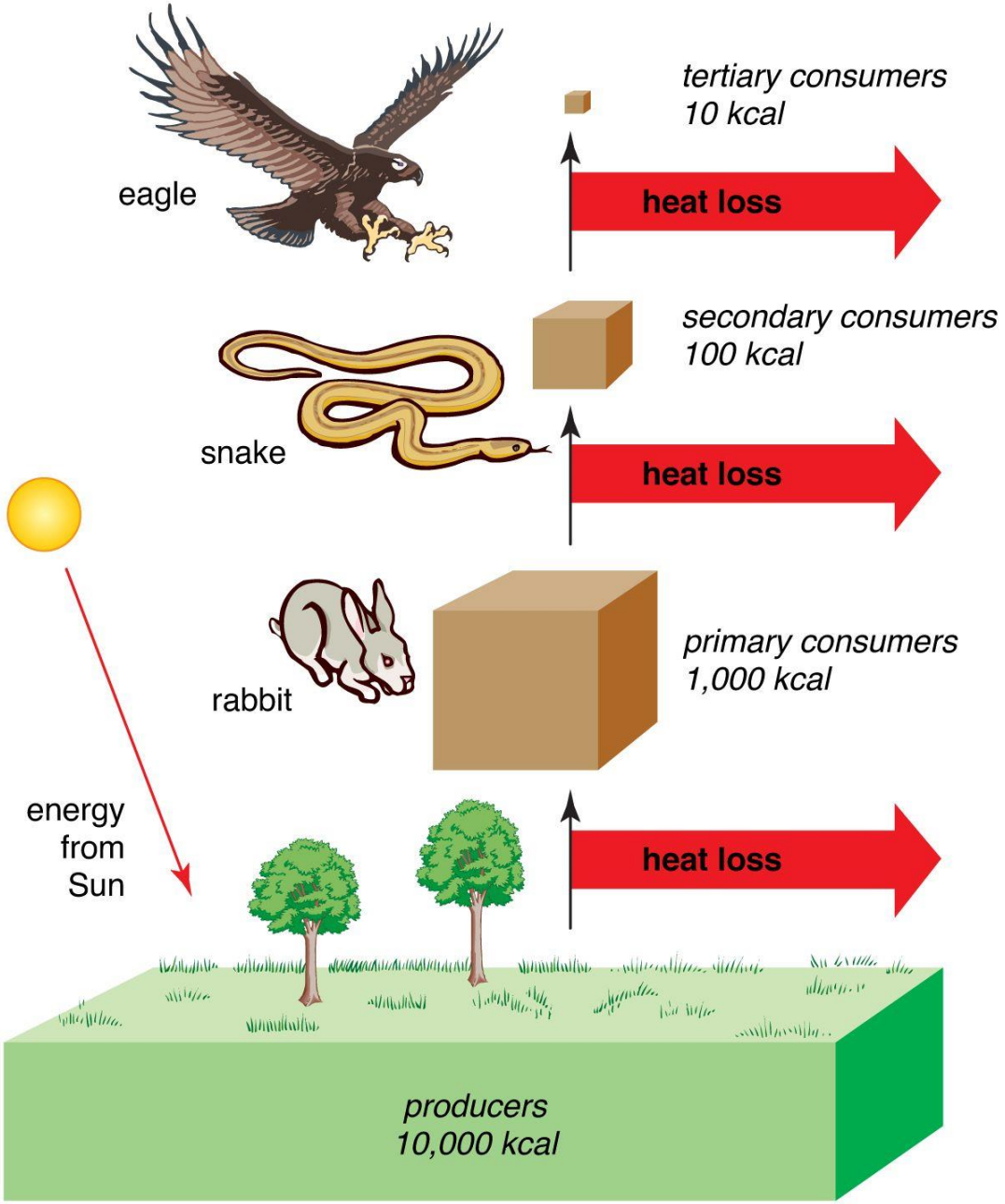
(Law of Conservation of Energy)

- **Energy is neither created nor destroyed**
- **Energy may change forms:**

  (light→chemical→ kinetic (ATP)
- **Energy may be transferred from place to place:**

  (producers→herbivores→carnivores-->)

Energy flow and trophic levels



First Law of Thermodynamics

(Law of Conservation of Energy)

- **Regardless of what transfers and transformations that take place, no net GAIN or LOSS of energy occurs**

- **The sum total of energy in a system remains the same (constant)**

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Million Dollar Question!

Is the ecosystem consistent with the first law?

Light Energy → Chemical Energy → Mechanical Energy → heat
In Green Plants used for work

LE

$6CO_2 + 12H_2O \xrightarrow[C\ hl]{} 6C_6H_{12}O_6 + 6H_2O + 6O_2 + ATPs$

100%

PRODUCERS
90% (1)

HEAT

HEAT

10%

HERBIVORES
90% (2)

HEAT

Total Photosynthesis/ Gross Production

Respiration

Net Primary Production

Gross 2ndary Production

Respiration

Net 2ndary Production

10%

CONSUMERS
90% (3)

10%

Back

Encarta Encyclopedia, Gary Retherford/Photo Researchers, Inc.

Second Law of Thermodynamics

(Law of Entropy)

Energy transformation is always accompanied by a degradation of energy

- *from a concentrated to dispersed form*
- *from organized to less organized*
- *from freely available to less available (useless) form*

HIGH QUALITY → LOW QUALITY

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Next

Another million dollar for you!

Is the ecosystem consistent with the second law?

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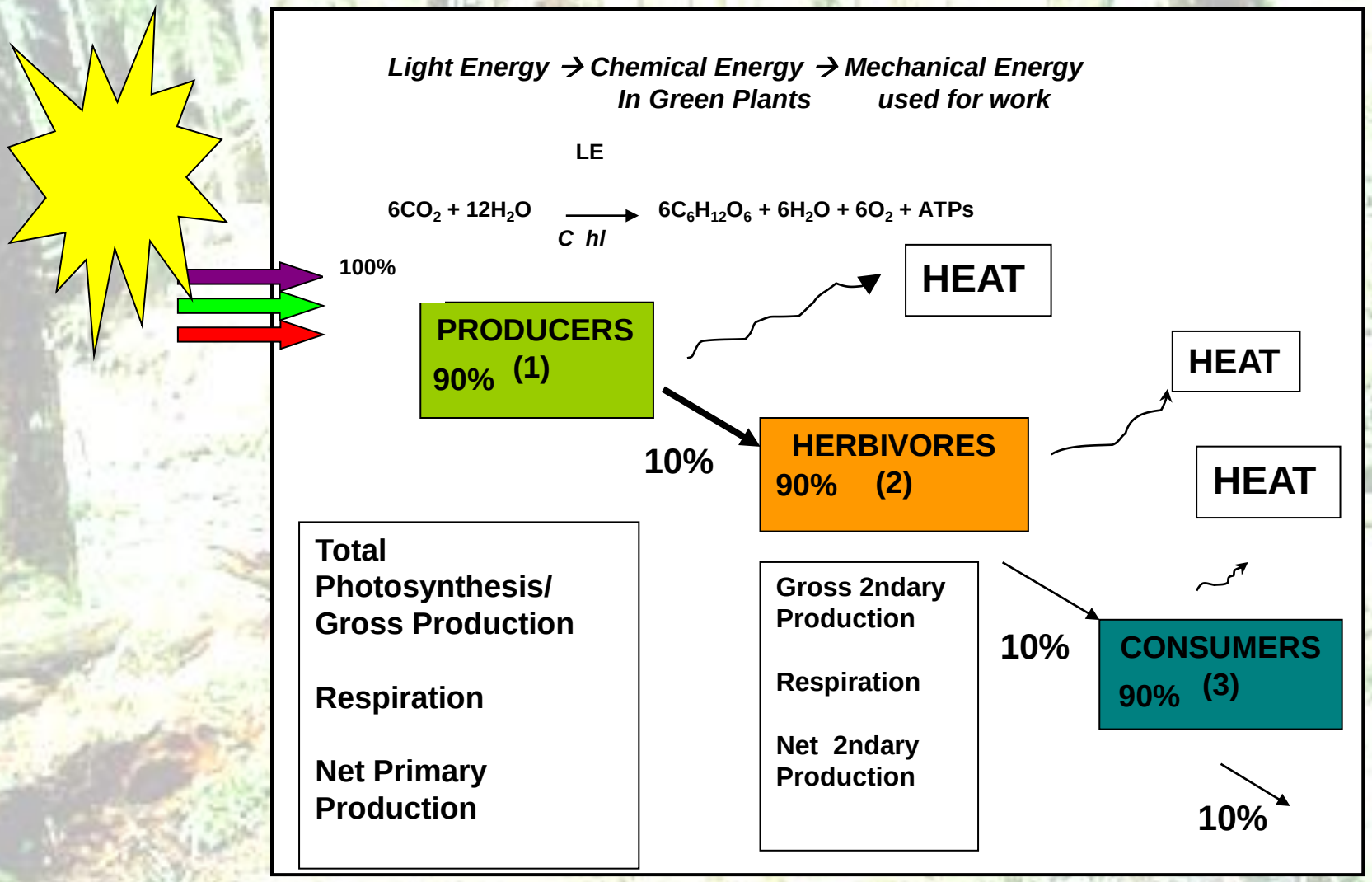

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Additional Information

- **Since some energy is always dispersed into unavailable heat energy, NO ENERGY TRANSFER is 100 % efficient!**

- **In a food chain, 90% of the stored energy is LOST as heat per transfer leaving only 10% of the level tissue available to the next trophic level.**

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Additional Information

- Ecosystems tend to approach **a state of entropy** (measure of disorder or amount of unavailable energy)
- This tendency for higher entropy is **counterbalanced** by the continual input of energy from the Sun…

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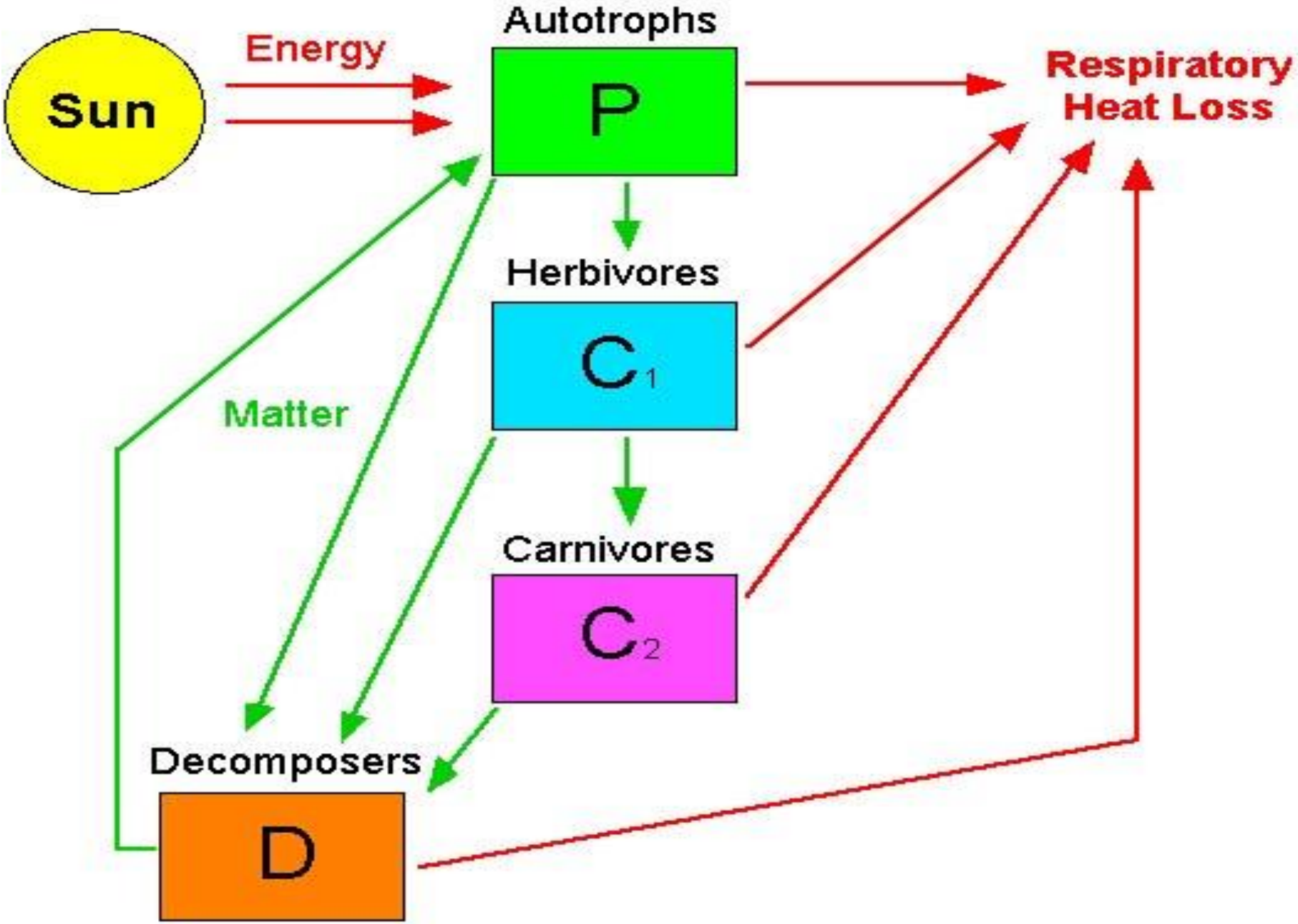
Next


Autotrophs
Energy
Sun
P
Respiratory
Heat Loss
Herbivores
C1
Matter
Carnivores
C2
Decomposers
D

CONCEPT OF PRODUCTION

- **Production** – energy harvested in a particular trophic level (which will be used in 2 ways) - Gross Production
  - **As fuel** (respiration and maintenance) → R
    Evidence: evolution of metabolic energy
  - **Stored in the organic material of the growing organism** → NP - accumulates overtime as biomass.

Back

- **Gross Production** – total production (energy) harvested (100%)
- **Net Production** – energy remaining in excess of respiration (10%)
- **Respiration** – for maintenance and performance of activities (90%)

Back

At the Producer Level

- ***Gross Primary Production*** **– total energy assimilated by plants in the process of photosynthesis; also known as *total photosynthesis***

- ***Respiration*** **– provides energy to be used for reproduction and maintenance (including photosynthetic process)**

- ***Net Primary Production*** **– the amount of storage of energy in plant tissues in excess of the respiratory utilization by plants during the period of measurement; also called apparent photosynthesis.**

Back

Net Production

- NPP = GPP – R
- Net Production accumulates over time as biomass. At anyone time, the stored energy is referred to as biomass.

  cal/sq.m.

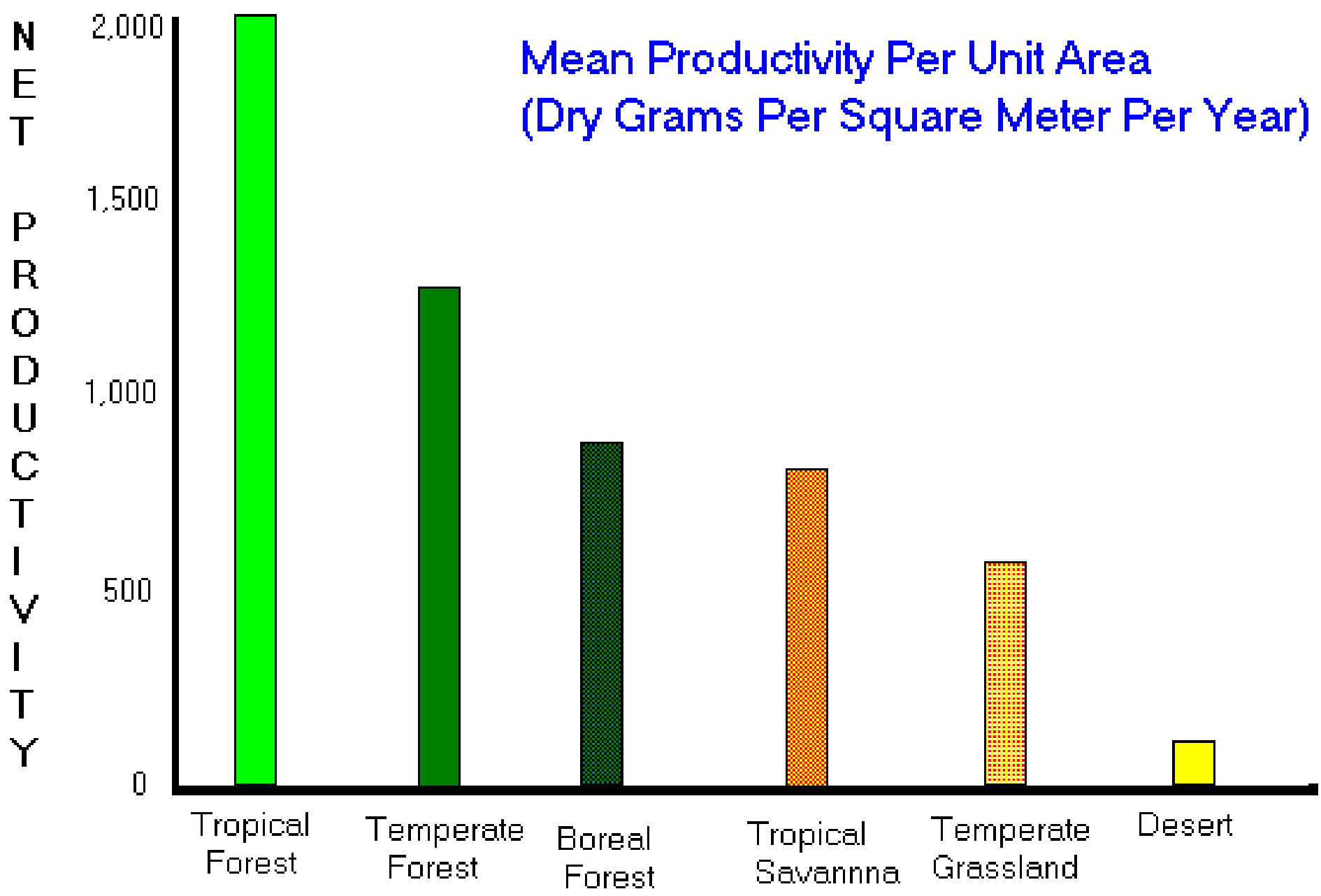
  g/sq.m.

  kg/ha

  - G-R > 0 → biomass increases
  - G-R < 0 → biomass decreases
  - G/R = 1 → biomass constant

Production versus productivity ?

Back


Mean Productivity Per Unit Area
(Dry Grams Per Square Meter Per Year)
NET PRODUCTIVITY
2,000
1,500
1,000
500
0
Tropical Forest
Temperate Forest
Boreal Forest
Tropical Savannna
Temperate Grassland
Desert

FOOD CHAINS, FOOD WEBS, AND TROPHIC LEVELS

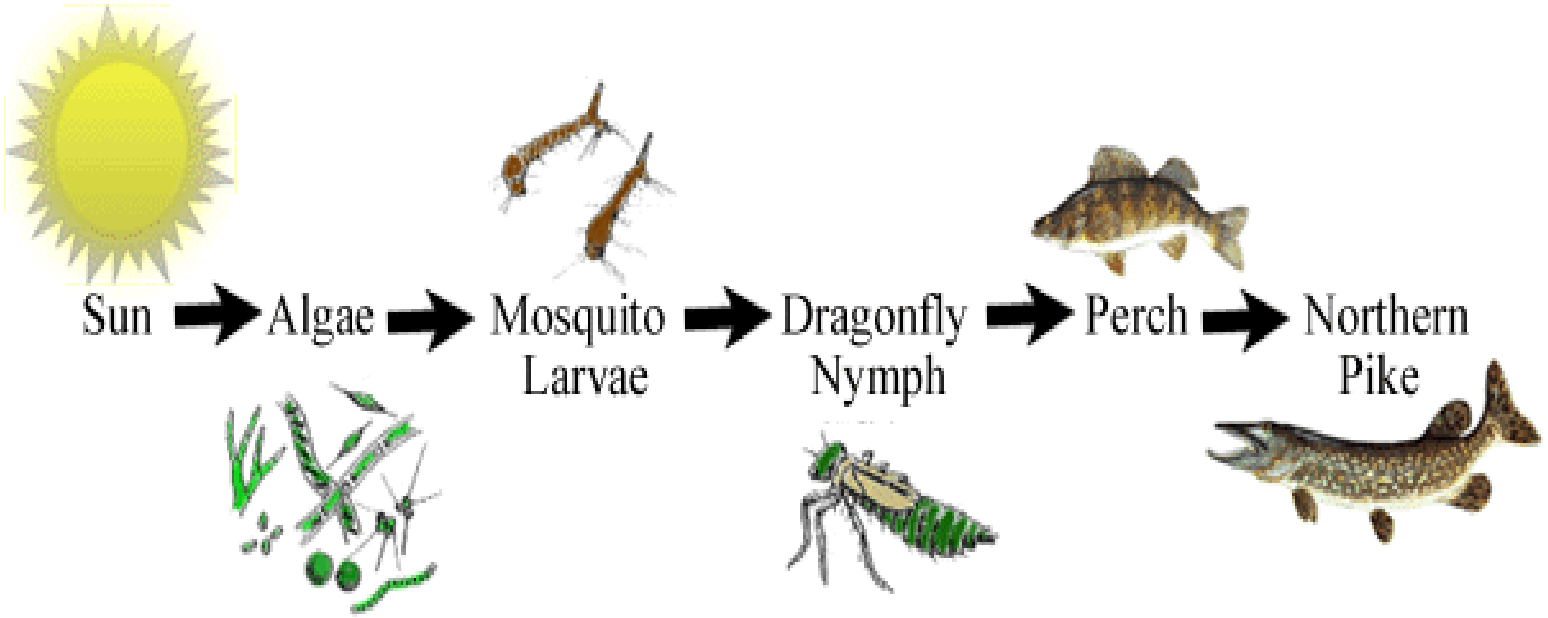
Food Chain – process of eating and being eaten; consists of a series of arrow pointing from one organism to the next.

Accomplishment :

_____

- **Food chains basically assumes a simple linear form.**
  - **plants → herbivores → carnivores → decomposers**
  - **grass → field mice → bacteria**
  - **phytoplankton → zooplankton → planktivores**

A FOOD CHAIN


Sun
Algae
Mosquito Larvae
Dragonfly Nymph
Perch
Northern Pike

COMPONENTS OF A FOOD CHAIN

- **Autotrophs (_____)** – plants (possesses net production; sets the spending limits for energy budgets of the entire ecosystem.

- **Heterotrophs (_____)** – other organisms aside from plants; depend on the generosity of other organisms for their food supply.

  a. Herbivores (plant eaters)
  - *Folivores (leaf-eaters)*
  - *Florivores (flower-eaters)*
  - *Frugivores (_____-eaters)*
  - *Gramivores (_____-eaters)*

b. <u>Carnivores</u> (animal flesh-eaters)

As levels of carnivores increase → number decreases but fierceness and size increase (1st order carnivore, 2nd order carnivore, etc.)

c. <u>Onmivores</u> (plant and animal eaters)

d. <u>Decomposers</u> – live by obtaining energy-rich molecules from the tissue of dead organisms.

Accomplishment: release nutrients back into mineral cycles.

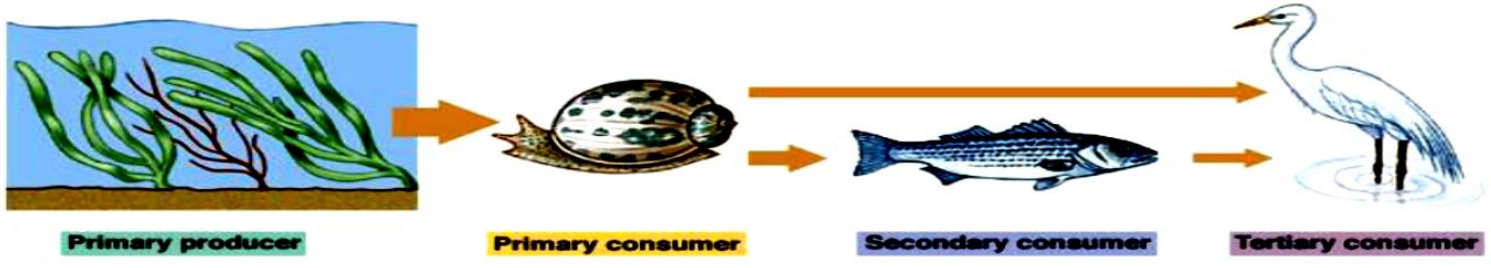
- **Macrodecomposers** – detritivores (ants, springtails, collembolans)
- **Microdecomposers** – true decomposers (bacteria and fungi of decay)

Other Feeding Groups

- **True Parasites**
- **Parasitoids (killers)**
- **Scavengers** – animals that eat dead plant and animal materials (beetles, crabs, vultures, gulls, etc.)
- **Saprophytes** – plants or fungi that eat dead plant matter, rarely animal matter (fungal species, Indian pipe, and beech drops)

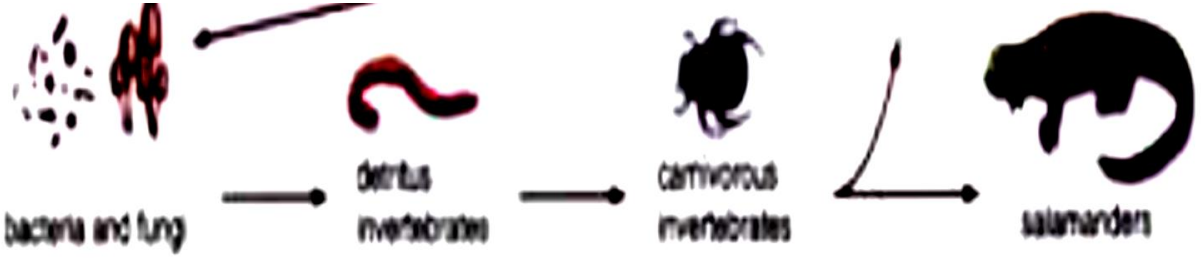
TYPES OF FOOD CHAIN

- **Grazing Food Chain**
  - starts from a green plant base then goes to grazing herbivores, and on to carnivores;
  - most common in deep aquatic systems but can also be found in terrestrial
    - ***grass → cow → man***
    - ***phytoplankton → zooplankton → planktivores → piscivores → cat → dog → "lasenggo" → cannibals (bwahhhhahaaa!!!)***



TYPES OF FOOD CHAIN

- **Detrital Food Chain**
  - from dead organic matter to microorganisms and then to detritivores and their predators
  - most common in terrestrial and shallow waters
    - dead leaves → mites → carnivorous mites
    - dung → bacteria → microbial consumers →



- **Parasitic Food Chain**
  - In which either the producer or consumer is parasitized
  - Food passes to a smaller organism than a larger one.
    - e.g. termites → *Triconympha*

THE FOOD WEB

- **Interlocking food chains!**
- **Herbivore species may feed on the same plant species**
- **Several herbivores and carnivores may eat several different plant and species, respectively.**

BACK

NEXT

Food Web Complexity

- *Chain Length* – average number of links between trophic levels.
- *Connectance* – $\frac{\text{actual number of links}}{\text{potential number of links}}$

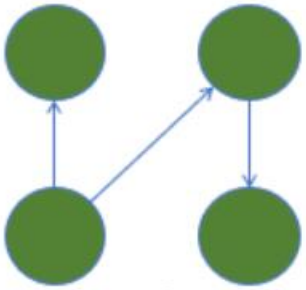
N = n(n-1)/2 = 19(18) / 2 = 71 [poten. Link]

e.g. 19 species

34 actual links

Connectance = 34/71= 0.20

- *Linkage Density* = number of links per species

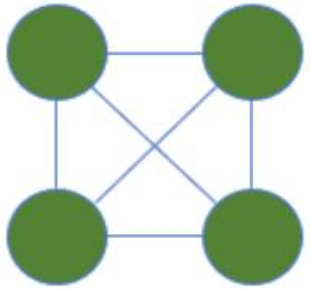


Number of actual connections = 3

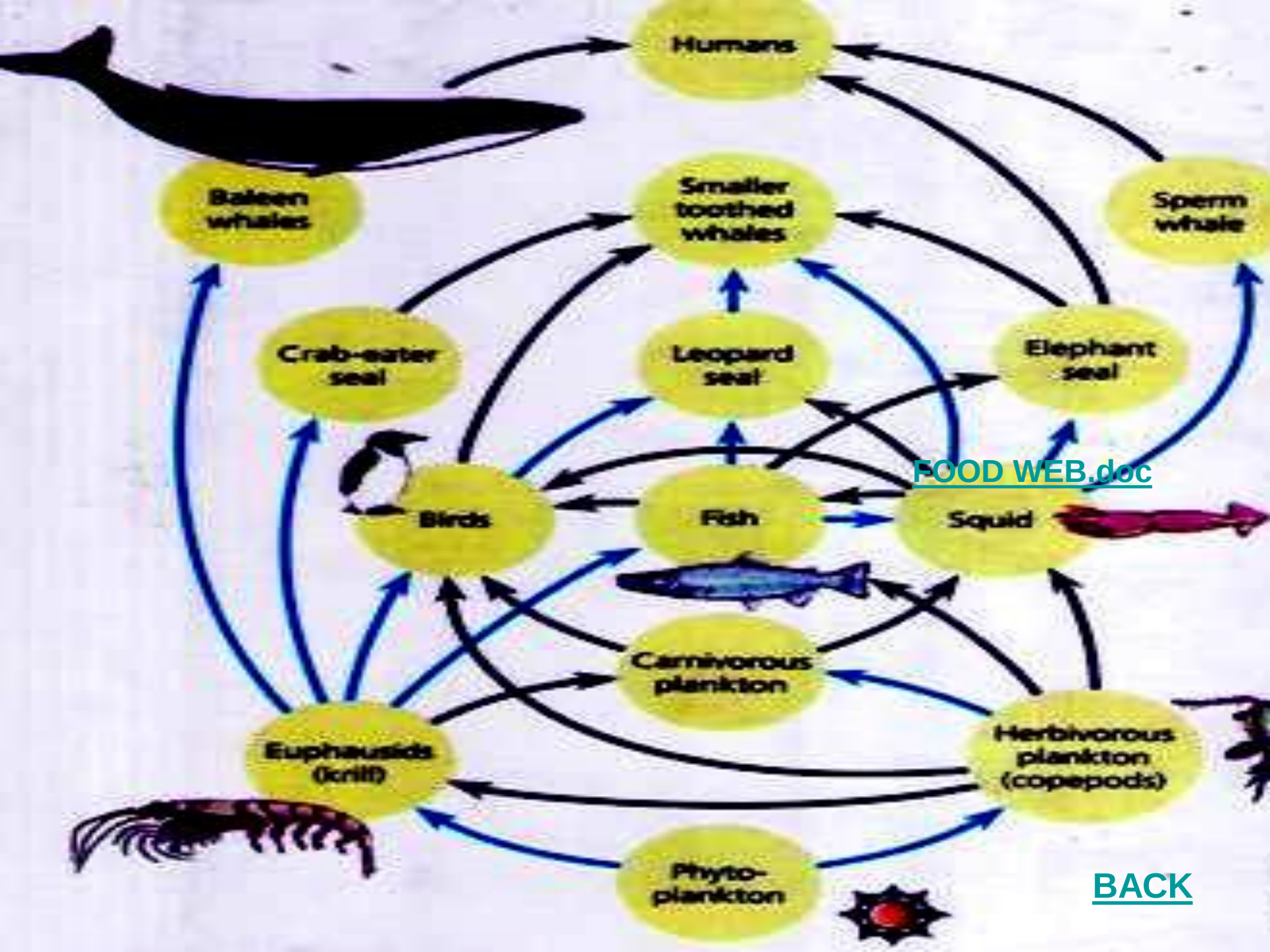
$$C = L/[S(S-1)/2]$$

$$C = 3/[4(4-1)/2]$$

Connectance = 3/6 = 0.5



Number of possible connections = 4(4-1)/2 = 6



FOOD WEB.doc

BACK

THE TROPHIC LEVELS

- Functional classification of organisms based on how many steps they are away from the producers.
- Same step(s) – same trophic level
- Limited to about 4-5 trophic levels! **why again**?
  - How about open oceans → longest food chain!

- Open oceans have the longest food chain because they have the highest diversity of species. Food chain length is determined by the PRMR (predator-prey mass ratio) which states that the greater ratios mean longer food chains.
- An open oceans PPMR is bigger compared to terrestrial ecosystem which has for example a deer eaten by a lion compared to plankton preyed upon by whale sharks.
- Open oceans can support longer food chains because of the diversity mentioned. Predators have more choices of prey thus enabling more trophic levels to feed from which stretch the rule of only 10% of the energy passed in each trophic level.
- Thus, PPMR and the diversity of organisms in an open ocean allow it to have the longest food chain.

Trophic levels

4. **Tertiary consumers**
(usually a "top" carnivore)

3. **Secondary consumers**
(carnivores)

2. **Primary consumers**
(herbivores)

1. **Producers**
(photosynthetic plants, algae, bacteria)

Consumers that feed at all levels:

Parasites
Scavengers
Decomposers

BACK

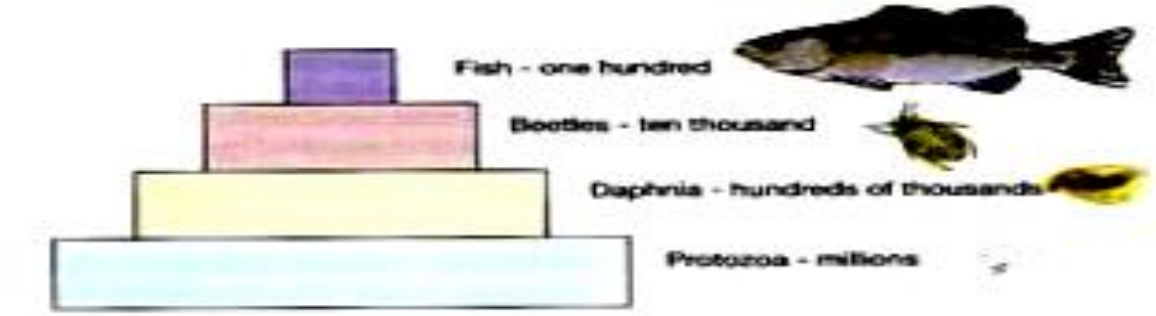
ECOLOGICAL PYRAMIDS

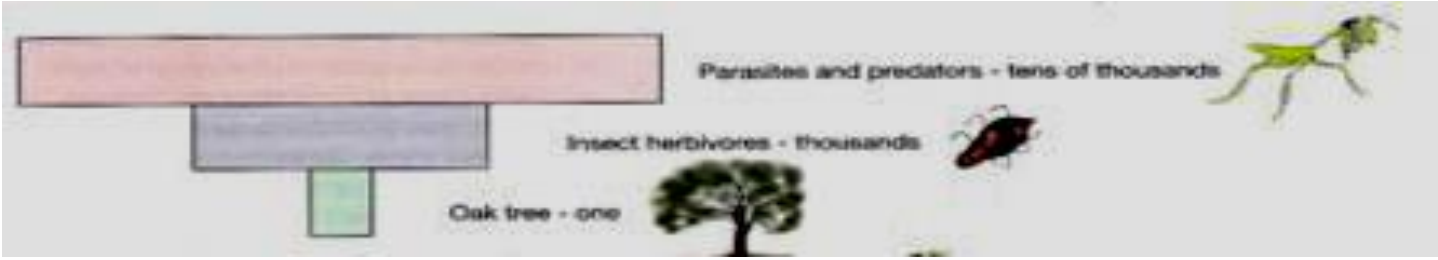
- Shows the trophic structure of an ecosystem representing *biomass*, *organism number*, or energy content of each trophic level in a food web.
- Base (producer level)

  Apex (highest consumer level)

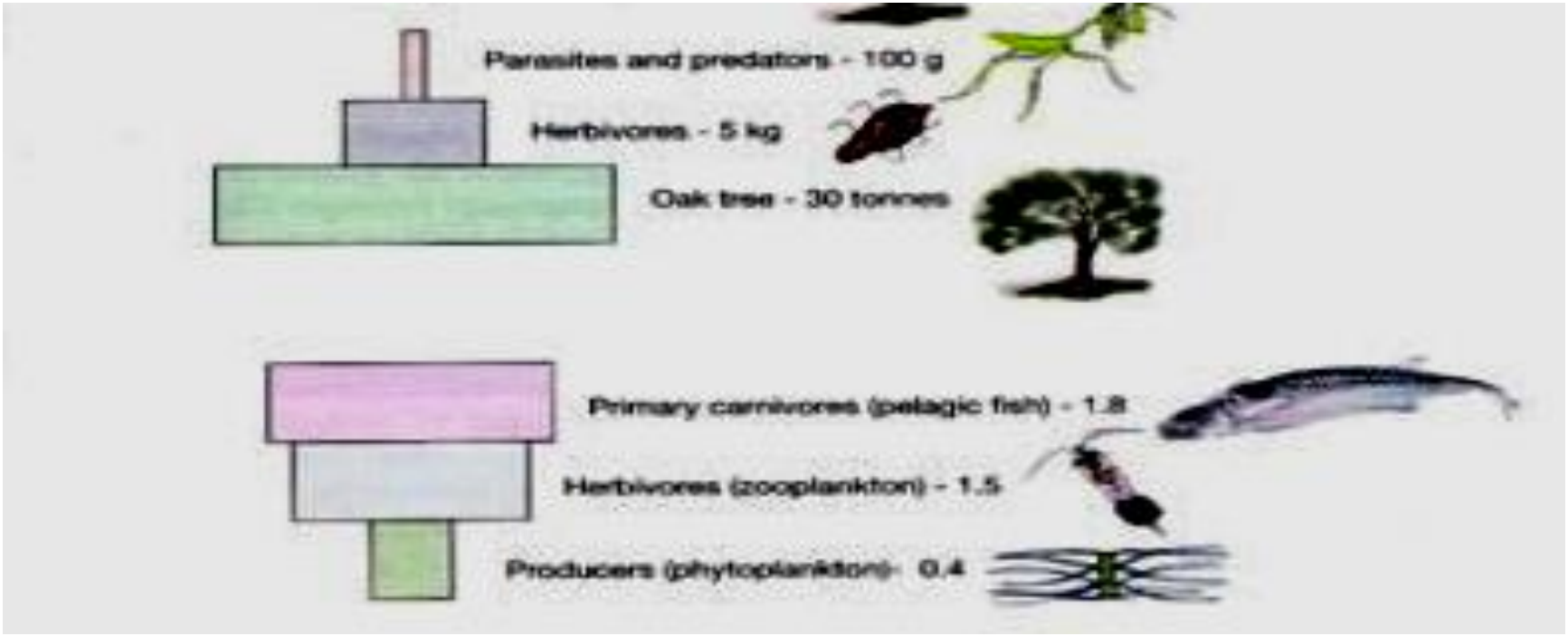
ECOLOGICAL PYRAMIDS

- Three types:
  - **Pyramid of Number** – shows the total number of individual organisms at each level in the food chain of an ecosystem

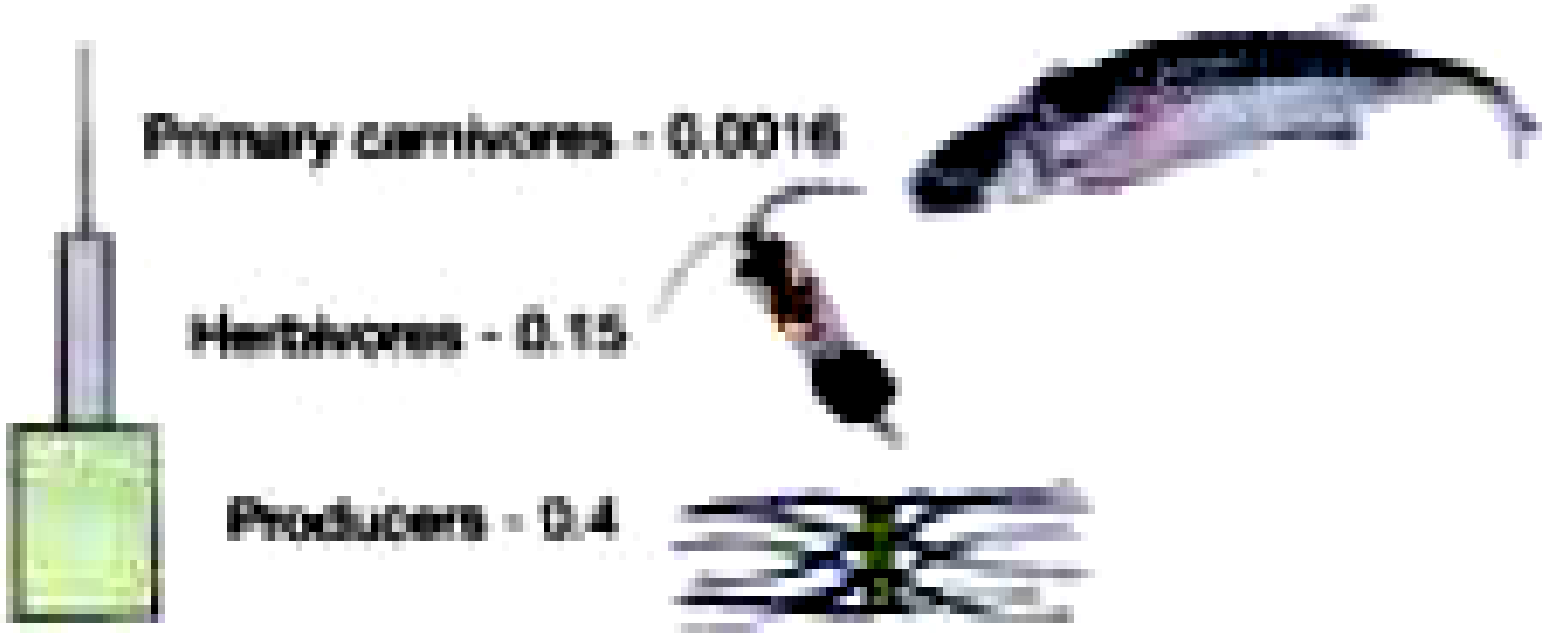




- **Pyramid of Biomass** – based on weight (biomass) of organisms in each trophic level at one time; underestimates number organisms



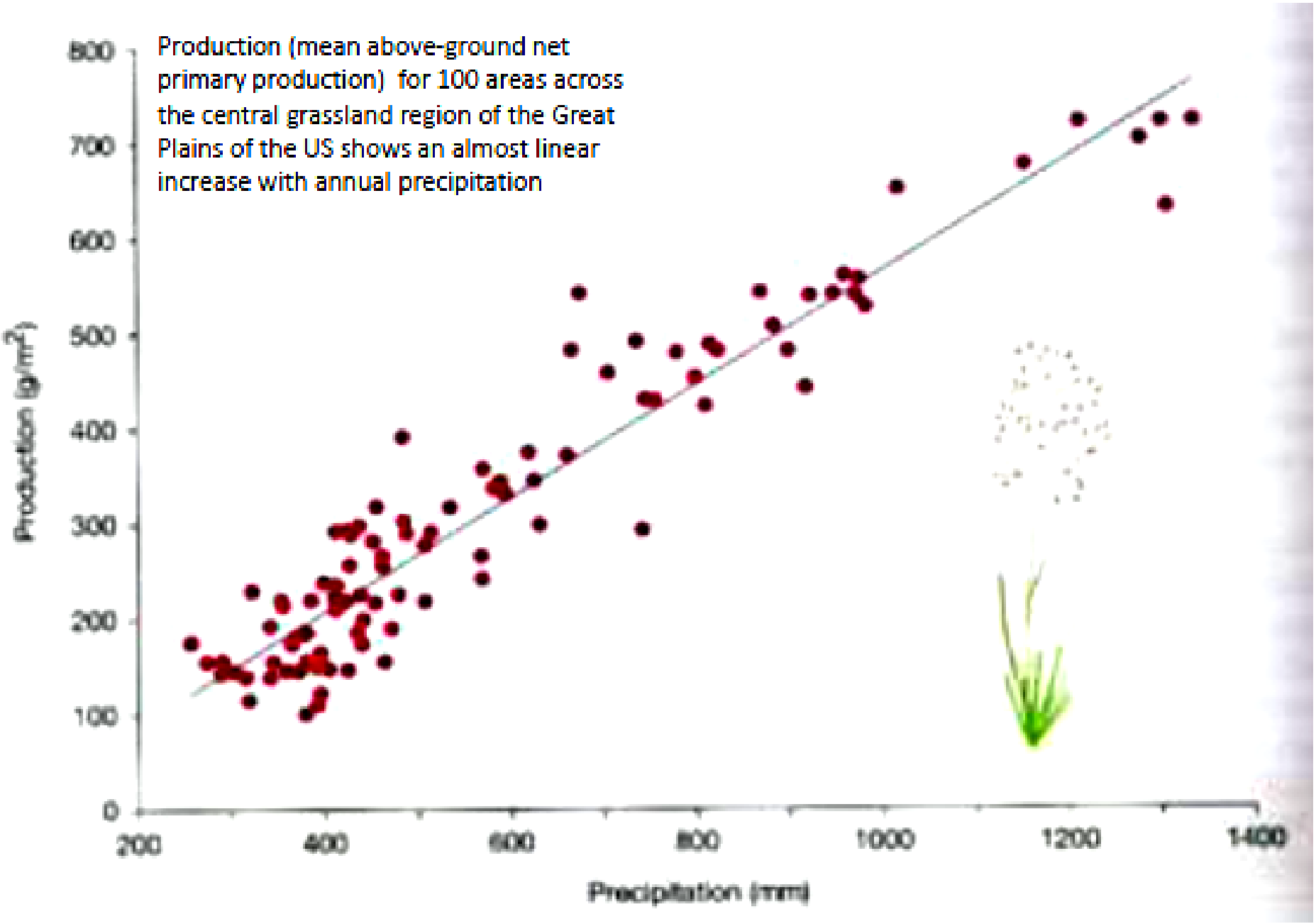
- **Pyramid of Energy** – based on total amount of energy in each trophic level and is always upright and never inverted.

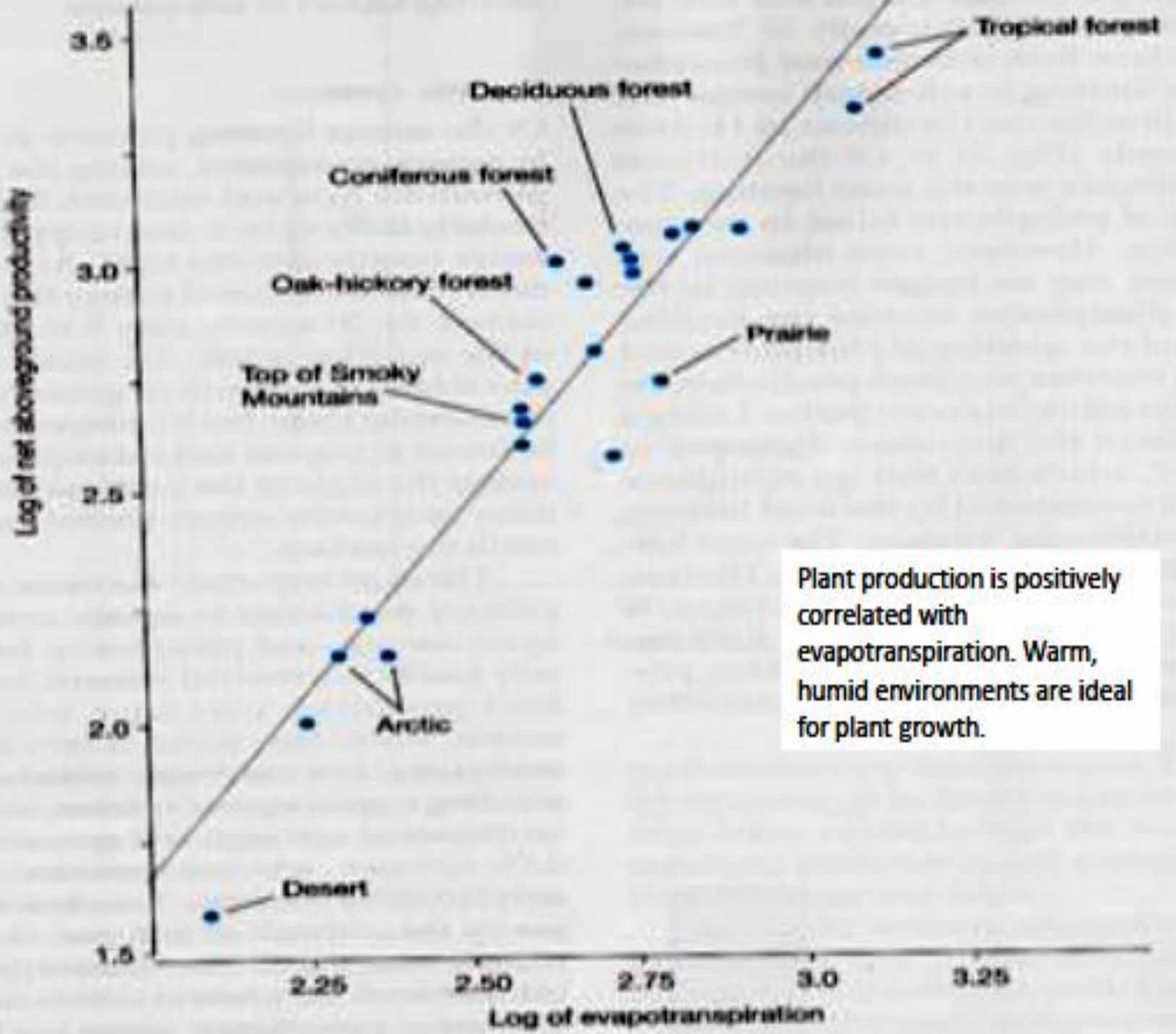


PRODUCTIVITY AND ECOLOGICAL EFFICIENCIES

- **PRODUCTIVITY**

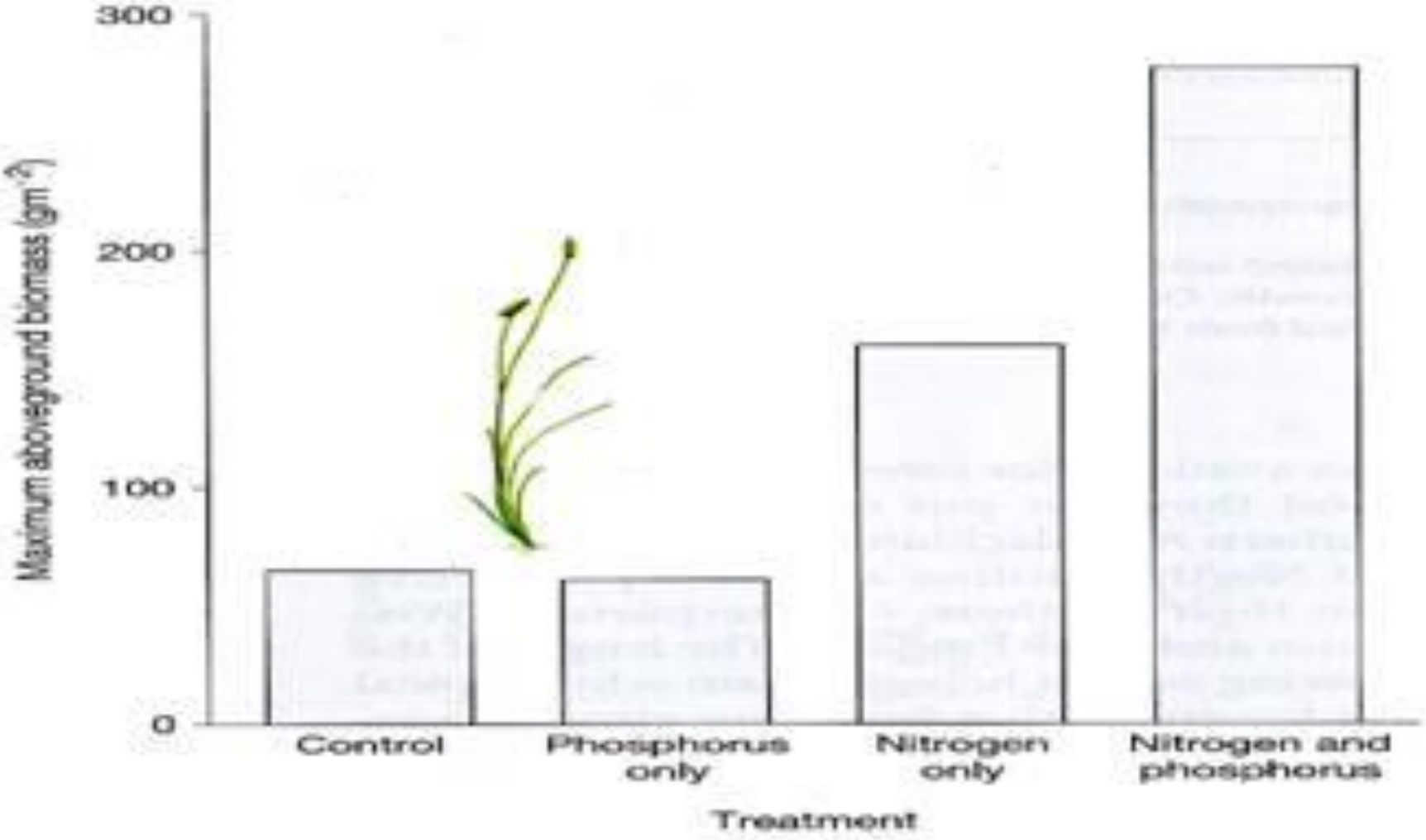
  Measurement of Production (Laboratory)
  - Terrestrial (Harvest Method)
  - Aquatic
    - Light and Dark Bottle Method
    - Cholorophyll Concentration
    - LAI
- **Limits to Primary Production**
  - Primary production is limited mainly by light, water, nutrients, and temperature


Production (mean above-ground net primary production) for 100 areas across the central grassland region of the Great Plains of the US shows an almost linear increase with annual precipitation
800
700
600
500
400
300
200
100
0
Production (g/m²)
200
400
600
800
1000
1200
1400
Precipitation (mm)


Tropical forest
Deciduous forest
Coniferous forest
Oak–hickory forest
Prairie
Top of Smoky Mountains
Arctic
Desert
Plant production is positively correlated with evapotranspiration. Warm, humid environments are ideal for plant growth.
Log of net aboveground productivity
3.5
3.0
2.5
2.0
1.5
2.25
2.50
2.75
3.0
3.25
Log of evapotranspiration

Evapotranspiration Rate

- measure of the amount of water entering the atmosphere from the ground and vegetation.
  - Desert – low evapotranspiration? Bakit wHY?
  - Concl: high temp coupled with high moisture → high productivity as in tropical rainforest.



Net aboveground primary production of a salt-marsh sedge in response to the addition of nutrients.
Nitrogen is more limiting than phosphorus, but once nitrogen becomes available and no longer limiting, phosphorus becomes the limiting factor.
Addition of N and P, increased the production most

Increase in lake primary production with increasing phosphorus concentration.

But may lead to eutrophication! Abangan!

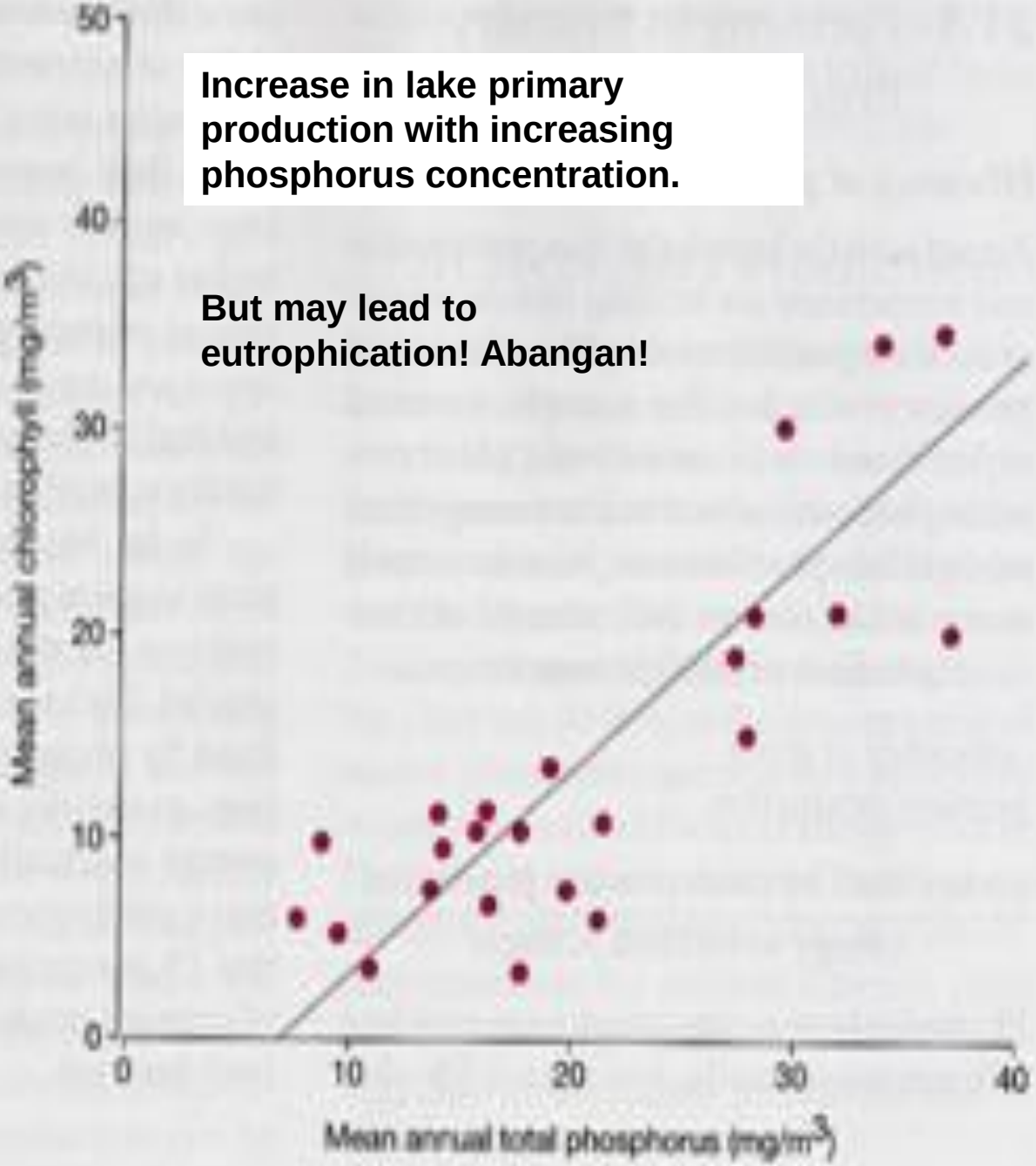


Figure 21.5 Increase in lake primary production, measured as chlorophyll concentrations, with phosphorus concentration. More algae grow as phosphorus levels increase. (*After Schindler, 1977.*)