Biology 20 Unit 1

Energy Flow Through the Biosphere

1.1 – How Energy Enters the Biosphere

- One of the requirements of all living things is energy
- All organisms use cellular respiration to obtain energy from chemical compounds
- These chemical compounds are produced by organisms known as producers

Producers

- aka autotrophs- primary producers
  - Require an energy source and inorganic nutrients to produce organic food molecules
  - Manufacture organic nutrients for all organisms
  - Green plants, algae, cyanobacteria – photosynthesis

Photosynthesis

- Photosynthesis is carried out by producers such as plants, algae and some bacteria
- The process of photosynthesis is often written as:

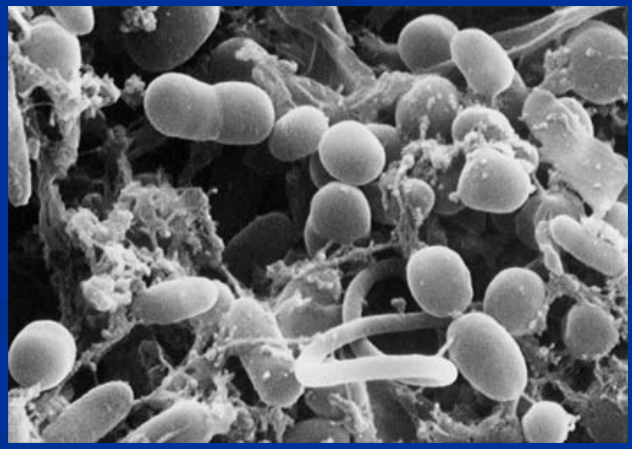
Photosynthesis and Solar Energy

- The Earth receives large amounts of energy from the sun
- However, very little of that energy is used for photosynthesis:

- 30% is reflected from the clouds and atmosphere
- 19% is absorbed by the atmosphere and clouds
- Of the remaining energy that reaches the ground, only 1 to 2% is used to drive photosynthesis

Chemosynthesis

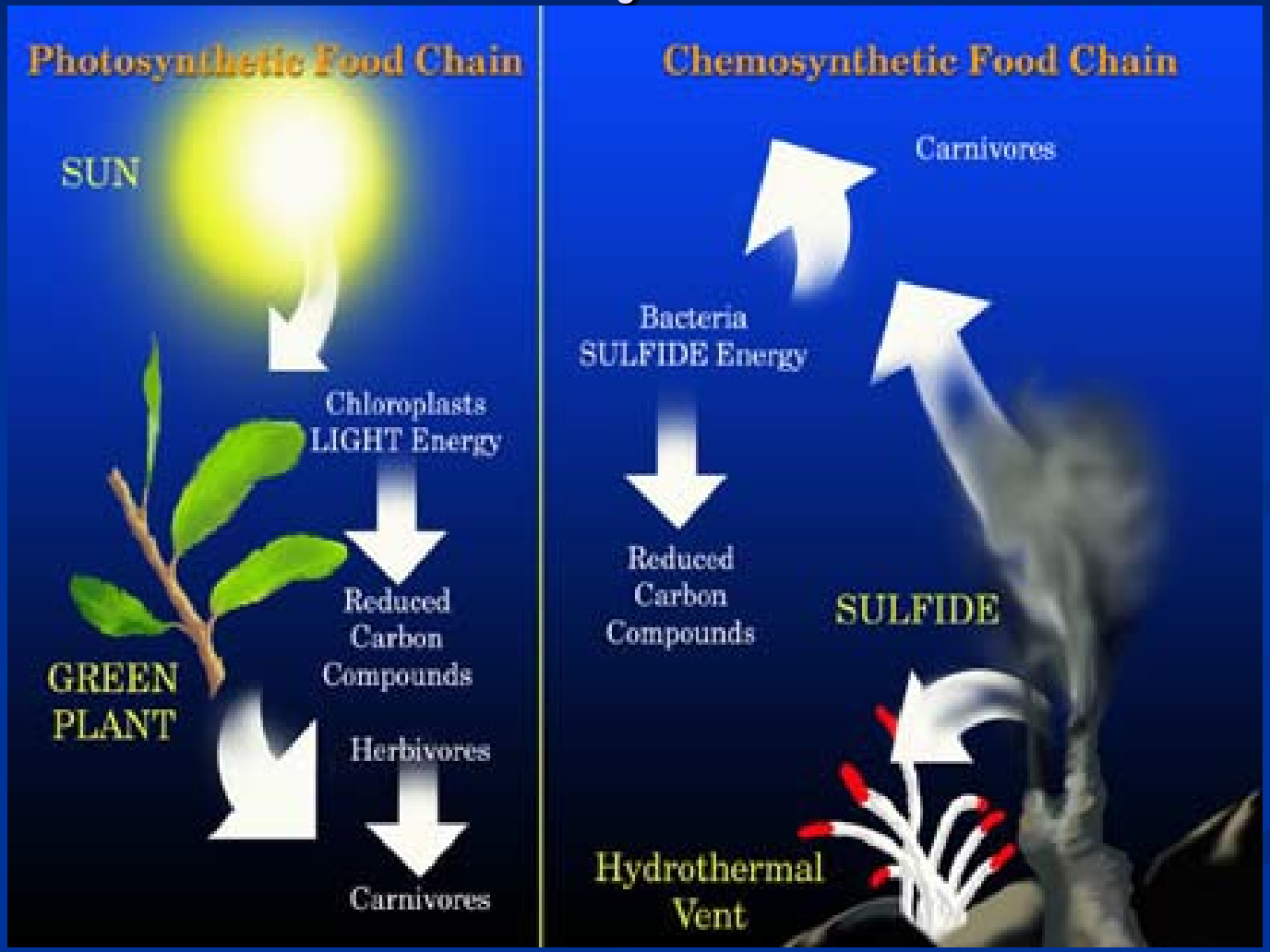
- Organisms that live in areas without life (such as the deepest parts of the ocean) cannot perform photosynthesis
- Near deep-sea vents in the ocean, specialized bacteria split hydrogen sulfide molecules that come out of the vents
- They use the energy obtained from breaking the chemical bonds to create energy-storing compounds



Chemosynthetic Organisms

- Other types of bacteria that carry out chemosynthesis have been found in other environments
- We now know that these organisms live in the cold ocean, in hot springs, salty lakes, deep caves, and even in soil
- Stanley Miller Experiment – Origins of life
- Secret life of plankton (phytoplankton & zooplankton)

Summary: Chemosynthesis vs. Photosynthesis



Consumers

- Consumers, aka heterotrophs, cannot capture the sun's energy directly
- Therefore, they must consume organic nutrients and include:
  - Herbivores, carnivores, omnivores
  - Decomposers – fungi, bacteria fungi clean up oil spills
    - Break down decaying matter releasing nutrients

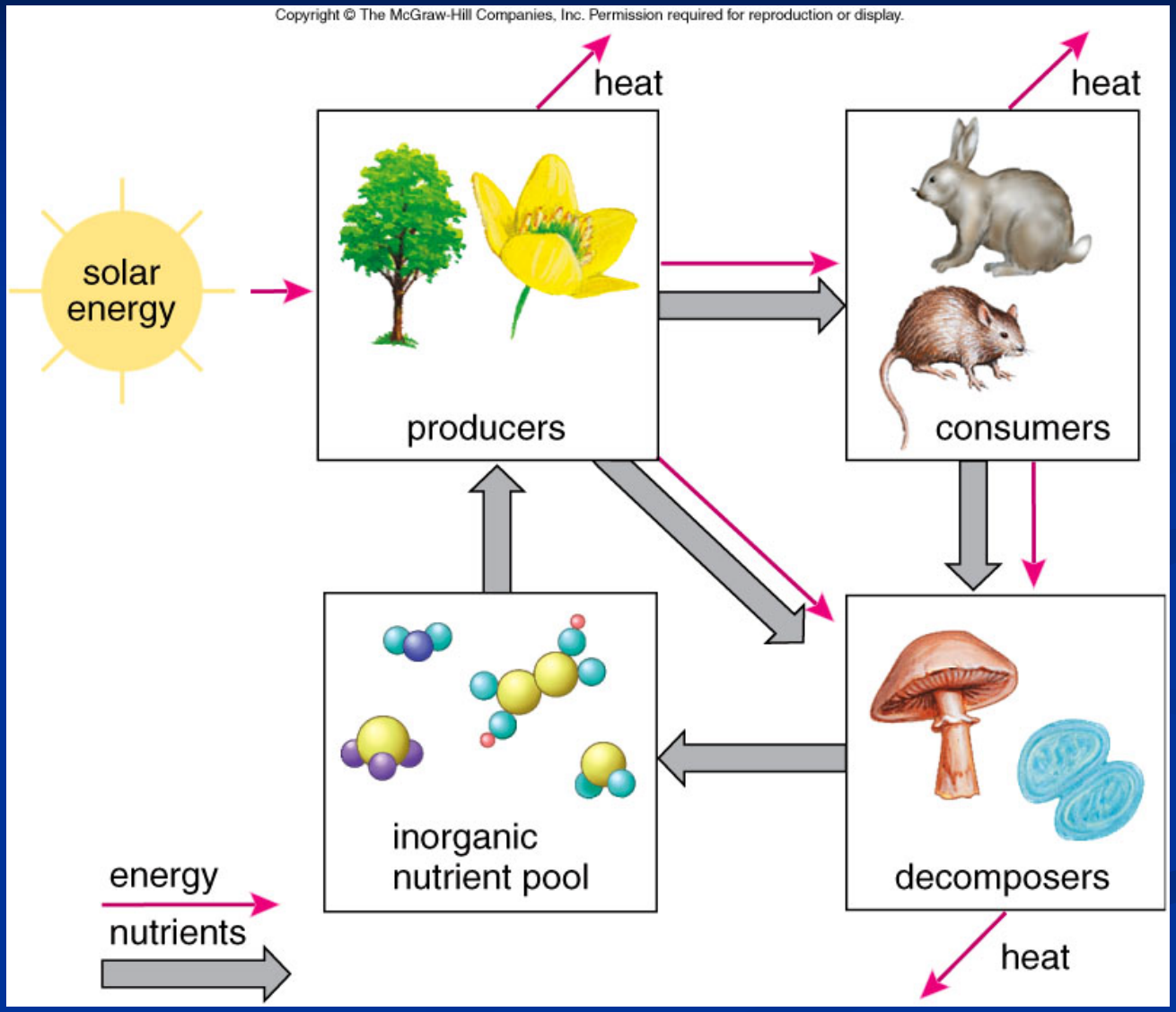
Levels of Consumers:

- Primary consumers (herbivores) eat producers
- Secondary consumers (carnivores) eat mainly herbivores
- Tertiary consumers are organisms that feed on other carnivores
- Occasionally, there are higher order consumers

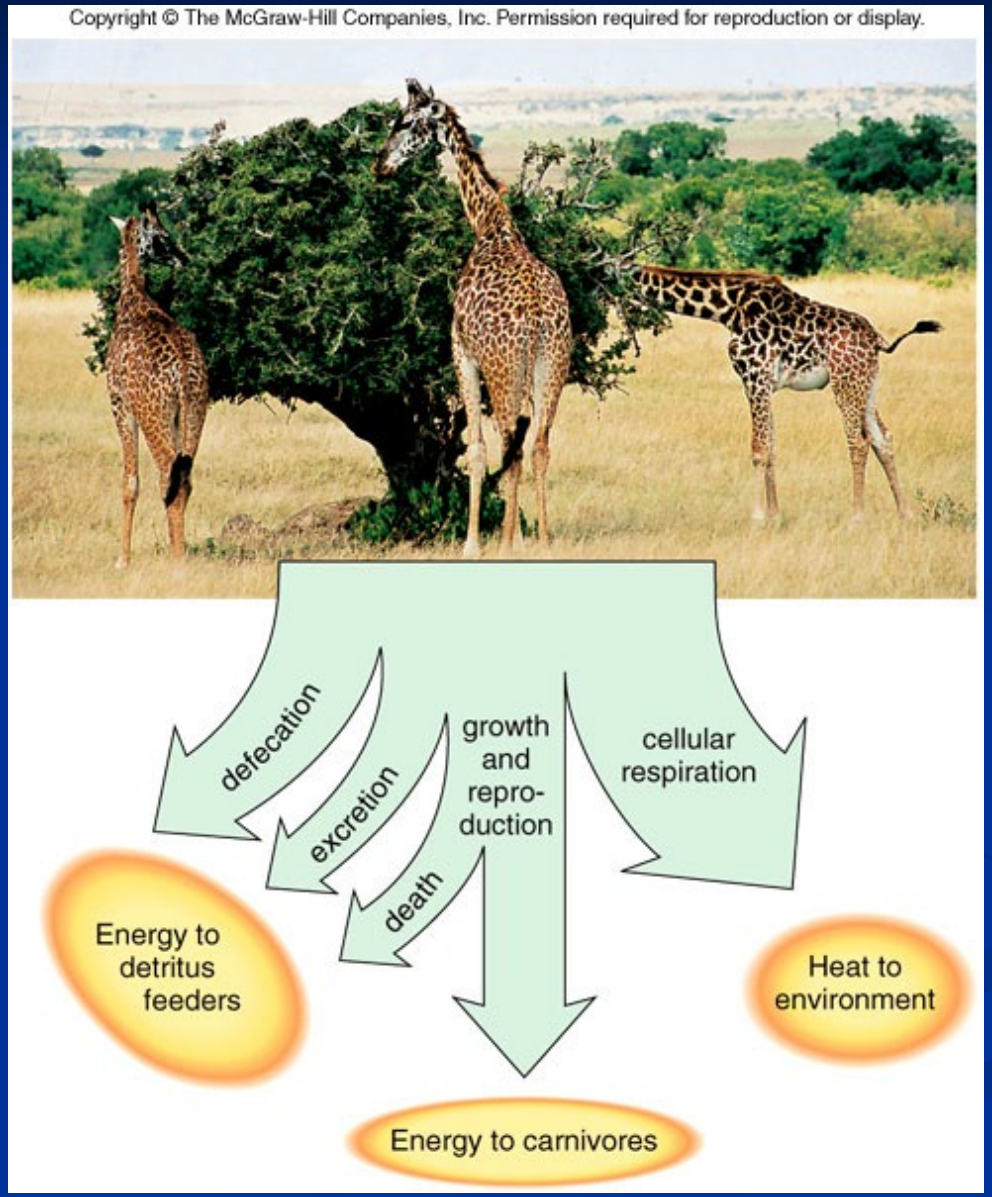
Decomposers

- Decomposers play an important role in ecosystems
- Without them, the nutrients trapped in the bodies of dead organisms would not be released
- Therefore, you can think of decomposers as nature's recyclers

Energy Flow and Chemical Cycling



Energy Balances



Energy in the Biosphere

- Earth can be considered a closed system
- The energy that the Earth receives does not cycle like matter does
- We are bound by the First and Second Laws of Thermodynamics:

Laws of Thermodynamics

- 1st : Energy is neither created nor destroyed, only converted in form
  - Therefore ecosystems depend on continual outside source of energy

- 2nd : with every conversion, some energy is given off as heat (nothing is 100% efficient)
  - Therefore the amount of available energy at each successive trophic level is less than the one below it (10% Rule)

Consequences of the Laws:

- As a result, we lose energy as it is passed along a food chain
- As a general rule, around 10% of the energy that is present at one level is passed on to the next
- This limits the number of trophic levels in an ecosystem to five or fewer

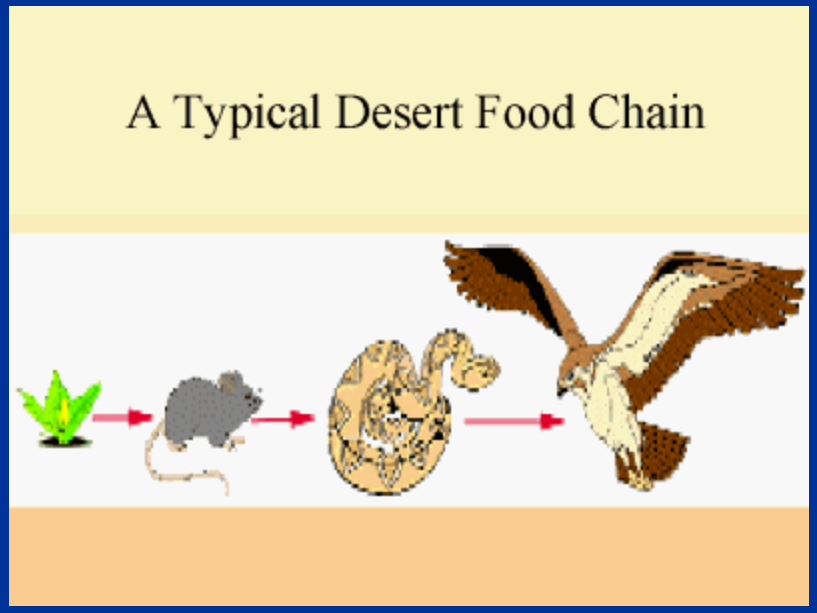
1.2 – How Energy is Transferred in the Biosphere

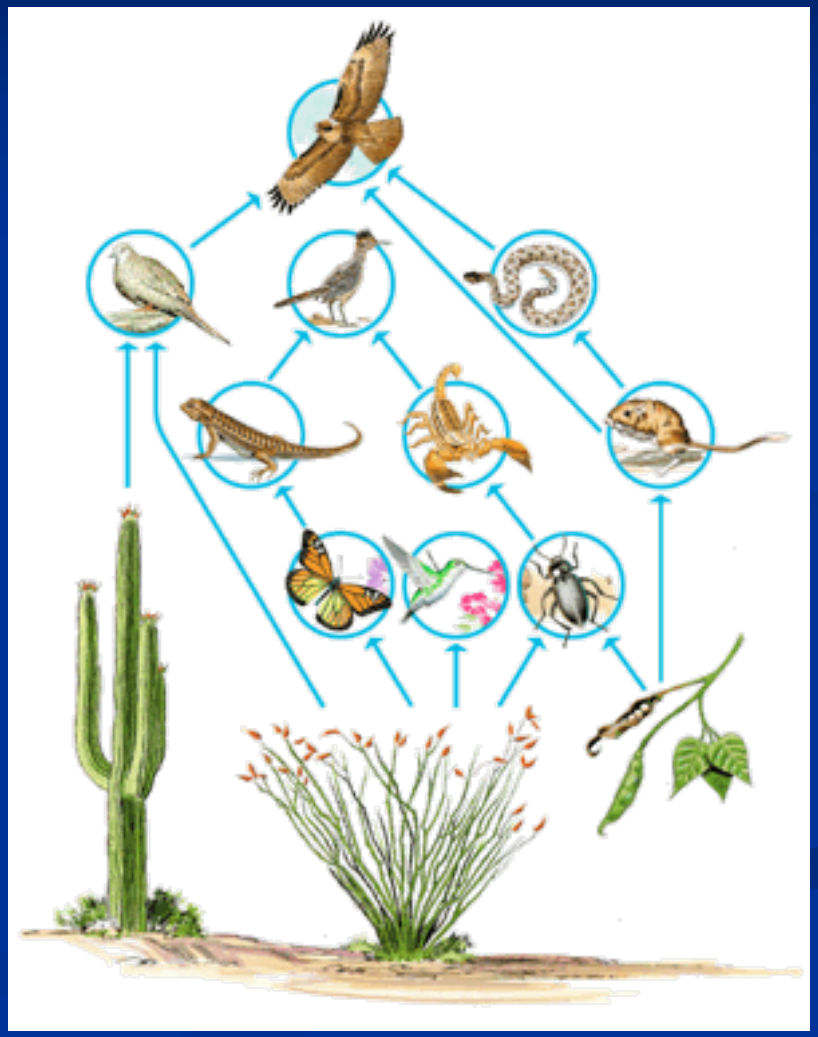
- We know that there are a number of trophic levels that exist in ecosystems
- Each trophic level represents a level through which energy and matter are transferred
- Trophic levels are basically the same as levels of producers, consumers, decomposers, etc
  - counted as the number of energy transfers away from the Sun. (ie: producers are the 1st trophic level)

Food Chains and Webs

- A food chain is a model showing a linear pathway through which energy moves in ecosystems
- Food webs show connections between different food chains

Food Chain vs Food Web

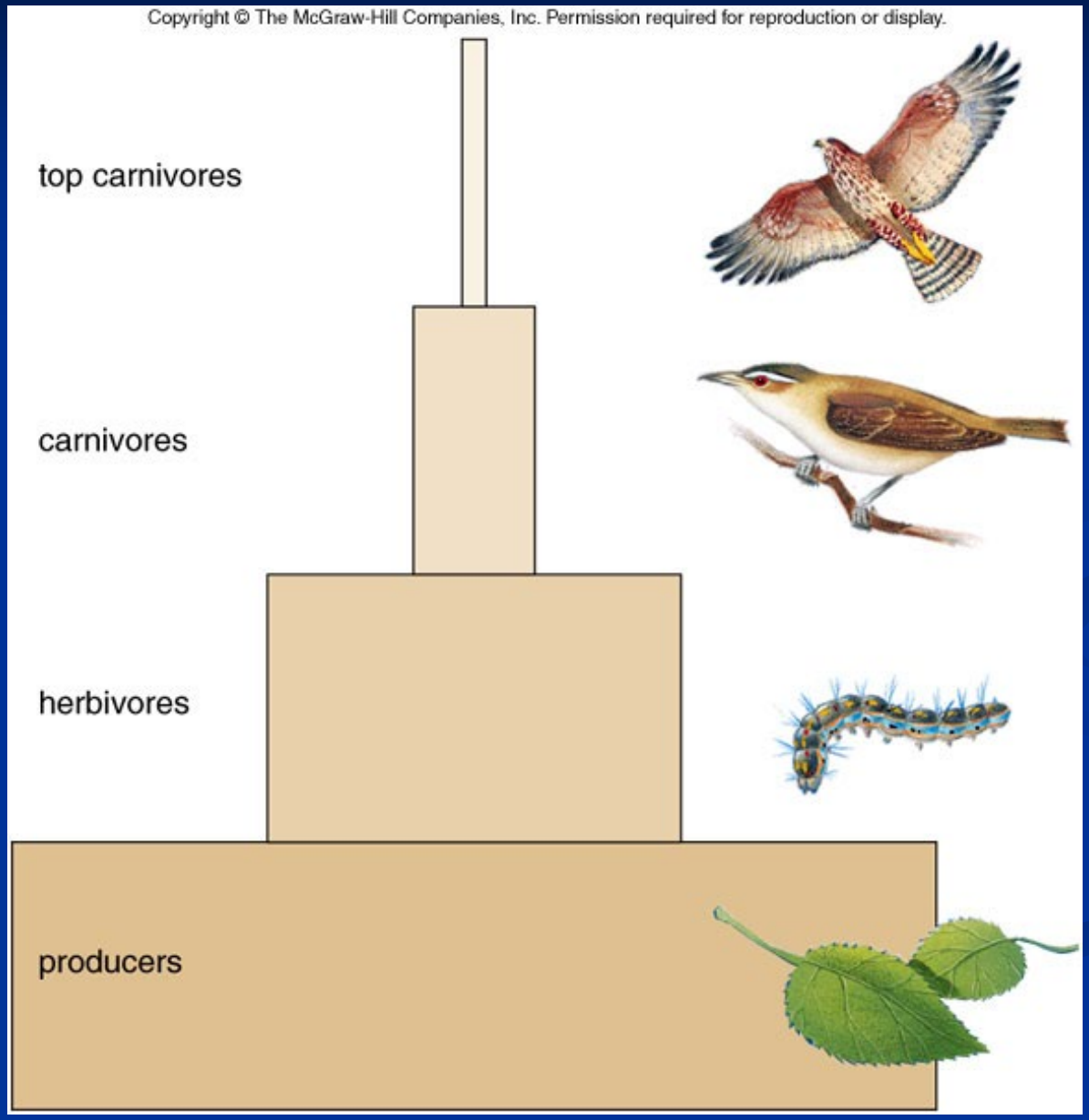




Ecological Pyramids

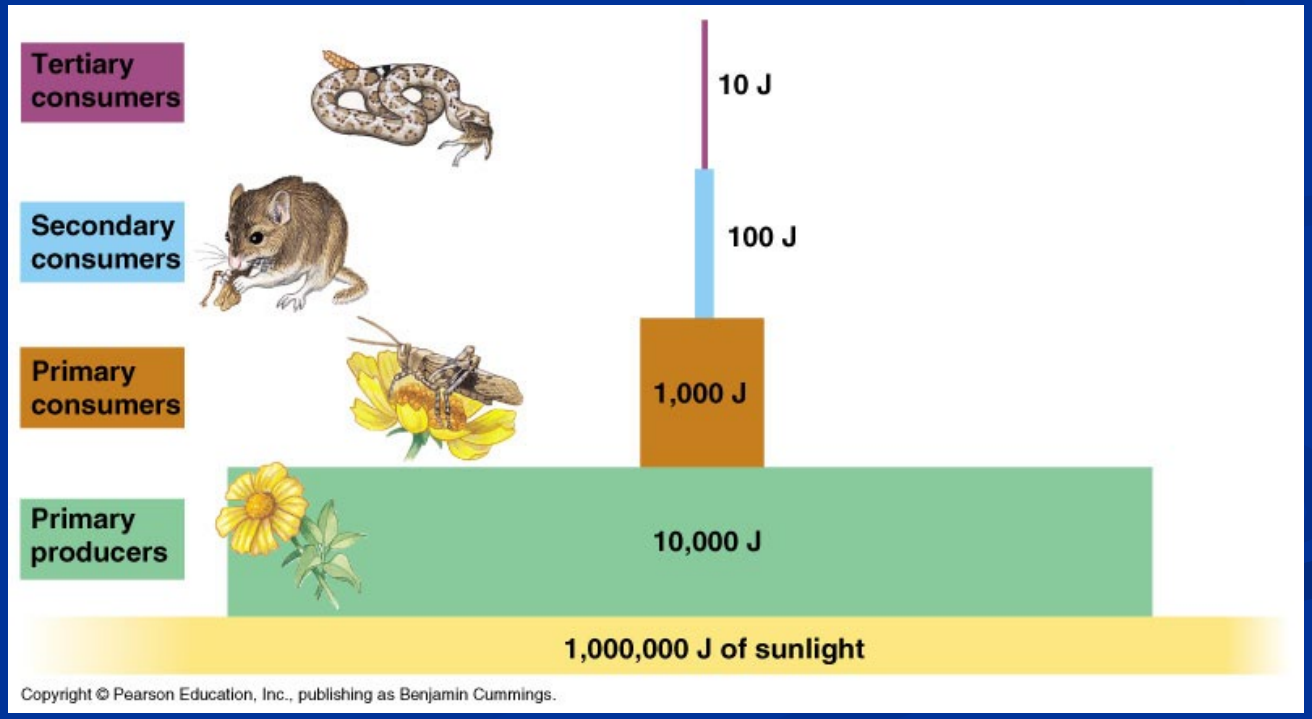
- Represent amount of available energy in each trophic level
- Producers (trophic level 1) are at the base – the most available energy
  - Energy is given off in less usable forms as producers are eaten by primary consumers, etc.
- They exist in three types:
  1. Energy
  2. Numbers
  3. Biomass

Ecological pyramid



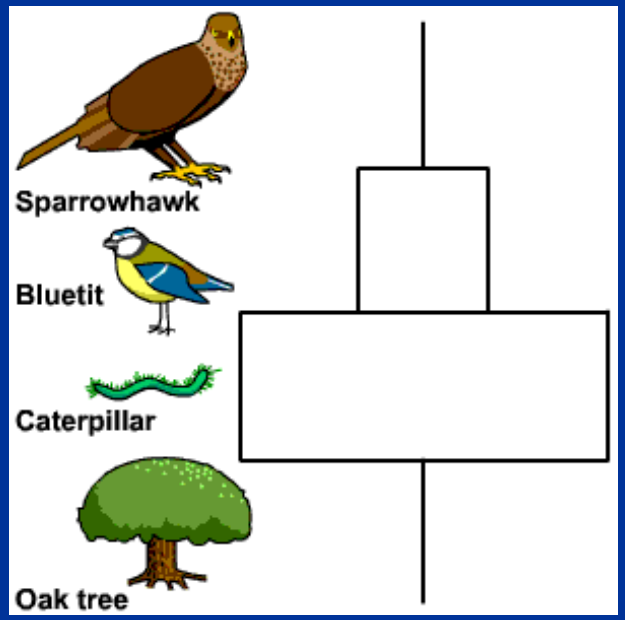
Pyramid of Energy

- A pyramid of energy represents the amount of energy that is transferred through each trophic level

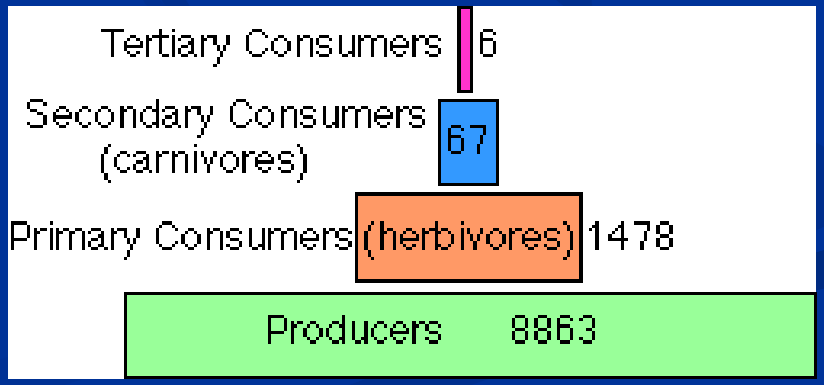


Pyramid of Energy

- Pyramids of energy will always be upright
- This is because these types of pyramids only represent the energy that is transferred through each trophic level



This pyramid of energy may match the pyramid of numbers shown on the left

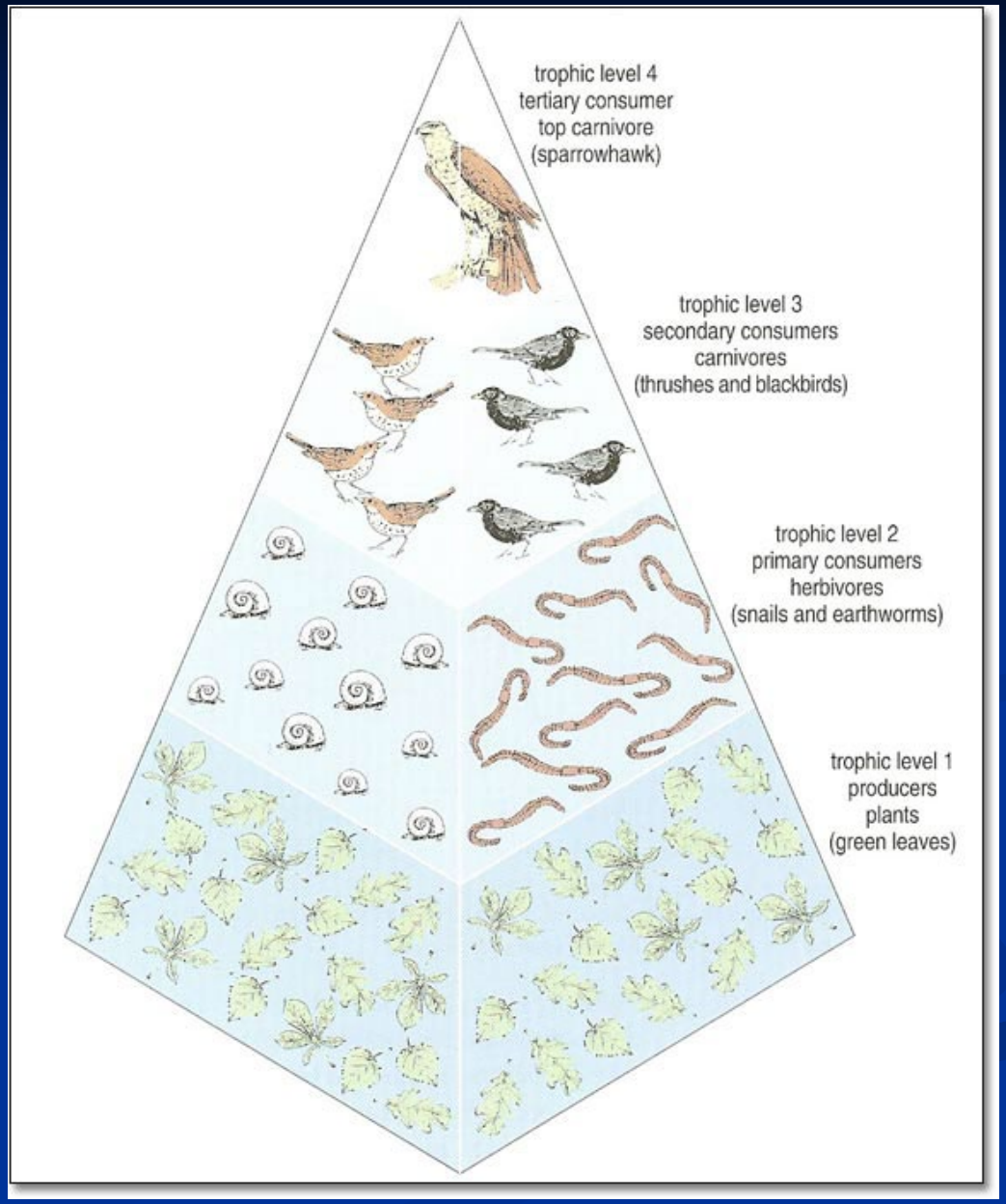


Disadvantages of the Pyramid of Energy

- To develop a pyramid of energy, we must know how much energy is contained in the tissues at each trophic level
- To do this, we must use calorimetry
- In this process, a sample of material is burned to determine how much energy it contains
- Therefore, it is very time consuming to determine values for a pyramid of energy

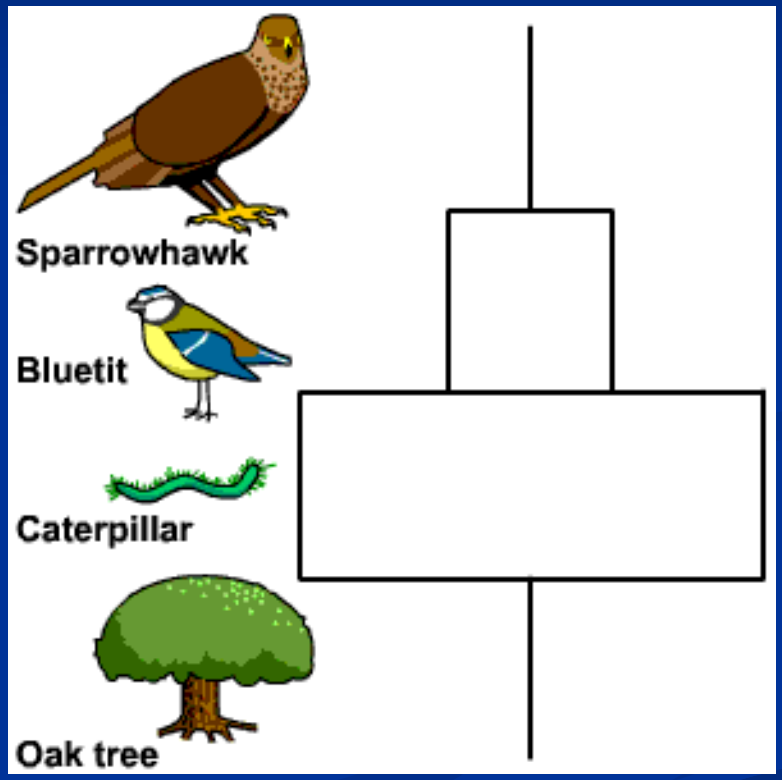
Pyramid of Numbers

- This represents the number of organisms that occupy each trophic level



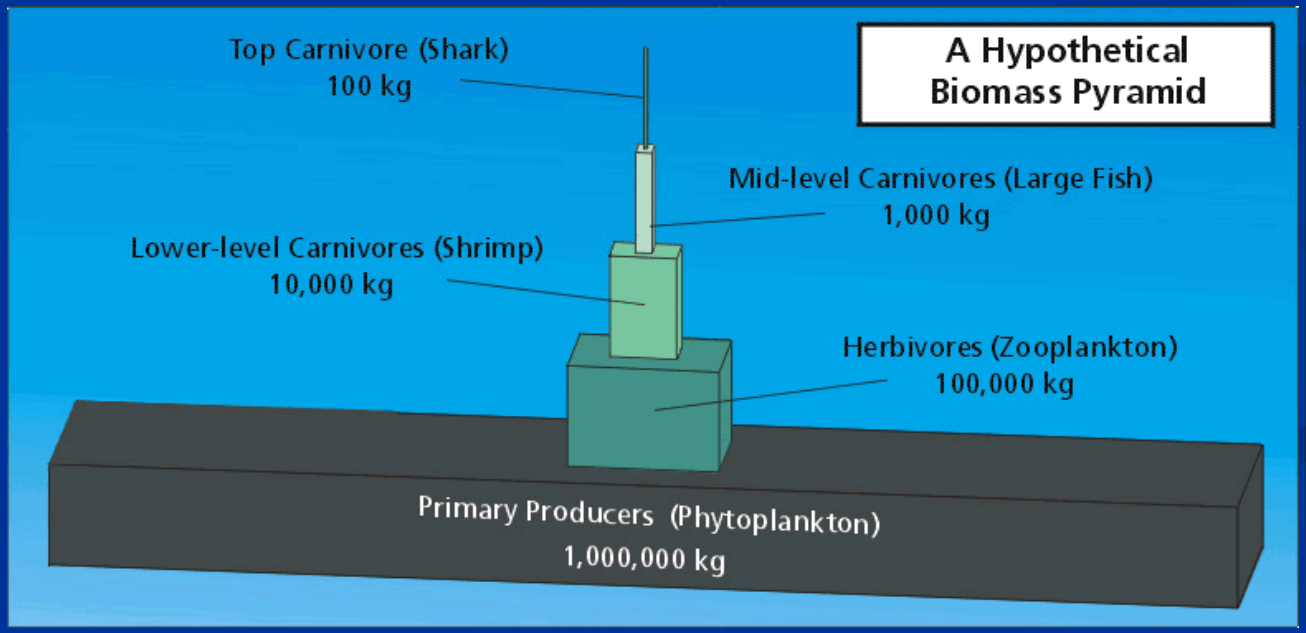
The Inverted Numbers Pyramid

- This inversion occurs when we have a large number of primary consumers feeding on a single producer
- There are a few cases where this will occur:



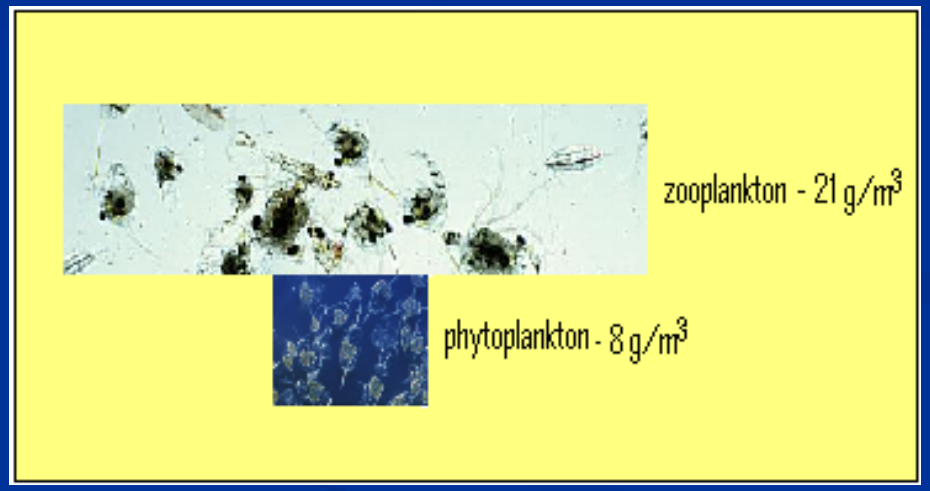
Pyramid of Biomass

- Biomass is the dry mass of living organisms per unit of area (found using numbers and average weight of each individual)
- The pyramid of biomass indicates the biomass present at each trophic level in an ecosystem

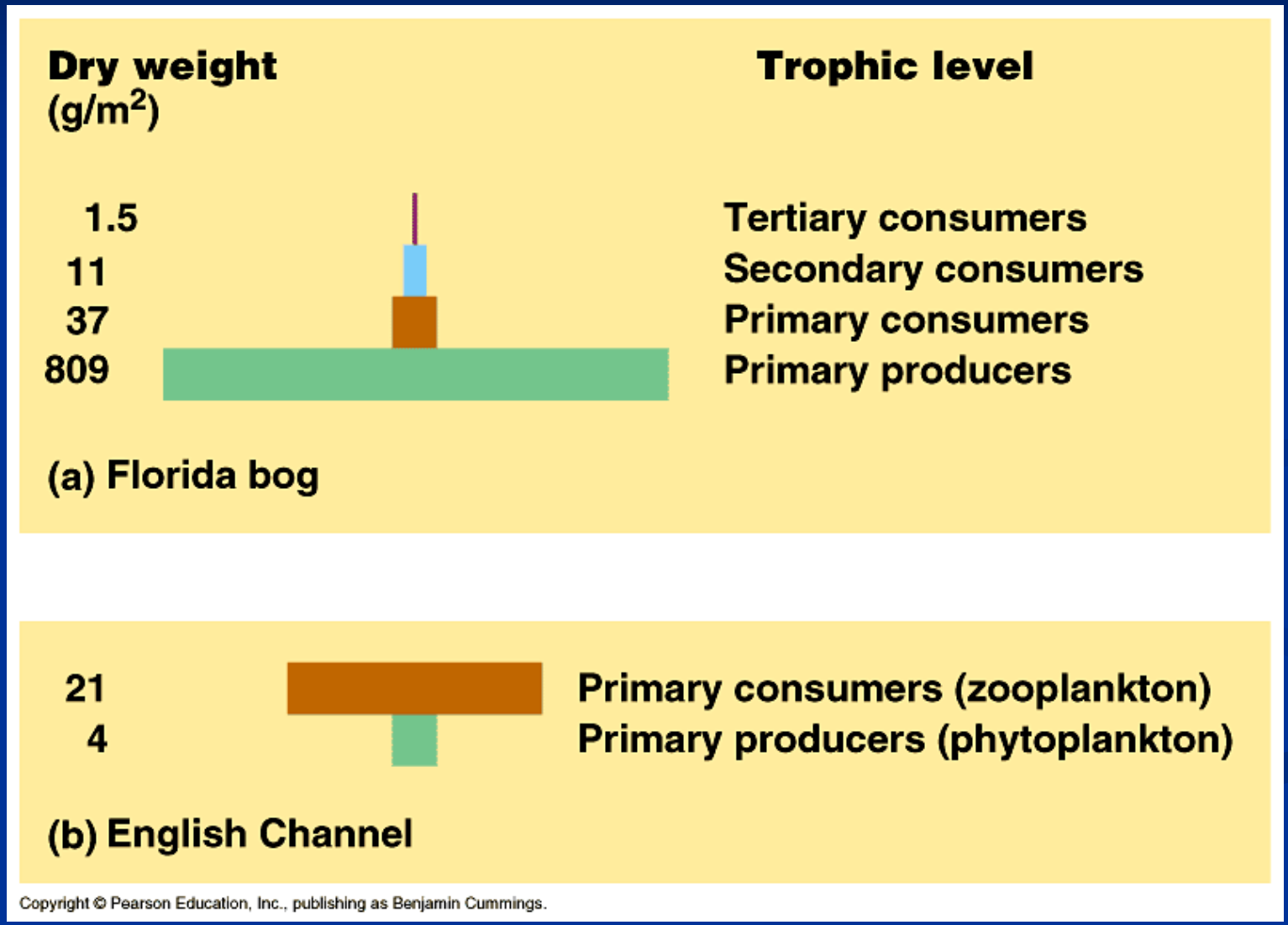


The Inverted Biomass Pyramid

- Ocean ecosystems may show an inverted biomass pyramid as the producers (phytoplankton) make up much less biomass than the zooplankton that feed on them
- Keep in mind, though that the phytoplankton transfer a larger amount of energy per kg of mass to the zooplankton



Comparing Different Biomass Pyramids



Advantages and Disadvantages of the Pyramids

- Pyramids of numbers and biomass can sometimes be inverted due to certain situations within ecosystems
- These inverted pyramids then lose their ability to accurately represent the passage of energy from one trophic level to the next

Energy Transfer and The Stability of Ecosystems

- As our climate changes, so will the distribution of organisms in our ecosystems
- If organisms at the bottom of these ecological pyramids are affected, then those changes will be passed on through the food chain
- If an ecosystem has fewer and less varied producers, then the food webs in this ecosystem will change, resulting in a more fragile ecosystem

Changing Ecosystems

- Large-scale changes in an ecosystem can be the result of two possible factors:

1. Natural Changes – these changes may include things like volcanic eruptions, earthquakes, floods, or fires. These changes can result in both a loss in energy and a loss in numbers of organisms.

2. Human interference – include pollution, land clearing, strip mining, and flooding (ie: due to dam construction).

   - There are three major human interactions that can adversely affect ecosystems:

I. Hunting and fishing can dramatically reduce numbers of organisms if there is no control on these industries. Remember there is big money to be made in fishing industries and black market poaching.

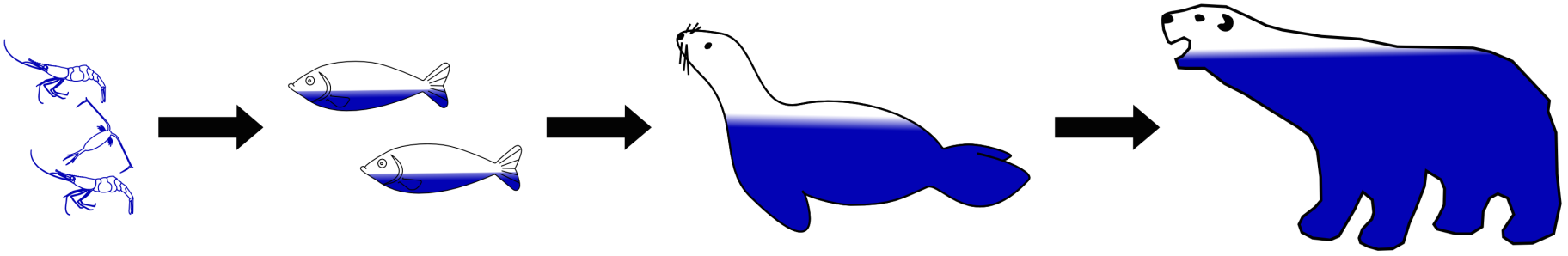
II. Another factor is something called monocultures. This refers to the clearing of many plant species in an area in order to grow a specific plant. This happens in rainforests as many trees and plants are cleared to grow crops.

III. The third major factor is the use of pesticides. The chemicals present in pesticides are designed to kill specific pests. However, sometimes these pests are eaten by predators before they are killed by the pesticide. The chemicals are then passed up the food chain and, because organisms in higher trophic levels must eat more organisms to maintain their energy, the chemical concentration grows as it moves up the food chain, affecting the higher-level organisms more. This effect is called biomagnification or biological amplification.

Biomagnification

- Explanation
- Minamata story
- Mad Hatters Disease
- Amoeba Sister

- Global distillation (the grasshopper effect)
- E.g. dioxins, furans, DDT, PCBs, Hg, Pb, PFA (Teflon)



Contaminant Levels

Biomagnification