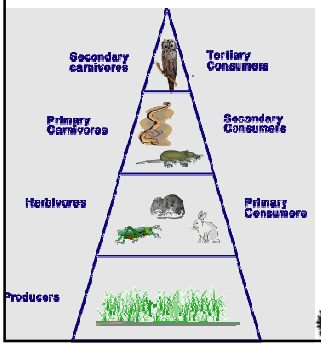
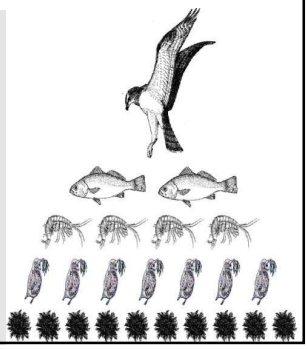
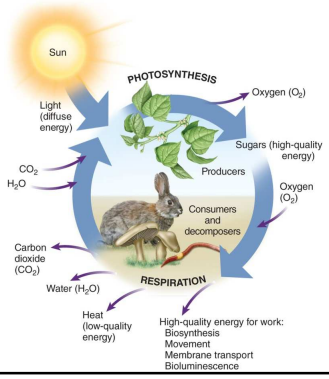
Ecosystems & Energy
Chapter 5



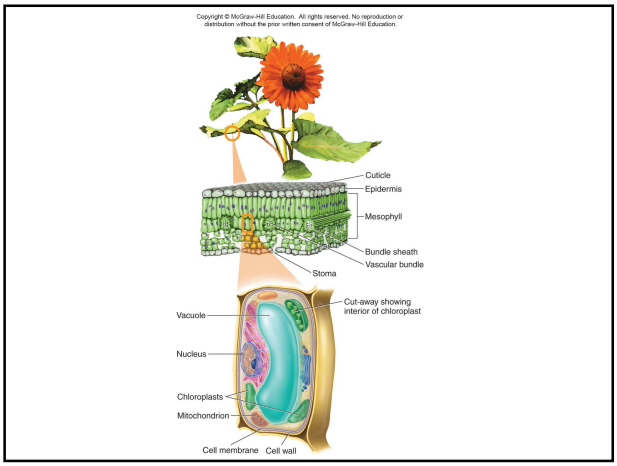


Energy Exchange in Ecosystems



Cells

- Cells - minute compartments in a living organism which carry out processes of life
  - Surrounded by lipid membrane controlling flow of materials in and out of cell
  - Interior may be sub-divided into organelles and sub-cellular particles.
- Enzymes - Molecular catalysts regulating chemical reactions. Enzymes are usually proteins.
- Metabolism - multitude of enzymatic reactions performed by an organism



From Species to Ecosystems

- Ecology – the scientific study of relationships between organisms and their environment
- Species - all organisms of the same kind that are genetically similar enough to breed in nature and produce live, fertile offspring
- Population - all the members of a species living in a given area at the same time
- Biological Community - all of the populations living and interacting in a particular area

From Species to Ecosystems

- Ecosystem - biological community and its physical environment
  - The physical environment includes non-living factors such as climate, water, minerals, sunlight.
  - It is difficult to define the boundaries of an ecosystem. Most ecosystems are open in that they exchange materials and organisms with other ecosystems.

- Gross Primary Productivity (GPP) is the total energy that is accumulated by plants through photosynthesis.
- Net Primary Productivity (NPP) is the energy left over after the plants use what they need for growing, living, etc.

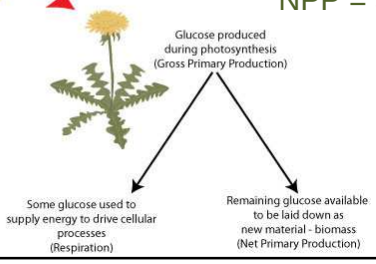
PROFITS = MONEY IN – COSTS

NPP = GPP – RESPIRATION

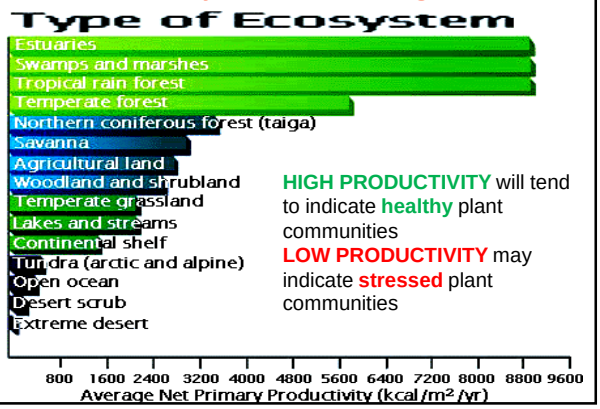
A bromeliad produces 1250 calories of energy and uses 750 calories of energy for growth. What is the NPP?

NPP = GPP - R

NPP = GPP – R
NPP = 1250-750
NPP = 500 cal



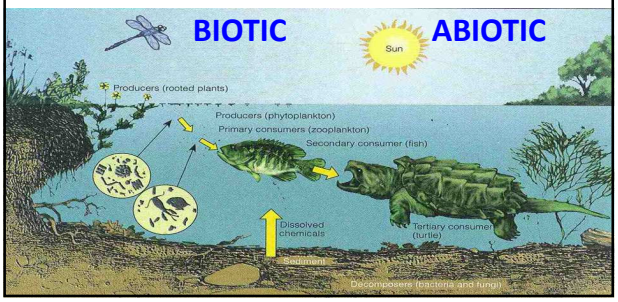
What Ecosystems Have High NPP?

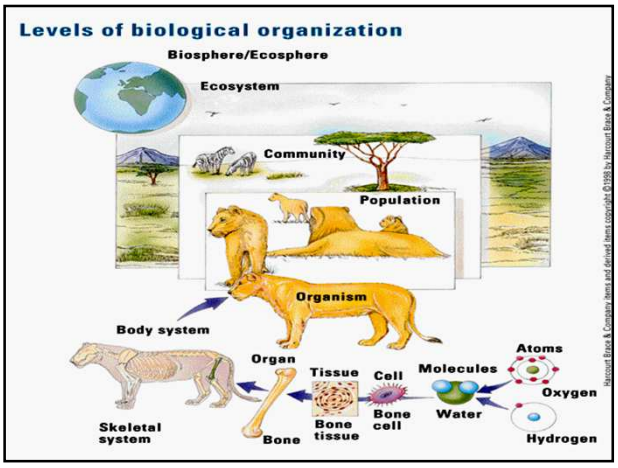


HIGH PRODUCTIVITY will tend to indicate **healthy** plant communities

LOW PRODUCTIVITY may indicate **stressed** plant communities

- **Ecology** - The study of ***relationships*** between organisms and their nonliving environment
- ***Eco*** = "house" ***ology*** = "study of"





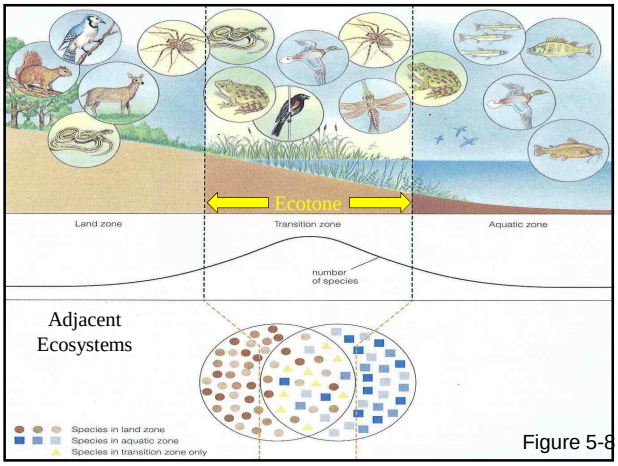
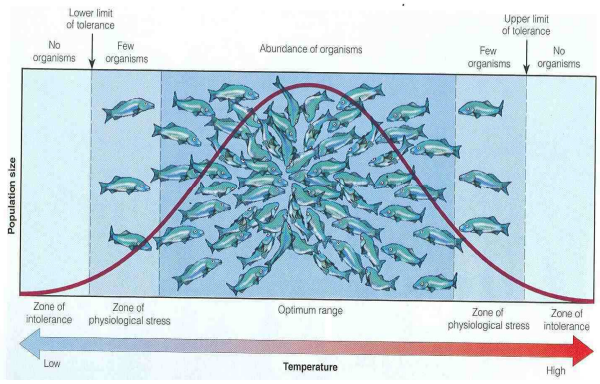
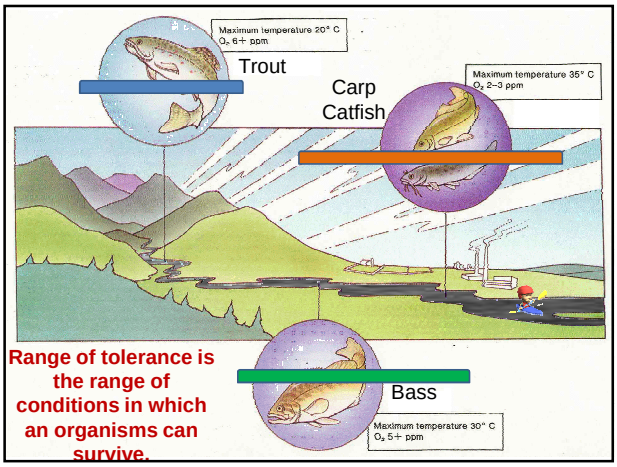


Figure 5-8

Range of tolerance is the range of conditions in which an organism can survive.





Range of tolerance is the range of conditions in which an organisms can survive.

Main Ecosystem Components

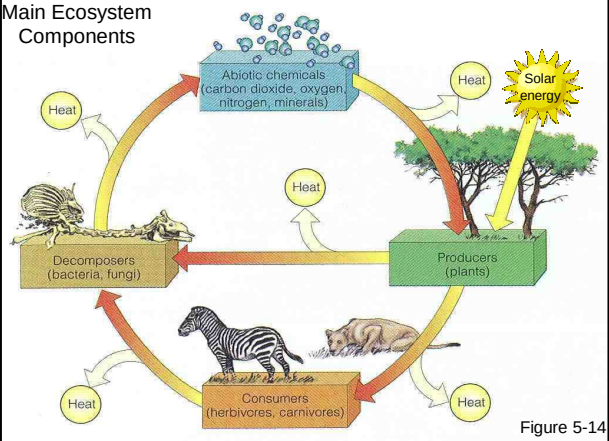


Figure 5-14

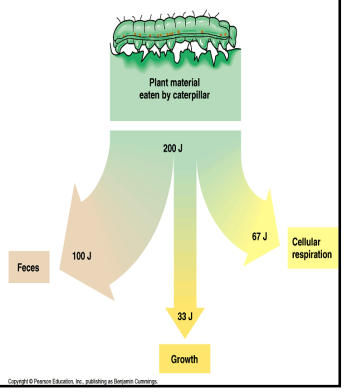
Measuring Energy

Two units commonly used:

- **Calories (c): amount of energy it takes to raise one g of water 1 °c**
- **Calories in food (C) = kilocalories(kcal) = 1000 calories**
- **Joules (J): 4.18 Joules = 1 calorie**

1st Law of Thermodynamics

- **Energy cannot be created nor destroyed**
- **May *change* from one form to another**



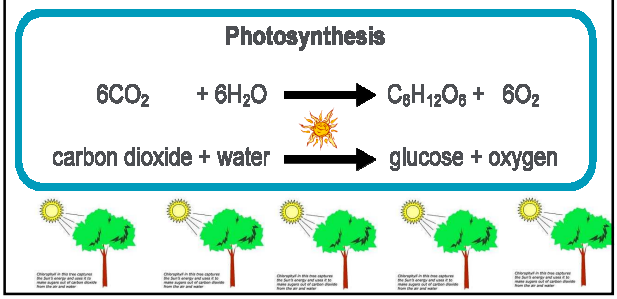
2nd Law of Thermodynamics

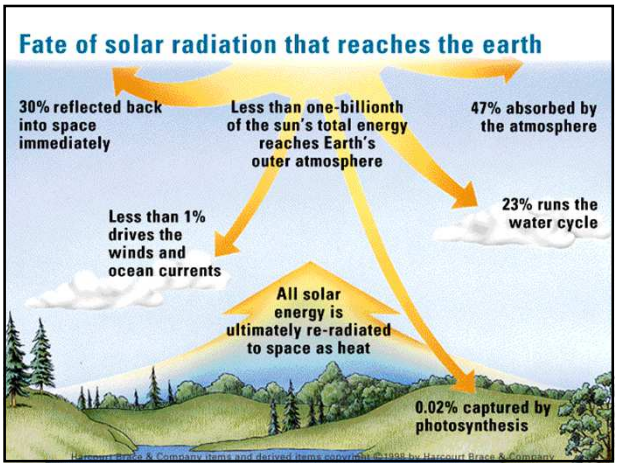
Energy goes from being concentrated to being more spread out

- **All reactions transform energy from higher to lower quality**
- **Systems spontaneously increase entropy**

How Energy Enters Ecosystems

- **Sun is ultimate source of energy for <u>most</u> ecosystems!**

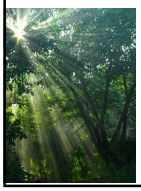


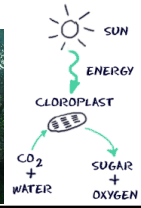


How Does Energy Move Through Ecosystems?

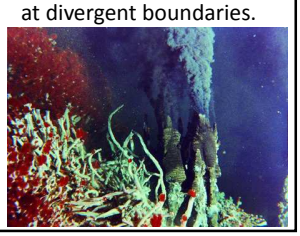
Producers (Autotrophs) – Organisms that can produce their own food.

- **Photo**trophs use photosynthesis. Use solar radiation to produce sugar
- Organisms: Plants, Algae, Bacteria, Phytoplankton
- Where?: Wherever there is sunlight





- **Chemo**trophs use Hydrogen Sulfide (H_2S) to produce sugars.
- Organism: Bacteria
- Where?: Deep Sea Vents at divergent boundaries.



Heterotrophs – cannot produce their own food and must eat other organisms to live.

- **Use Cellular Respiration to break down stored sugars .**
- **Primary consumers: Herbivores**

Cellular Respiration

$$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{Energy}$$

Heterotrophs

- **Secondary Consumers: Carnivores**
- **Tertiary Consumers: Carnivores**

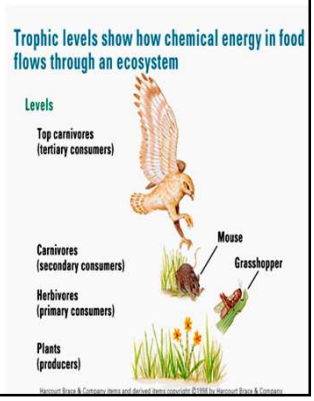
- **Omnivore – eat plants and meat**
- **Detritivore – decompose plant and animal parts as well as organic fecal matter**

Saprotrophs

- **Decomposers: Feed off dead organic matter in soil, release nutrients.**
- **Fungi and Bacteria**

Trophic Levels

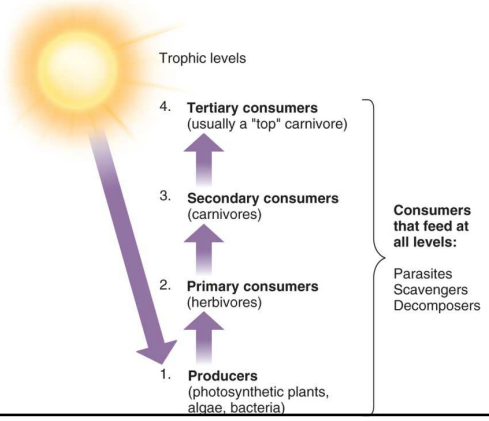
- **Food Chains (simple)**
- **Food Webs (complex)**
- **Trophic Levels: A feeding position in a food chain (producer, primary consumer, secondary consumer, etc. Energy flows from *one trophic level* to *another***

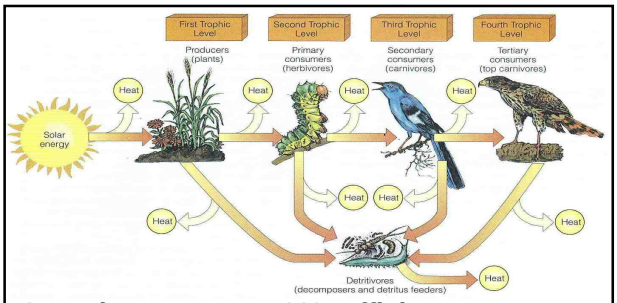


Trophic Levels

Organisms can also be identified by the type of food they consume:

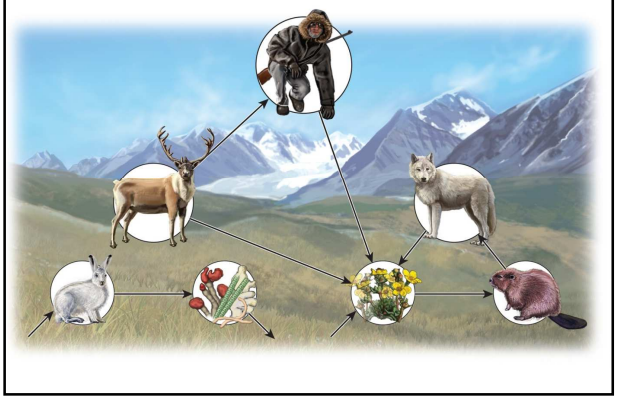
	Food source:	Example:
– Herbivores	(Plants)	{Deer}
– Carnivores	(Meat)	{Wolves}
– Omnivores	(Plants/Meat)	{Bears}
– Scavengers	(Carcasses)	{Crows}
– Detritivores	(Debris)	{Ants}
– Decomposers	(All)	{Bacteria}





- **Organisms are *not* 100% efficient**
  - **Only 10% of the energy at one level makes it to the next level (90% released as heat, organisms use energy for growth, waste)**

A Food Web



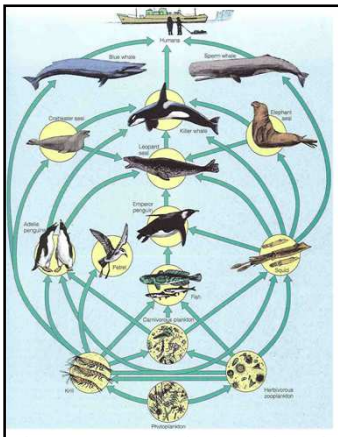
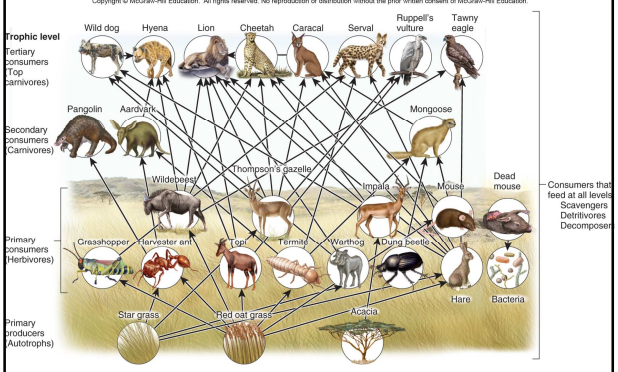


Figure 5-17: Marine Food Web

FOOD WEBS

- The more connections, the more stable the ecosystem.
- Usually no more than 3-4 levels in a food chain/web
- ***Fewer and fewer*** organisms as you go up?
- Can you explain why?

A Food Web



Food Chains and Food Webs

- Photosynthesis is at the base of all ecosystems so photosynthesizers (usually plants) are called the producers.
- Productivity - the amount of biomass produced in a given area during a given period of time.
  - Photosynthesis is described as *primary productivity* because it is the basis for all other growth in an ecosystem.
  - *Secondary productivity* - manufacture of biomass by organisms that eat plants

Food Chains and Food Webs

Food Chain - linked feeding series

Food Web – interconnected food chains as most consumers have multiple food sources.

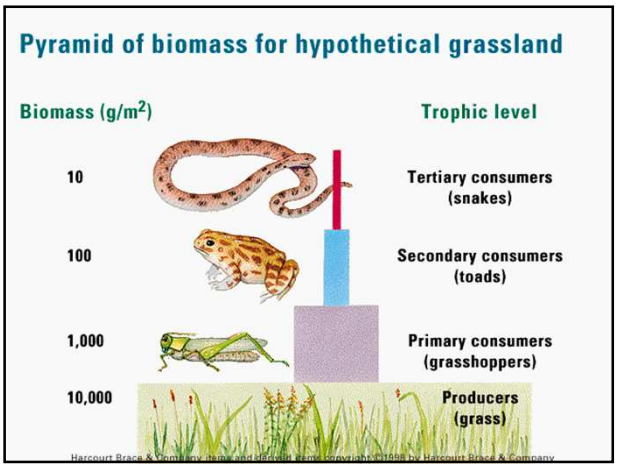
Trophic level - An organism's feeding status in a food web. Plants are at the producer level while animals are consumers. Animals that eat plants are primary consumers (herbivores) while animals that eat other animals are secondary and tertiary consumers (carnivores or omnivores). The organisms that recycle dead bodies and remove waste are scavengers/detritivores and decomposers.

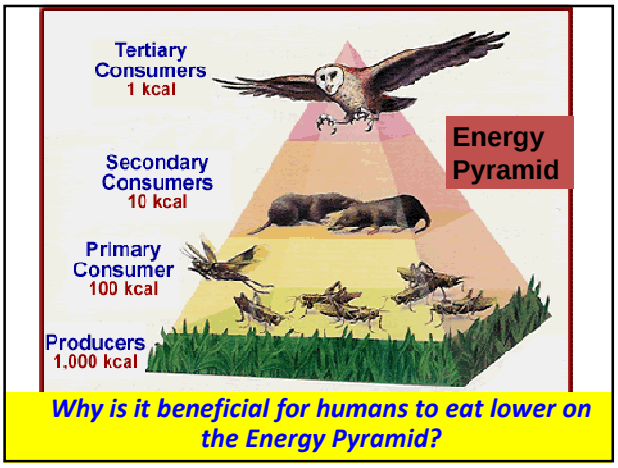
Trophic Pyramids

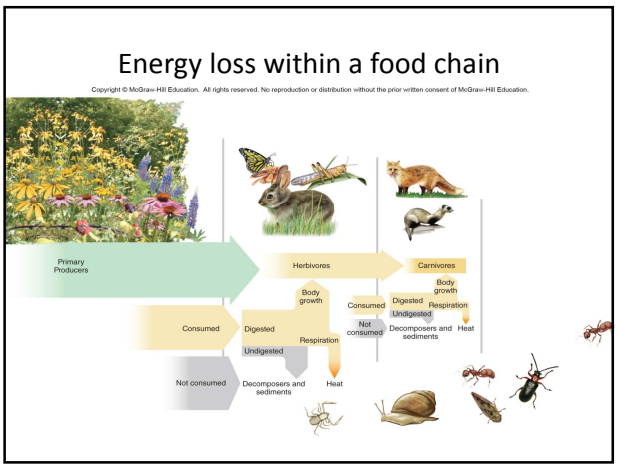
- **Pyramid of #'s shows the number of individuals at each trophic level.**
- **Can be inverted if the producer is large and supports a large number of organisms above. it.**

Ecological Pyramids

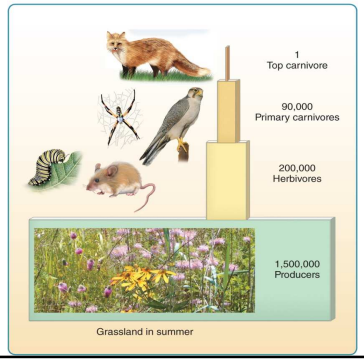
- If the organisms at various trophic levels of a food chain are arranged diagrammatically they form a pyramid with many more producers than consumers forming the broad base of the pyramid.
- Due to the Second Law of Thermodynamics, energy is lost at each level of the pyramid.
  - Energy is lost as heat in metabolic processes.
  - 10% Rule (Energy / Biomass transfer)
    - 100 kg clover
      - 10 kg rabbit
        - » 1 kg fox


Pyramid of biomass for hypothetical grassland
Biomass (g/m2)
Trophic level
10
Tertiary consumers (snakes)
100
Secondary consumers (toads)
1,000
Primary consumers (grasshoppers)
10,000
Producers (grass)


Tertiary Consumers 1 kcal
Secondary Consumers 10 kcal
Primary Consumer 100 kcal
Producers 1,000 kcal
Energy Pyramid
Why is it beneficial for humans to eat lower on the Energy Pyramid?


Energy loss within a food chain
Primary Producers
Herbivores
Carnivores
Consumed
Digested
Undigested
Not consumed
Body growth
Respiration
Decomposers and sediments
Heat

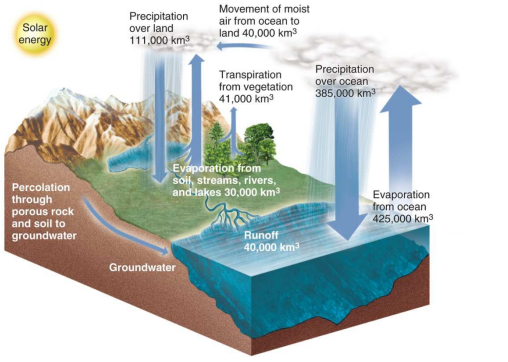
Energy Pyramid



Material Cycles

- Hydrologic Cycle - path of water through the environment
  - Solar energy continually evaporates water stored in the oceans and land, and distributes water vapor around the globe.
  - Condenses over land surfaces, supporting all terrestrial systems
  - Responsible for cellular metabolism, nutrient flow in ecosystems, and global distribution of heat and energy

Hydrologic Cycle



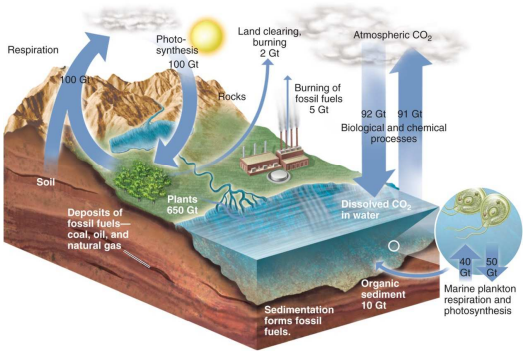
Carbon Cycle

- Begins with intake of CO_2 during photosynthesis. Carbon atoms are incorporated into sugar which is eventually released by cellular respiration either in the plant or in organisms that consumed it.
- Sometimes the carbon is not recycled for a long time. Coal and oil are the remains of organisms that lived millions of years ago. The carbon in these is released when we burn them. Some carbon is also locked in calcium carbonate (fossil shell deposits of limestone).

Carbon Cycle

- The parts of the cycle that remove carbon dioxide from the atmosphere (live vegetation) are called carbon sinks.
- The parts of the cycle that release carbon dioxide are called carbon sources.
- Burning of fuels generates huge quantities of carbon dioxide that cannot be taken up fast enough by the carbon sinks. This excess carbon dioxide contributes to global warming.

Carbon Cycle



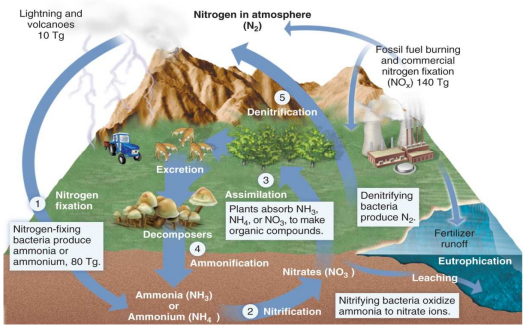
Nitrogen Cycle

- Nitrogen is needed to make proteins and nucleic acids such as DNA (Chap. 2).
- Plants take up inorganic nitrogen from the environment and build protein molecules which are later eaten by consumers.
- Nitrogen-fixing bacteria change nitrogen to a more useful form by combining it with hydrogen to make ammonia. Other bacteria convert ammonia to nitrites and nitrates, which can be taken up by plants to make proteins.

Nitrogen Cycle

- Nitrogen re-enters the environment:
  - Death of organisms
  - Excrement and urinary wastes
- Nitrogen re-enters atmosphere when denitrifying bacteria break down nitrates into N_2 and nitrous oxide (N_2O) gases.
- Humans have profoundly altered the nitrogen cycle via use of synthetic fertilizers, nitrogen-fixing crops, and fossil fuels.

Nitrogen Cycle



Root nodules on a bean plant

Members of the bean family (legumes) have nitrogen-fixing bacteria living in nodules of their root tissue.

Phosphorous Cycle

- Phosphorous is needed to make DNA, ATP (the energy currency of the cell) and other important biomolecules (Chap. 2).
- Phosphorous compounds are leached from rocks and minerals and usually transported in aqueous form.
  - Taken in and incorporated by producers
    - Passed on to consumers
      - Returned to environment by decomposition
- Cycle takes a long time as deep ocean sediments are significant sinks

Phosphorus Cycle