Some Fundamental Principles of Ecology

BI 201 Natural History of Guam

Class Presentation 27

- What is Ecology?
  - Ecology is the study of the interrelationships between organisms and their environment and each other
  - The fundamental unit of study in ecology is the ecosystem
    - An ecosystem is a relatively self-contained system consisting of the physical and chemical environment, plus all the living organisms in a given area

- By self-contained, scientists mean that the amount of matter that flows into and out of an ecosystem is small compared to the quantities that are recycled in a continuous exchange
- It is the dynamics of this flow and adaptations of species to this flow that constitutes the subject matter of *ecology* of natural systems
- Ecologists usually regard an ecosystem as an isolated unit, but this is merely a useful simplification; actually, ecosystems interact with one another

- Ecosystems consist of both biotic and abiotic components
  - Abiotic components are nonliving, including factors such as:
    - Chemicals (H_2O, $CaCO_3$, organics)
    - Climatic factors (light, temperature, rainfall, humidity, wind, etc.),
    - Physiographic factors (rivers, mountains, valleys, soil, etc.)
  - Biotic components are living

- Biotic Components
  - Biotic community
    - A community consists of interacting groups of plants and animals inhabiting the same physical environment
    - A biotic community consists of
      - i) producers, and
      - ii) consumers

- Producers
  - Producers are autotrophic organisms that synthesize organic matter from inorganic materials, and form the base of ecological trophic structures
  - Autotroph
    - An autotroph is any organism that is able to utilize inorganic sources of carbon, hydrogen, etc. as starting materials for synthesis of organic compounds, using either sunlight or chemical energy
    - Photoautotrophs use energy from sunlight for synthesis
    - Chemoautotrophs use chemical energy for synthesis

- Note that many texts state that producers *manufacture their own food*, when in fact, they manufacture organic matter making up their bodies
- These organic materials are thereafter available as a reservoir of chemical energy for both the producer and any organisms that may feed upon it
- This definition includes *photosymbionts*, which are functional autotrophs (organisms that possess symbiotic photosynthetic algae in their tissues, such as reef-building corals and giant clams)

- Consumers
  - Consumers are organisms that obtain organic materials by consuming other organisms, the by-products of other organisms, or the remains of dead organisms
  - By definition, consumers are heterotrophs
  - Classes of consumers
    - Herbivores (feed exclusively on plants)
    - Carnivores (feed exclusively on flesh of other animals)
    - Detritivores (feed on *detritus* [decaying remains of dead organisms])

- Flow of Energy
  - All activity, whether physical or biological, is the result of the movement of *energy*
  - Energy is the ability to do *work*
    - Work is force applied through a distance

      $W = F \bullet d \bullet \cos\Theta$
    - Energy occurs in many forms
      - For example, heat, light, chemical, electrical, nuclear, etc.

- All forms of energy can be transformed into other forms
- Energy transformations obey certain physical laws of thermodynamics
  - First Law of Thermodynamics
    - A.k.a. the Law of Conservation of Energy
    - States that "In any energy transformation, energy is neither created nor destroyed"
    - The first law applies to both living and nonliving systems, so every organism must fulfill its energy needs by relying on energy transformations within its ecosystem or adjacent ones

- Second Law of Thermodynamics
  - "In every energy transformation, some energy is always lost in the form of heat that is thereafter unavailable to do further work"
  - The energy that is lost as heat cannot be transformed back into a more concentrated form to perform work ever again; it is essentially lost forever
  - Energy can never be recycled; it only flows through an ecosystem

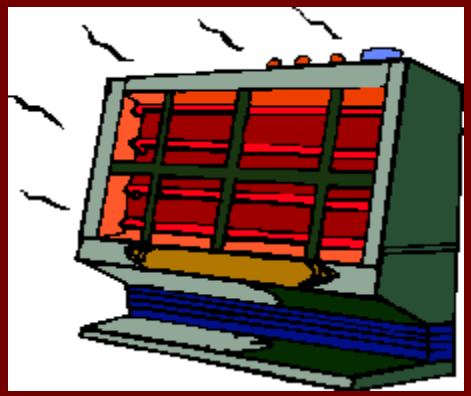
- Biological consequences of the second law
  - Organisms (being highly organized systems) require a continual input of energy in order to maintain their organization
    - e.g., in humans, 5 million red blood cells break down every second; thus, energy is constantly needed to manufacture new cells
  - Energy cannot be recycled as most materials can be
  - Energy that is being lost as heat is continually being replaced by the inflow of solar energy, which is more ordered than heat energy and can be trapped by green plants as chemical energy in bonds of organic matter

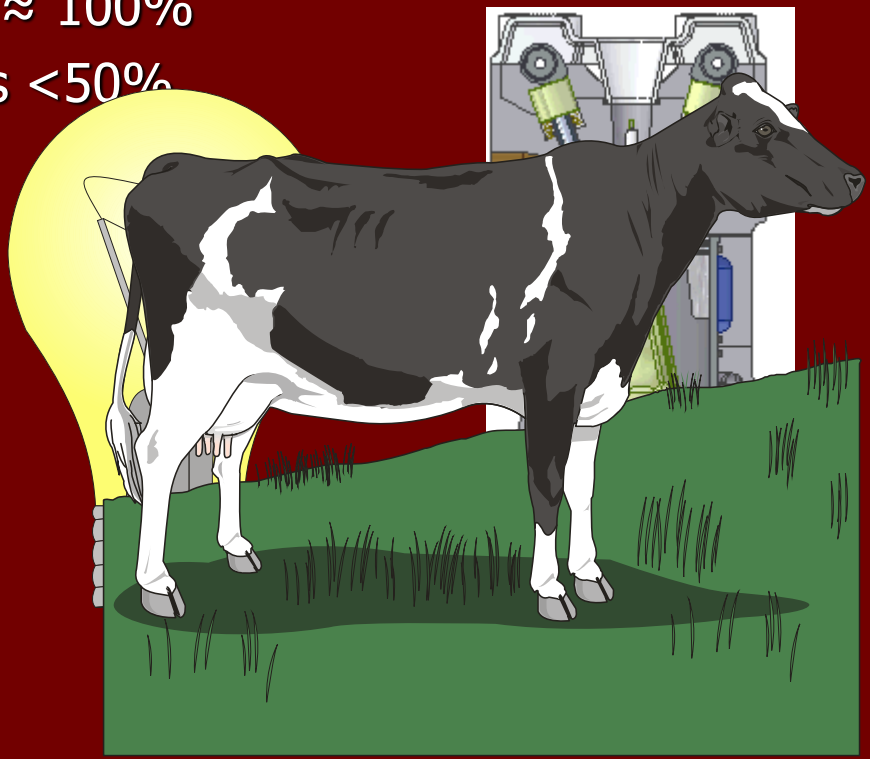
- Efficiency
  - Efficiency is a measure of the percentage of total energy input that is transformed into work or some other usable form of energy

$$P.E. = \frac{\text{Energy output as work}}{\text{Total energy input}} \times 100$$

where P.E. = percent efficiency

- Some examples of efficiency
  - gasoline engine = 20-25%
  - incandescent light = 5%
  - oil furnace = 65%
  - electric space heater ≈ 100%
  - most living organisms <50%





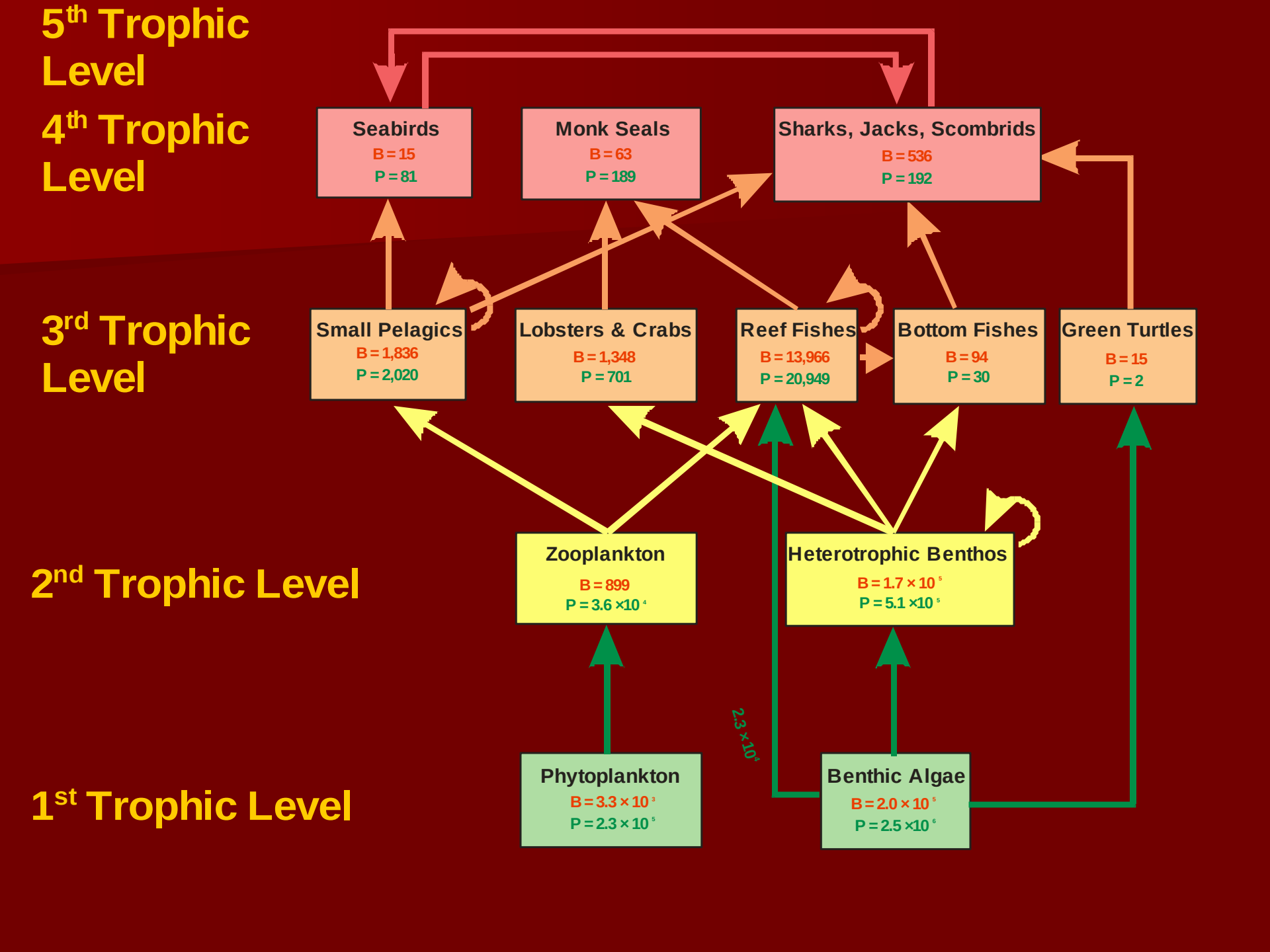
- Trophic Relations: Energy Flow in Biotic Communities
  - Because energy is the currency of life, ecologists are especially interested in trophic relations of biotic communities
  - All organisms, dead or alive, are potential sources of food energy for other organisms
  - This energy always moves in only one direction: from producers to consumers

- Ecologists map the movement of food energy in the form of a food chain
  - A food chain is a simple, straight-line pathway of food energy flow

    Seaweed ➡ crab ➡ fish
- However, herbivorous fishes feed on seaweeds, as well
- Therefore, food energy flow is seldom a simple, straight-line path

- Natural ecosystems consist of complicated networks of many interconnected food chains, making up a food web
  - Each group of organisms along an energy pathway occupies a *trophic level* or feeding level
  - Because producers capture solar energy and make it available to consumers, they occupy the 1st trophic level
  - Herbivores occupy the 2nd trophic level

- Carnivores feeding upon herbivores (i.e., *primary carnivores*) occupy the 3rd trophic level
- Carnivores feeding upon other carnivores (i.e., *secondary carnivores, tertiary carnivores,* etc.) occupy the 4th and successive trophic levels
- Some organisms function at more than one trophic level


5th Trophic Level
4th Trophic Level
3rd Trophic Level
2nd Trophic Level
1st Trophic Level
Seabirds
B = 15
P = 81
Monk Seals
B = 63
P = 189
Sharks, Jacks, Scombrids
B = 536
P = 192
Small Pelagics
B = 1,836
P = 2,020
Lobsters & Crabs
B = 1,348
P = 701
Reef Fishes
B = 13,966
P = 20,949
Bottom Fishes
B = 94
P = 30
Green Turtles
B = 15
P = 2
Zooplankton
B = 899
P = 3.6 ×10 4
Heterotrophic Benthos
B = 1.7 × 10 5
P = 5.1 ×10 5
2.3 ×10 4
Phytoplankton
B = 3.3 × 10 3
P = 2.3 × 10 5
Benthic Algae
B = 2.0 × 10 5
P = 2.5 ×10 6