A Lesson of Ecology

Natural systems are maintained and constrained by processing energy.

Energy flows through ecosystems

- Second Law of Thermodynamics

During any transformation of energy, some energy is always converted into heat which warms the surroundings and can no longer be used to perform useful work.

- Thus, energy transformations are not completely reversible and energy cannot be recycled.

Energy Converter

Energy Input

Useful Energy (can perform work)

Energy Diverted as Heat (can’t perform useful work)

Note: The first law of thermodynamics is met.
E input = Diverted E + Useful E
Species in an ecosystem are divided into trophic levels

- Trophic levels are determined by the main source of nutrition for a species.
- Trophic levels are given names:

**Trophic levels**

- Reflected solar E
- Producer
- 1º consumer
- 2º consumer
- Decomposer Food Chain

- R = metabolic heat (respiration)
- NU = not used (E in dead organic matter)
- NA = not assimilated (E in feces)
- I = ingested E
Lecture 16

Flow of energy through a food chain

10% rule of thumb

Ranges from:
ca. 5% in carnivores to
ca. 20% in herbivores

% of assimilated food that is respired

Producer 1st 2nd 3rd
Lecture 16

There are limits to the length of food chains!

One thing seems certain, however: one cannot take literally the well-known jingle by Jonathan Swift, or the whimsical diagram of Hegner:

Big fleas have little fleas
Upon their backs to bite 'em
And little fleas have lesser fleas
And so, ad infinitum.

From Robert Hegner as found in Odum 1971

Energy flow

• More energy is available to organisms eating lower on the food chain.
• Most top carnivores need to be food generalists.
• Eating at more than one level turns chains into webs.
• Animals (including humans) that eat at more than one level are called omnivores.

Some materials accumulate in food chains
Biological Magnification Can Have Serious Biological Effects

Primary Productivity

- Gross Primary Productivity (GPP)
  Rate of accumulation by $P_s$
  Usually measured as biomass but could also be expressed as $E$
- Net Primary Productivity (NPP)
  $NPP = GPP - R_{plant}$
  Rate of incorporation of organic matter into plant tissue (kg dry wt / m² * yr)
  NPP is available to heterotrophs.

Energy Flow Diagram

- $R_1$, $R_2$, $R_3$ (longwave emission)
- $1^\text{st}$ consumer
- $2^\text{nd}$ consumer
- $B$ (biomass)
- $1^\text{st}$ consumer
- $2^\text{nd}$ consumer
- $R_1$, $R_2$, $R_3$

 NU = not used; NA = not assimilated; B = biomass; I = ingested
Energy Flow

• For most primary producers
  10-50% of E gained in P, is removed by R
  NPP = (0.5 ↔ 0.9) x GPP
  R = (0.5 ↔ 0.1) x GPP

• Factors controlling primary productivity
  Moisture
  Temperature
  Solar radiation
  Nutrients (N, P)