Thurs: Seminar

Fri: No Class

Mon: Read. 8.1 to 8.3

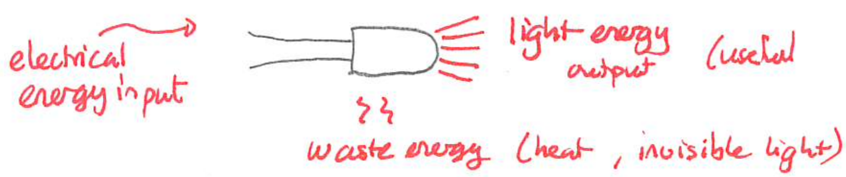
Saturday: Eclipse viewing

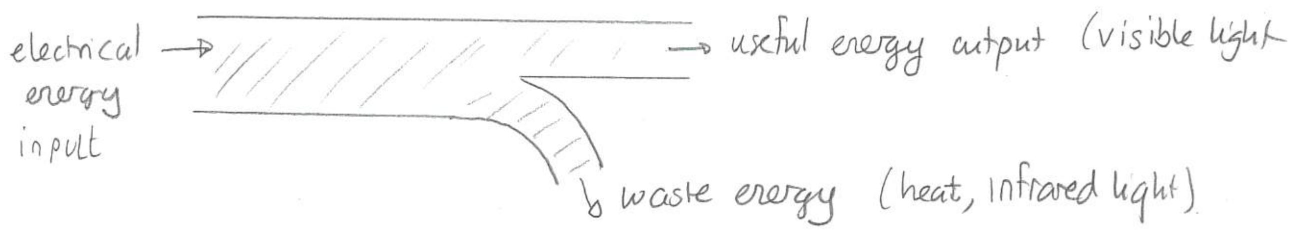
Energy transfer and efficiency.

Many physical processes can be viewed in terms of energy flows. The energy flow consists of

input energy ⇝ total energy to drive system
useful output " ⇝ energy of desired output
waste energy ⇝ energy that cannot easily be retrieved

For example consider an LED bulb.





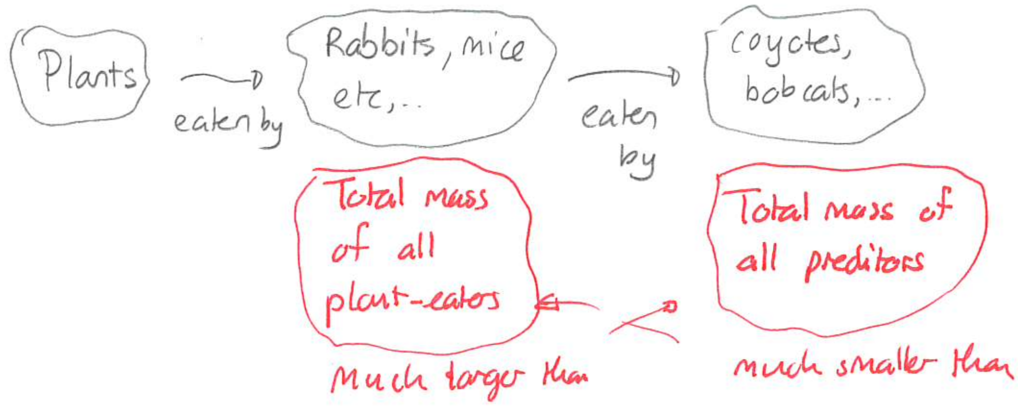
We can quantify this via

$$\text{efficiency} = \frac{\text{useful output energy}}{\text{input energy}}$$

Note that input energy = useful output + waste

Quiz 1 80%

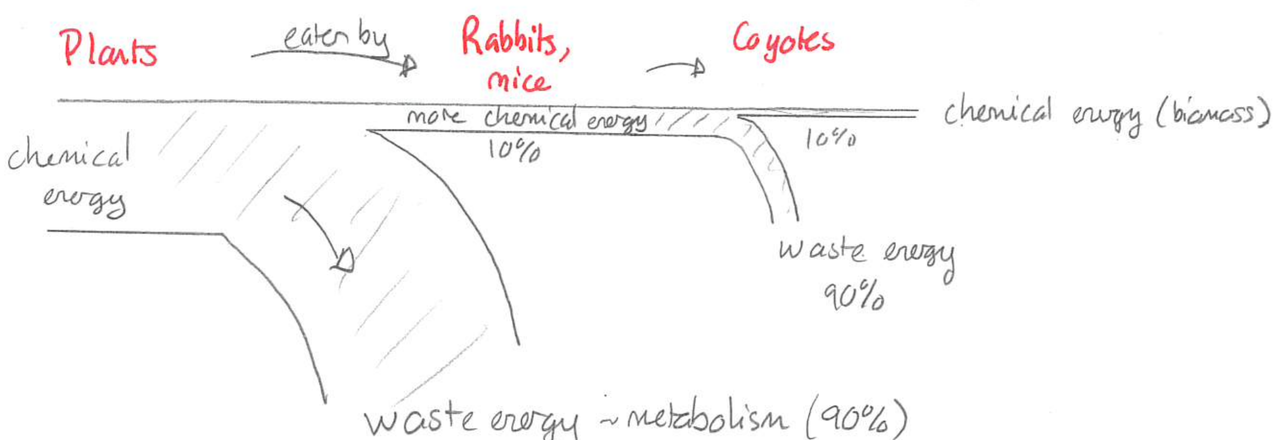
Energy flow processes like this can be applied to biological systems this can answer questions about the total mass at various levels in an ecosystem. In any ecosystem one has a food chain



This can be explained by an energy flow process. Animals use energy to:

1) maintain metabolic processes ~ breathing, moving, reproduction, ...
2) build mass (new material - biomass)

These energy processes are inefficient in terms of building biomass.

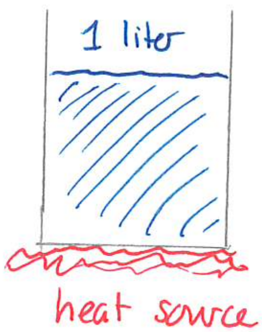


This explains the roughly 10% reduction at each level

"Why Big Fierce Animals Are Rare" Paul Collinvaux

Power

An important consideration in some energy transfer processes is the rate at which energy is transfered. Consider the process of heating water.



If we want to raise the temperature from 20°C (68F) to 100°C (212F) then standard calculations from thermal physics show that this requires 329600 J, assuming no heat is lost during the process. This is the same regardless of how quickly the process happens. Sometimes we want to consider

Total energy required AND Time taken to deliver total energy

One way to combine these is

Power = rate at which energy is supplied

The formal definition is:

$$\text{Power} = \frac{\text{energy supplied / used}}{\text{time taken}}$$

energy supplied / used → in Joules

time taken → in seconds

Power ↓ In Watts.

Quiz 2

1 Power

Four light bulbs use energy in various time intervals as described below.

	Energy	Time	Power
Bulb 1	1000 J	10 s	1000J/10s = 100W
Bulb 2	1000 J	20 s	1000J/20s = 50W
Bulb 3	2000 J	10 s	2000J/10s = 200W
Bulb 4	2000 J	20 s	2000J/20s = 100W

a) Determine the power delivered by each bulb.

b) If the time stays the same, does the power increase, decrease or stay constant as the energy delivered increases?

c) If the energy delivered stays the same, does the power increase, decrease or stay constant as the time increases.

a) Power = $\frac{\text{energy}}{\text{time}}$ (see table for results

b) Increases compare bulb3 to bulb 1.

c) Decreases compare bulb4 to bulb3.

2 Energy consumed by a bulb

A bulb consumes 45 W of power. How much energy does it consume in 10 minutes?

Means 45J in 1second. In 10 minutes there are 10×60 = 600s. So It will consume

$$45 \times 600 \text{ J} = 27000 \text{J}$$

3 Paying for electricity

A utility company pays for the fuel to deliver electricity to houses. One house has ten 20 W bulbs. Another has two 20 W and a 500 W microwave oven. Does it make sense for the utility to charge based on the total power of all of the appliances in teh two houses? If so, why? If not, is there a more sensible way?

The utility should charge for the energy used. Power is the energy per second so we need to consider the specific appliances and how long they were used.

Examples: Bulbs run for one hour = 60 min x 60 s = 3600 s

Microwave run for 5 minutes. = 5 min x 60 s = 300 s

In this situation.

each bulb uses 20 W x 3600 s = 72000 J

microwave " 500 W x 300 s = 150000 J.

So

First house uses 10 x 72000 J = 720000 J

Second " " 2 x 72000 J + 150000 J = 292000 J

and in this example the first uses more than the second.