- Energy flows through living systems . . .living is work!!
- Cells **NEED** energy to perform all of the things that cells do.
- In most ecosystems, energy enters as ***sunlight***.
  - Light energy trapped in organic molecules is available to both photosynthetic organisms and others that ***eat them***.
- Photosynthesis and cellular respiration are both processes that ***transfer*** energy from one form to another
  - Constant input of solar energy
  - Chemical elements ***recycled***
  - Energy is lost from living systems in the form of ***heat*** or used by the cell to do work – it is NOT recycled!!!!
- The two processes that provide energy in this world are ***photosynthesis*** and ***cellular respiration***
  - Photosynthesis (putting together with light) converts radiant energy into chemical energy – producing food for the plant – a byproduct of this food production is oxygen
  - Cellular respiration takes this "food" and breaks it down into a form of energy our cells can use – ATP

✓The mitochondria of eukaryotes (including plants & algae) use the organic products (sugars) of photosynthesis as ***fuel*** for cellular respiration (CR).

✓CR uses the oxygen produced by photosynthesis. CR also uses the energy stored in the organic molecules to make ATP; which powers most cellular work.

✓The waste products of CR, carbon dioxide and water, get recycled as the raw materials for photosynthesis.

✓But energy is NOT RECYCLED!! It flows into an ecosystem as sunlight and leaves as heat.

## Cellular respiration and fermentation are catabolic, energy-releasing pathways

- Organic molecules store energy in their arrangement of atoms *(specifically…..where?????)*

- Enzymes aid in the breakdown of complex organic molecules that have LOTS of energy into simpler waste products with LESS energy.

- Some of the released energy is used to do WORK and the rest is dispersed as ***HEAT***.

- Metabolic pathways that release the energy stored in complex organic molecules are ***catabolic***.

•One type of catabolic process, **fermentation**, leads to the partial breakdown of sugars in the ***absence of oxygen*** (*more on this process later ☺*)

•A more efficient and widespread catabolic process, **cellular respiration**, uses oxygen as a *reactant* (starting material) to complete the breakdown of a variety of organic molecules.

•Most of the processes in cellular respiration occur in the mitochondria.

- Cellular respiration is similar to the burning of gasoline in an automobile engine, though it is MORE efficient!

- The overall process is:

  - **Organic compounds + $O_2$ → $CO_2$ + $H_2O$ + Energy**
    (the fuel)

- Carbohydrates, fats, and proteins can ***all*** be used as the fuel, but we will start looking at this process using the *monomer* glucose.

  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + Energy (ATP + heat)

- The catabolism of glucose is ***exergonic*** with a delta G of - 686 kcal per mole of glucose.

  - Some of this energy is used to produce ATP that will perform cellular work.

# Cells recycle the ATP they use for work

- ATP, adenosine triphosphate, is the crucial molecule in cellular energetics (the "currency" of energy).
- It is the chemical equivalent of a ***loaded spring*** *(What type of energy would this be?????).*
  - The close packing of three negatively-charged phosphate groups is an unstable, energy-storing arrangement.

•Loss of the ***end phosphate group*** "relaxes" the "spring" (and in the process, frees up energy).

•The price of most cellular work is the conversion of ATP to ***ADP and inorganic phosphate*** (Pi).

•An animal cell regenerates ATP from ADP and Pi by the catabolism of organic molecules.

- The transfer of the terminal phosphate group (Pi) from ATP to another molecule is called ***phosphorylation***.
  - This changes the shape of the receiving molecule, allowing it to ***perform work*** (transport, mechanical, or chemical).
  - When the phosphate groups leaves the molecule, the molecule returns to its alternate shape.