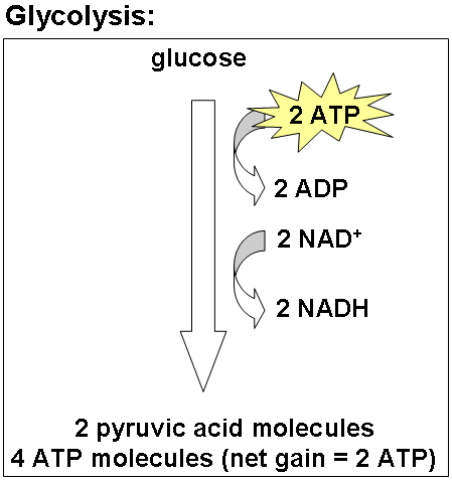
How Organisms Obtain Energy (Part 2)

- The energy that plant and animal cells can use is stored and released by ATP molecules.
- Food that is eaten by animals or made by plants during photosynthesis is the source of energy to make ATP.
    - ⋆ Cells need the energy in ATP to carry out all activities!!!
- If oxygen is present, then the steps that change energy in food into usable energy for the cell are:
    1. Glycolysis
    2. Cellular Respiration
        - 2a. Krebs Cycle (Citric Acid Cycle)
        - 2b. Electron Transport Chain

1. Glycolysis (Pre-Step to Cellular Respiration *or* Fermentation)

Where in the cell does glycolysis happen?

Cytoplasm



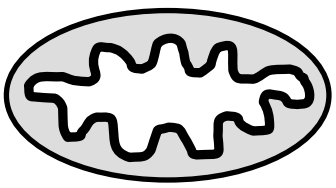
During glycolysis, 1 molecule of glucose is broken down into 2 molecules of pyruvic acid,
2 molecules of ATP, and 2 molecules of NADH.
Only 2% of total energy in glucose is captured in the ATP made in this step.

2. Cellular Respiration is the process that breaks down glucose (or other food molecules) to release energy for cells *if* oxygen is available.

Cellular respiration is also known as aerobic respiration, because it uses oxygen.

Where in a cell does cellular respiration happen?

In the mitochondria of animal cells & plant cells.



2a. Krebs Cycle

Where in the mitochondria does the Krebs Cycle happen? In the matrix

- During the Krebs Cycle, 2 molecules of pyruvic acid made during glycolysis each go through 9 reactions to produce the following molecules:

  - Carbon Dioxide (CO_2) – leaves the cell as a by-product
  - 3 NADH
  - 1 $FADH_2$
  - 2 ATP

  } High energy molecules that are used in the electron transport chain (the next step)

2b. Electron Transport Chain (ETC)

- In this step, $FADH_2$ & NADH give high energy electrons to enzymes in the inner membrane of the mitochondria.

The electrons are passed down the electron transport chain until oxygen finally accepts the electrons and water is made.

- Hydrogen (H+) ions build up outside the inner membrane, which causes a difference in electrical charge. This difference in electrical charge is used to change ADP into ATP.

- Together, the Krebs Cycle and ETC produce 34 ATP molecules.
- Glycolysis + Cellular Respiration (Krebs Cycle + ETC) produce 36 ATP molecules.
- Lots of chemical energy is produced for the cell → a total of 36 ATP molecules for 1 glucose molecule.

Overall Cellular Respiration Reaction (including glycolysis):

Glucose + Oxygen ⟶ Carbon Dioxide + Water + Energy

$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O + ATP$

If oxygen is not available…

- Anaerobic Respiration – happens when oxygen is NOT available.
- Fermentation releases energy from food molecules by producing ATP without oxygen. Alcoholic fermentation or lactic acid fermentation still use the pyruvic acid made during glycolysis.

Comparing Photosynthesis and Cellular Respiration

	Photosynthesis	**Cellular Respiration**
Function (job)	Energy storage (makes food)	Energy release
Organism(s)	Plants	Plants and Animals
Location in the cell	Chloroplasts	Mitochondria
Reactants	CO_2 and H_2O	$C_6H_{12}O_6$ and O_2
Products	$C_6H_{12}O_6$ and O_2	CO_2 and H_2O
Equation	$6\ CO_2 + 6\ H_2O \longrightarrow C_6H_{12}O_6 + 6\ O_2$	$C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O + ATP$