All cells need ENERGY.

**ATP**

The food we eat can't be used directly by the cell as energy. It's like going to the grocery store in the United States and paying with pesos - it doesn't work. We have to convert that energy into something the cell can use. That something is ATP.

**Adenosine Triphosphate**

3 phosphates

**ATP**

Energy is stored in these bonds.

**ADP**

Energy is released when the bond is broken.

When the bond is broken there are two (di) phosphates left. This ADP can be regenerated to an ATP using the energy from the food we eat (or in the case of photosynthesis - make).
What happens to the food we eat?

Glycolysis

6 carbon glucose is converted into 2 molecules of 3 carbon pyruvate

Also NET
2 ATP
2 NADH

Transition

pyruvate

CO₂

acetyl CoA

Krebs Cycle

acetyl CoA

CO₂

Electron Transport Chain

FADH₂

NADH

Donate high energy electrons (and H⁺) to the chain that sets up the energy gradient to power ATP synthase to make ATP

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Fermentation

Oxygen is NOT Available

We need to recycle the NADH so that fermentation can continue.

Pyruvate is continued through the cycle.

Lactic Acid

pyruvate → lactic acid

\[ \text{H} \]

NADH → NAD^+

Alcohol

pyruvate → alcohol

\[ \text{H} \]

NADH → NAD^+

Fermentation isn’t the only possible pathway if oxygen isn’t available.

Some organisms can move into an alternative form of cellular respiration that uses something other than oxygen.

Oxygen

Fermentation allows cells to keep making ATP without oxygen. It isn’t as efficient as cellular respiration – it doesn’t make very much ATP.
3 Steps of Cellular Respiration

glycolysis

- Occurs in cytoplasm
- Does NOT require oxygen
- NET 2 ATP (costs 2 to get started)

![Glucose to Pyruvate](image)

- glucose $\rightarrow$ ATP 
- pyruvate $+ \text{NADH} + \text{ATP}$

citric acid cycle

- There is actually a transition step that converts pyruvate to Acetyl CoA and makes NADH before the citric acid/Krebs cycle

- Occurs in the mitochondria.
- Only occurs if oxygen is present.
- Makes ATP (the goal)
- Makes NADH and FADH\(_2\) that will be used in the next step
- Carbon dioxide is a waste product.

electron transport chain

NADH and FADH\(_2\) donate their electrons to the electron transport chain. Which uses the energy to fuel the ATP synthase and make ATP.

Oxygen is the final electron acceptor which forms water.

\[ \text{C}_{6}\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{Energy} \]
Role of Glucose in Cellular Energy

Organisms eat food or rely on the food they make via photosynthesis for energy.

Unfortunately cells can’t recognize food as energy so it has to be converted to ATP.

CARBON

Glucose is a sugar and is our most preferred energy source.

It is often represented as a ring structure.

The machinery to make ATP is most efficient when using glucose and oxygen.

C₆H₁₂O₆ + 6O₂ → 6CO₂ + 6H₂O + Energy

Glucose oxygen Carbon dioxide water ATP

4 Steps to Make ATP from Glucose

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