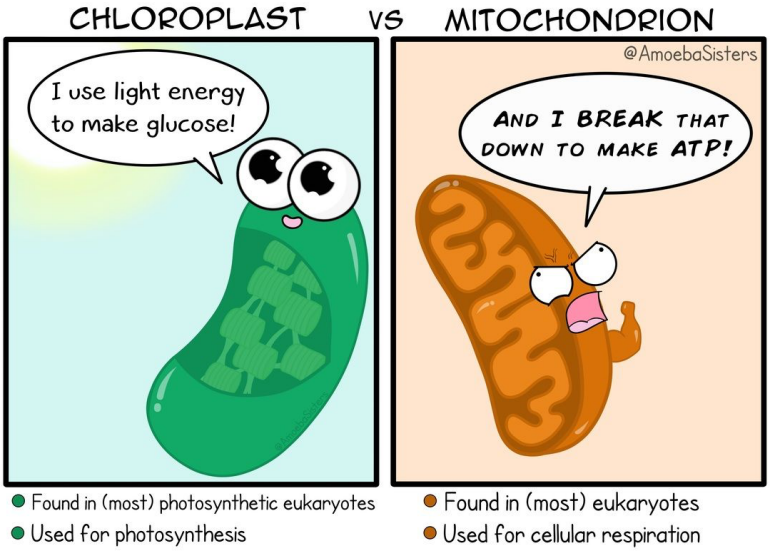
02 – CELLS AS THE BASIS OF LIFE

2.2 - Cellular Respiration



Cell Chemistry

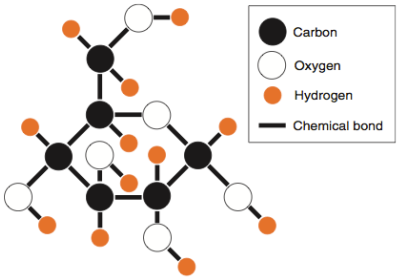
cell metabolism =

All metabolic reactions involve changes in energy (form or storage):

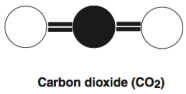
a) Anabolic Reactions (synthesis):

b) Catabolic Reactions (break down):

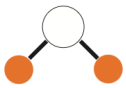
Energy in Bonds



Glucose ($C_6H_{12}O_6$)



Carbon dioxide (CO_2)



Water (H_2O)

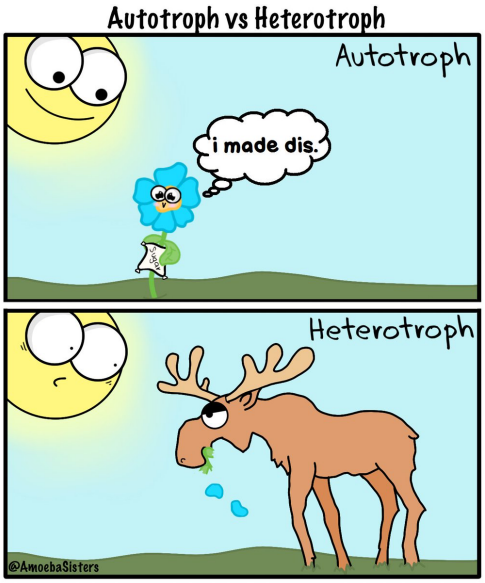
energy rich
reactants/substrates

energy poor
products

Autotrophs vs Heterotrophs

2.2.1 Cells require **inputs** of suitable forms of energy, including **light** energy or **chemical** energy in complex molecules.

☑ Distinguish between autotrophs and heterotrophs.



Sunlight for Photosynthesis

2.2.2 The sun is the main source of energy for life.

sunlight energy

↓ **photosynthesis**
*in **chloroplasts** (plants and some protists)*
**some bacteria do a simplified version with pigments in cytoplasm*

stored chemical energy (in bonds)

↓ **respiration**
*in cytoplasm and **mitochondria***

useful chemical energy in the form of ATP

Photosynthesis

☑ Recognise that photosynthesis is important in the **conversion** of **light** energy into **chemical** energy, as illustrated by the following equation:

Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2$$

carbon dioxide + water $\xrightarrow[\text{chlorophyll}]{\text{light}}$ glucose + oxygen

Aerobic Respiration

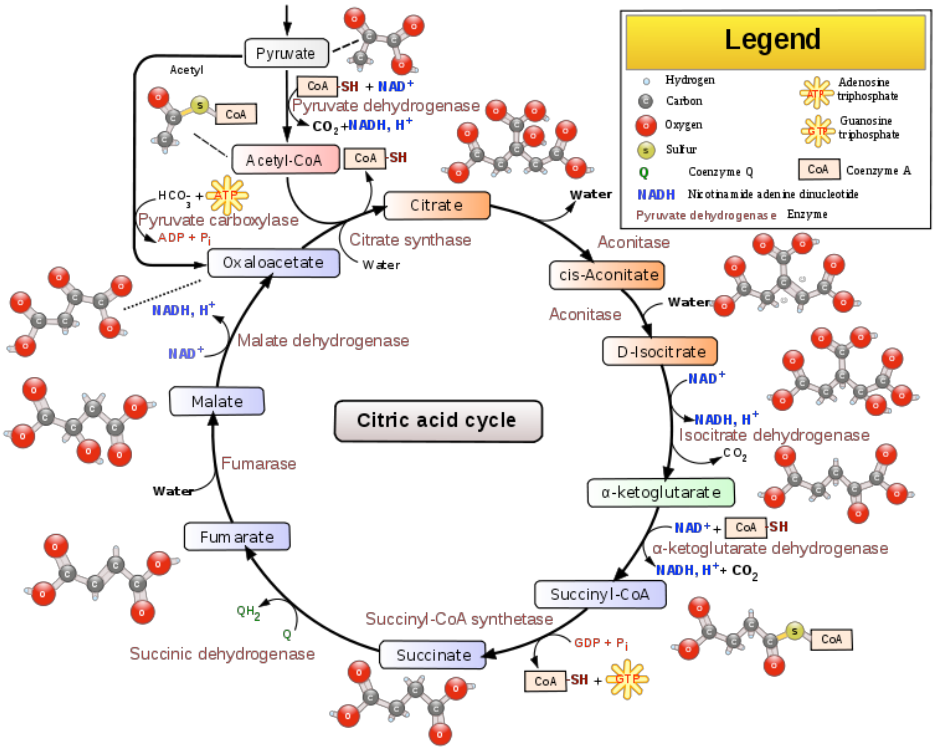
2.2.3 Energy transformations occur within all living cells.

☑ Explain how most autotrophs and heterotrophs **transform** chemical energy for use through **aerobic respiration**, as illustrated by the following equation:

Glucose + Oxygen ⟶ Carbon Dioxide + Water + Energy

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

Woah… its more complex than it looks :)



Anaerobic Respiration
(fermentation)

☑ Explain that fermentation is an anaerobic **alternative** to aerobic respiration:

In plants and yeast:

alcohol fermentation

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

glucose ⟶ ethanol + carbon dioxide

In animals (and some bacteria):

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3$$

glucose ⟶ lactic acid

lactic acid fermentation

Energy Release Efficiency
(aerobic respiration vs fermentation)

☑ Compare the amount of energy released through aerobic respiration and fermentation (anaerobic respiration).

Respiration produces energy in the usable form of ATP molecules.

Aerobic Respiration	**= 36-38 net ATP**
Alcohol Fermentation	**= 2 net ATP**
Lactic acid Fermentation	**= 2 net ATP**

NET ATP Production?

☑ Recognise that energy is **required** to break chemical bonds and energy is **released** when new bonds are formed.

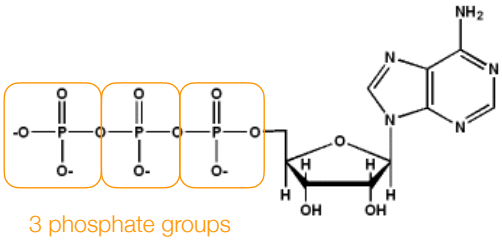
input
(E^a, etc)

output

Formation of ATP

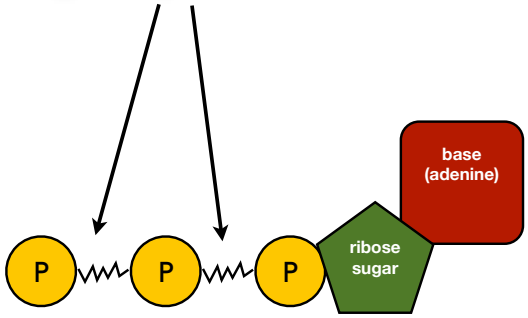
☑ Describe the conversion of ATP to ADP and P_i, which releases energy for some metabolic reactions.

What is ATP?
adenosine triphosphate



3 phosphate groups

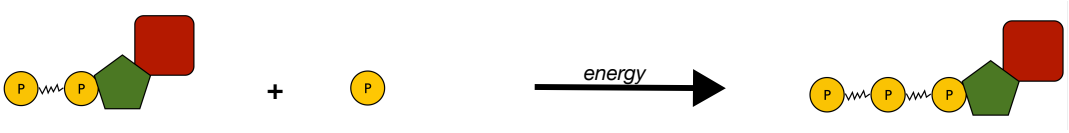
Energy storing covalent bonds



used to store and transfer energy

Formation of ATP

☑ Describe the conversion of ATP to ADP and P_i, which releases energy for some metabolic reactions.



ADP + **P_i** —energy→ **ATP**

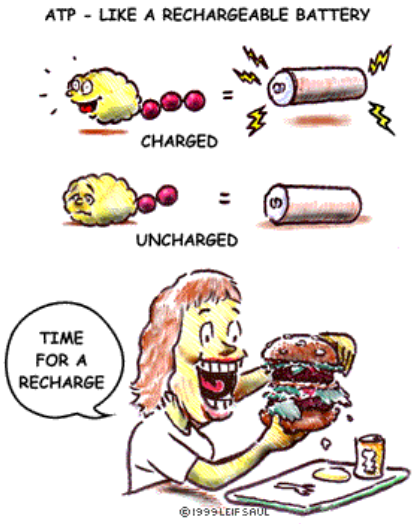
adenosine diphosphate + **inorganic phosphate** —energy→ **adenosine triphosphate**

ADP and Pi are both negatively charged ions in the cytoplasm.
Energy is required to overcome the repulsion to bond them.

This energy used to bond them is stored in the chemical bond between the two reactants.

Formation of ATP

☑ Describe the conversion of ATP to ADP and P_i, which releases energy for some metabolic reactions.

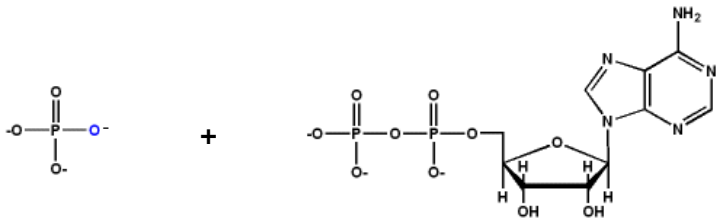


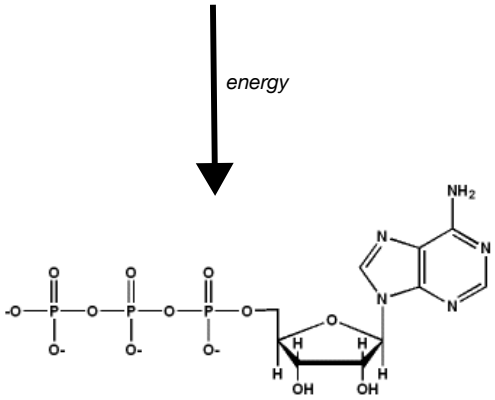
The energy used by human cells requires the hydrolysis of **100** to **150** moles of ATP daily, which is around 50 to 75 kg.

A human will typically use up his or her body weight of ATP over the course of the day. Each equivalent of ATP is recycled **500**-750 times during a single day (100 / 0.2 = **500**).

Formation of ATP

☑ Describe the conversion of ATP to ADP and P_i, which releases energy for some metabolic reactions.





Key:
Cells break down large molecules into smaller ones, and the energy released by doing this is transferred into molecules of ATP.

Releasing Energy from ATP

☑ Describe the conversion of ATP to ADP and P_i, which releases energy for some metabolic reactions.

Hydrolysis
When a larger molecule (eg. ATP) is broken down into smaller molecules (eg. ADP and P_i) by reaction with water:

The energy released in the hydrolysis of ATP is used in key processes for life in cells…

Input & Output Needs of Cells

2.2.3 In order to survive, cells require an input of matter, including gases, simple nutrients, and ions, and the removal of wastes.

☑ **Compare** the inputs and outputs of **autotrophs** and **heterotrophs**

Plants	**Animals**
inputs (raw materials):	**inputs (raw materials):**
outputs (waste):	**outputs (waste):**

***stoma, vacuoles, ventilation, sweat, urine**