Cellular respiration

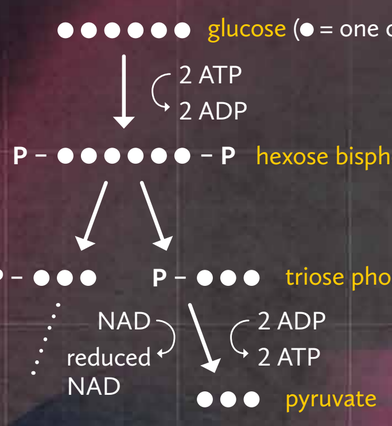
BigPicture

We need energy to live, but how do we get it? We eat food and, via the process of respiration, we transfer the energy within this food to energy our bodies can use. Respiration is the chemical process of releasing energy from organic compounds. It is a series of enzyme-controlled reactions in which energy is transferred to produce adenosine triphosphate (ATP) from adenosine diphosphate (ADP) and inorganic phosphate (P_i).

GLYCOLYSIS

Occurs in cytoplasm

Oxidation of glucose to form pyruvate



Net products:
- 2 ATP
- 2 reduced NAD
- 2 pyruvate

Is oxygen available? **YES** / **NO**

CYTOPLASM

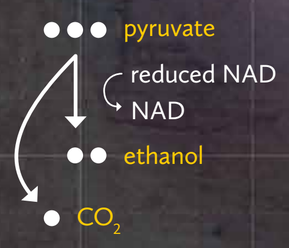
ANAEROBIC RESPIRATION

Occurs in cytoplasm

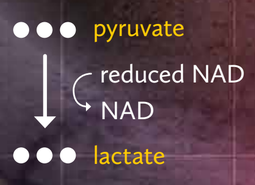
Respiration that uses final electron acceptors other than oxygen

Net ATP yield:
2 ATP (from glycolysis)

Plants (and some micro-organisms, e.g. yeast):



Animals (and some micro-organisms, e.g. *Lactobacillus*):



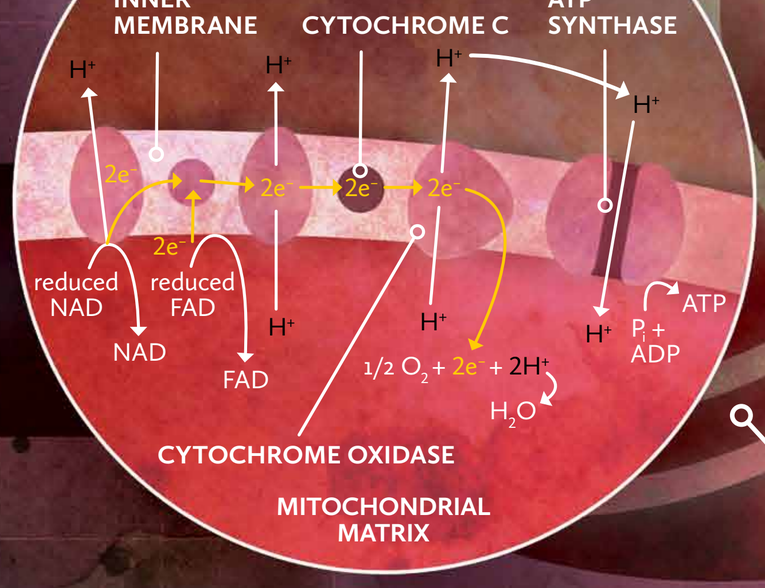
ELECTRON TRANSPORT CHAIN

Using electron transport to power the transport of protons (H^+), leading to the production of ATP

Net ATP yield:

The amount of ATP made per molecule of glucose varies according to conditions. In theory, each can yield a maximum of 38 ATP, but around 30 is more likely.

Glycolysis and Krebs cycle	4 ATP	38 ATP
10 x reduced NAD (electron transport chain)	30 ATP	
2 x reduced FAD (electron transport chain)	4 ATP	



MITOCHONDRION

KEY TO SYMBOLS

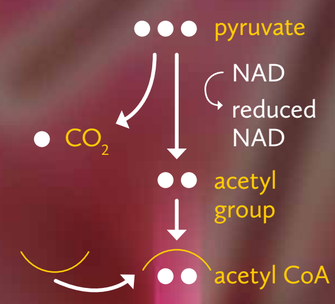
Carbon atom: ●
Phosphate group: P
Coenzyme A: ◡

AEROBIC RESPIRATION

LINK REACTION

Occurs in mitochondrial matrix

Removal of hydrogen and carbon dioxide from pyruvate (decarboxylation)



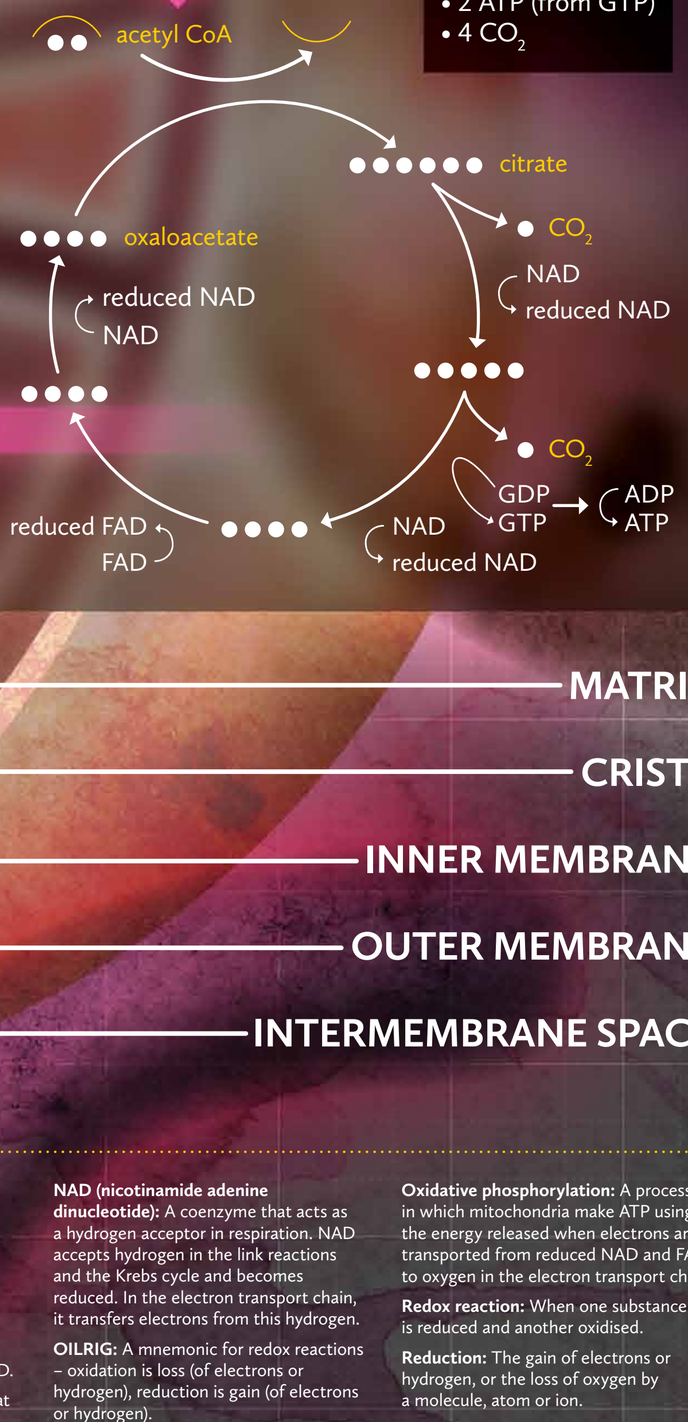
Net products:
- 2 reduced NAD
- 2 CO_2
- 2 acetyl CoA

KREBS CYCLE

Occurs in mitochondrial matrix

Complete oxidation of acetyl CoA

Net products (two turns of cycle):
- 6 reduced NAD
- 2 reduced FAD
- 2 ATP (from GTP)
- 4 CO_2



MATRIX

CRISTA

INNER MEMBRANE

OUTER MEMBRANE

INTERMEMBRANE SPACE

GLOSSARY

Acetyl CoA: An intermediate formed in the link reaction by the joining of coenzyme A (CoA) and a two-carbon compound. This enters the Krebs cycle.

ADP (adenosine diphosphate): A molecule found in all living cells that is involved in the transfer of energy. It is produced when a phosphate group is removed from ATP, a process that releases energy.

Aerobic: Using oxygen.

Anaerobic: Without oxygen.

ATP (adenosine triphosphate): A molecule found in all living cells that is involved in the transfer of energy. Most of a cell's ATP is made during respiration.

ATP synthase: An enzyme that catalyses the synthesis of ATP in oxidative phosphorylation.

Coenzyme: Small non-protein organic molecules that bind to and are required for the activity of their associated enzyme. An example is coenzyme A (CoA), which combines with a two-carbon compound during the link reaction to form acetyl CoA.

Cytochrome oxidase: Terminal component of the electron transport chain, which oxidises cytochrome c. This is where oxygen is actually consumed, by acting as the final electron acceptor and being converted to water.

Decarboxylation: A chemical reaction that releases carbon dioxide (CO_2).

Electron carrier: A molecule that can accept one or more electrons and donate them to another in an electron transport chain. They include NAD, FAD and the cytochromes.

FAD (flavine adenine dinucleotide): A coenzyme that acts as a hydrogen acceptor in respiration. FAD accepts hydrogen in the Krebs cycle and becomes reduced. In the electron transport chain, it transfers electrons from this hydrogen.

GDP (guanosine diphosphate): A molecule converted to GTP during the Krebs cycle.

Glycolysis: The splitting of sugar. This process, in which glucose is oxidised, takes place in the cytoplasm. It is the first stage of both aerobic and anaerobic respiration.

GTP (guanosine triphosphate): A molecule produced during the Krebs cycle that donates a phosphate group to ADP to make ATP. It is also very important elsewhere in the cell.

Hydrogen carrier: A molecule that can accept hydrogen atoms or ions and donate them to another carrier. Hydrogen carriers include NAD and FAD.

Mitochondrion: A rod-shaped body that supplies chemical energy to eukaryotic cells (plural: mitochondria).

NAD (nicotinamide adenine dinucleotide): A coenzyme that acts as a hydrogen acceptor in respiration. NAD accepts hydrogen in the link reactions and the Krebs cycle and becomes reduced. In the electron transport chain, it transfers electrons from this hydrogen.

OILRIG: A mnemonic for redox reactions – oxidation is loss (of electrons or hydrogen), reduction is gain (of electrons or hydrogen).

Oxidation: The loss of electrons or hydrogen (called dehydrogenation), or the gain of oxygen by a molecule, atom or ion.

Oxidative phosphorylation: A process in which mitochondria make ATP using the energy released when electrons are transported from reduced NAD and FAD to oxygen in the electron transport chain.

Redox reaction: When one substance is reduced and another oxidised.

Reduction: The gain of electrons or hydrogen, or the loss of oxygen by a molecule, atom or ion.

Substrate-level phosphorylation: A process that makes ATP through the donation of a phosphate group from an intermediate directly to ADP, for example during glycolysis.

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