C1.2

Cellular Respiration (HL)

CELLULAR RESPIRATION – Gradual breakdown of nutrient molecules such as **glucose** & fatty acids in a series of reactions that ultimately release energy in the form of **ATP**.

SUMMARY OF PROCESS

The process of cellular respiration starts with the entry of **GLUCOSE** into the cell via a transporter called **GLUT**.

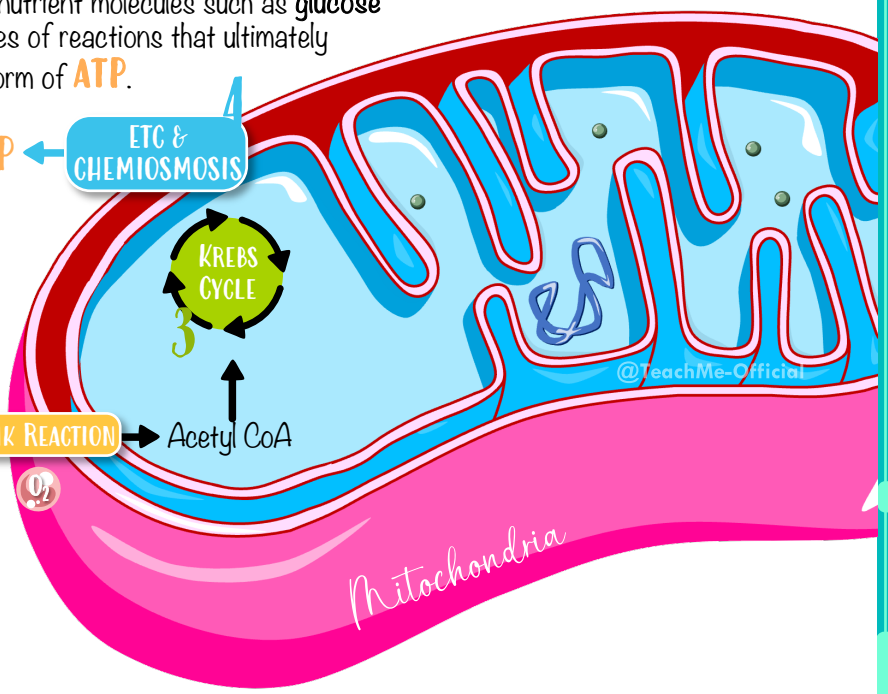
From page 2, each of the steps of respiration are shown in detail.

GLUCOSE → 1 GLYCOLYSIS → Pyruvate → 2 LINK REACTION → Acetyl CoA

Pyruvate → O_2 → Anaerobic Respiration (See page 4)

3 KREBS CYCLE

4 ETC & CHEMIOSMOSIS → ATP



BIG BRAIN TIP!

Remember the structures of the mitochondria covered in section B2.2

REDOX – Cellular Respiration is considered to be a **REDOX** reaction: when **OXIDATION** & **REDUCTION** occur together.

REDUCTION

- Gain of electrons
- Gain of hydrogens
- Loss of oxygen
- Results in product with higher potential energy

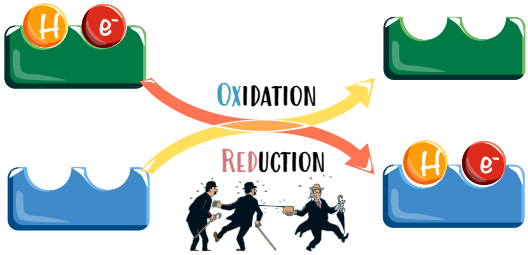
A general type of chemical reaction resulting in products with higher potential energy than the reactants

&

OXIDATION

- Loss of electrons
- Loss of hydrogen
- Gain of oxygen
- Results in product with lower potential energy

A general type of chemical reaction resulting in products with lower potential energy than the reactants



BIG BRAIN TIP!

OILRIG

Oxidation Is Loss of electrons & hydrogen
Reduction Is Gain of electrons & hydrogen

CELLULAR RESPIRATION EQUATION (Aerobic)

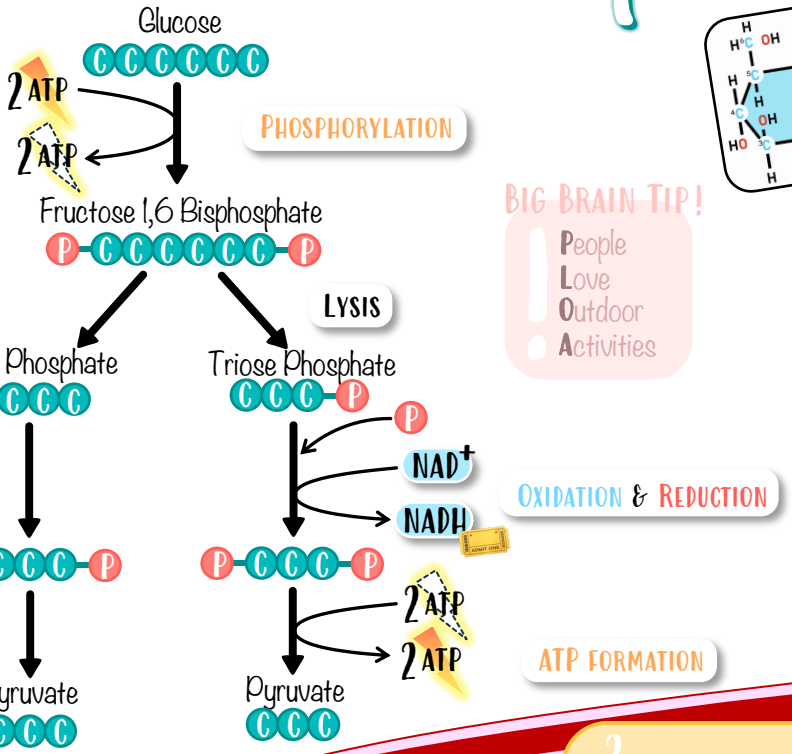
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{ENERGY (ATP \& HEAT)}$$

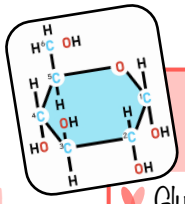
OXIDATION

REDUCTION

C1.2

Cellular Respiration (HL)





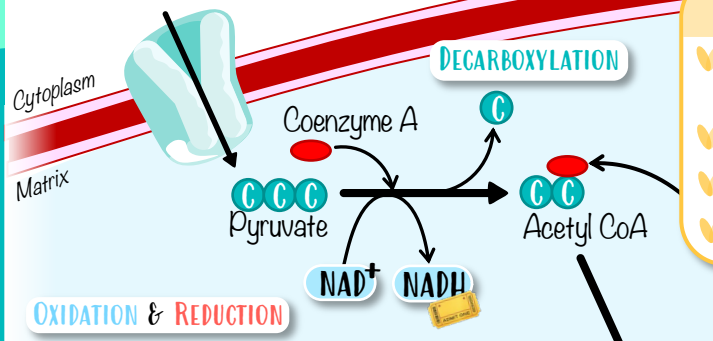
GLYCOLYSIS 1

Glucose Splitting

- Glucose undergoes PHOSPHORYLATION to form fructose 1,6 bisphosphate (less stable).
- Fructose 1,6 bisphosphate splits (LYSIS) to form 2 triose phosphates.
- Each triose phosphate undergoes OXIDATION, while NAD+ undergoes REDUCTION.
- An inorganic phosphate is added to triose phosphate.
- Enzymes then take the phosphate groups and add them to ADP to form ATP.

BIG BRAIN TIP!

People Love Outdoor Activities



LINK REACTION 2

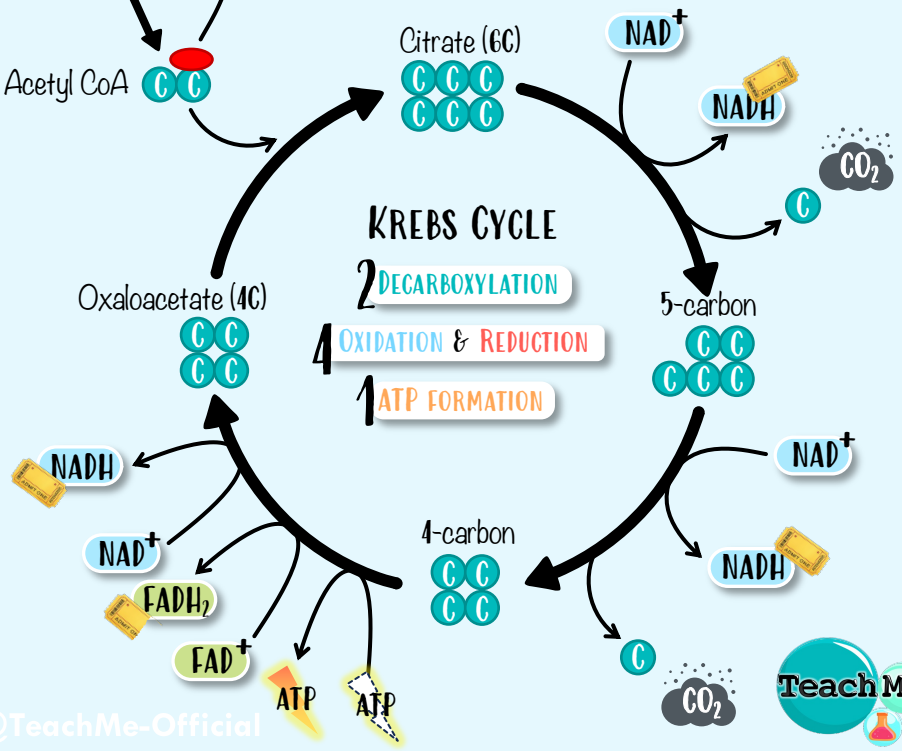
- If oxygen is present, pyruvate enters the mitochondria (via active transport).
- Pyruvate (3C) is DECARBOXYLATED to form acetyl (2C).
- Acetyl is OXIDIZED and NAD+ is REDUCED.
- Acetyl group combines with CoA (coenzyme A) to form acetyl CoA.

BIG BRAIN TIP!

Remember the KREBS CYCLE will run TWICE for each GLUCOSE molecule

KREBS CYCLE (CITRIC CYCLE) 3

- Acetyl CoA combines with oxaloacetate to form citrate.
- Citrate gets OXIDIZED while NAD+ is REDUCED to NADH. Citrate undergoes DECARBOXYLATION to form a 5C molecule.
- The 5C molecule gets OXIDIZED and NAD+ is REDUCED to NADH. The 5C molecule is DECARBOXYLATED to from a 4C molecule.
- The 4C molecule gets OXIDIZED. NAD+ is REDUCED to NADH and FAD (flavin adenine dinucleotide) is REDUCED to $FADH_2$. ATP formation also occurs (ADP converted to ATP).
- This results in reformation of oxaloacetate (4C) and the cycle can repeat.



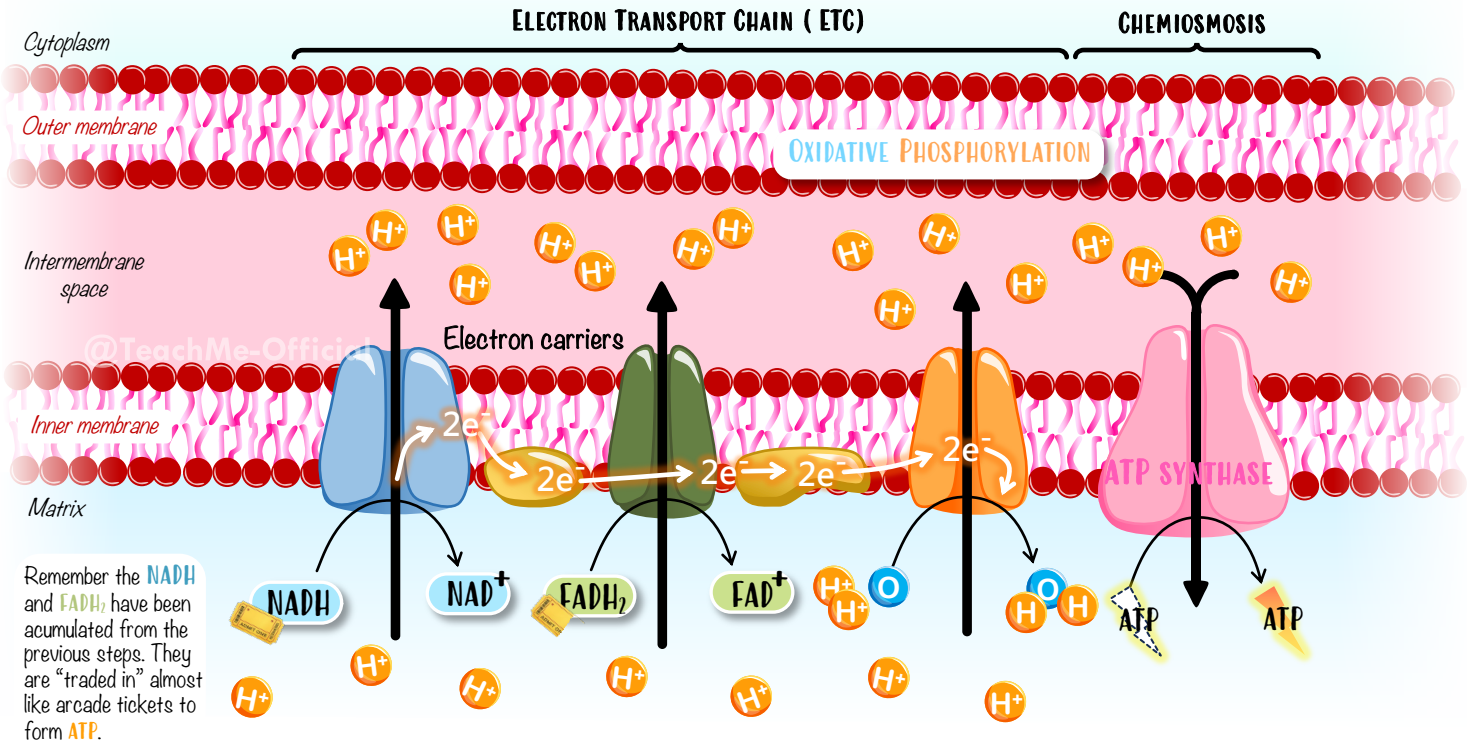
Cellular Respiration (HL)

Electron Transport Chain 4

- NADH is Oxidized (proton and electrons are dropped off in the matrix).
- The electrons pass into the ETC along the electron carriers.
- The movement of the electrons down the chain, powers the transfer of protons into the inter membrane space to form a Proton Gradient.
- $FADH_2$ brings its electrons and proton into the chain at a later stage.
- Oxygen (Final Electron Acceptor), combines with electrons & two protons to form water.

Chemiosmosis 5

- Protons move through the ATP synthase down their concentration gradient (from the intermembrane space into the matrix).
- Their energy is used to phosphorylate ADP into ATP.



Remember the NADH and $FADH_2$ have been acumulated from the previous steps. They are "traded in" almost like arcade tickets to form ATP.

Summary

	Glycolysis	Link Reaction	Krebs Cycle	Electron Transport Chain
ATP	2	0	2	28
NADH	2	2	6	...
$FADH_2$	0	0	2	
Pyruvate	2	Acetyl CoA 2	[None]	0
CO_2	0	CO_2 2	CO_2	4

1 NADH = 2.5 ATP

1 $FADH_2$ = 1.5 ATP

Total

2ATP + 2ATP + 25ATP (from NADH) + 3ATP (from $FADH_2$) = 32 ATP

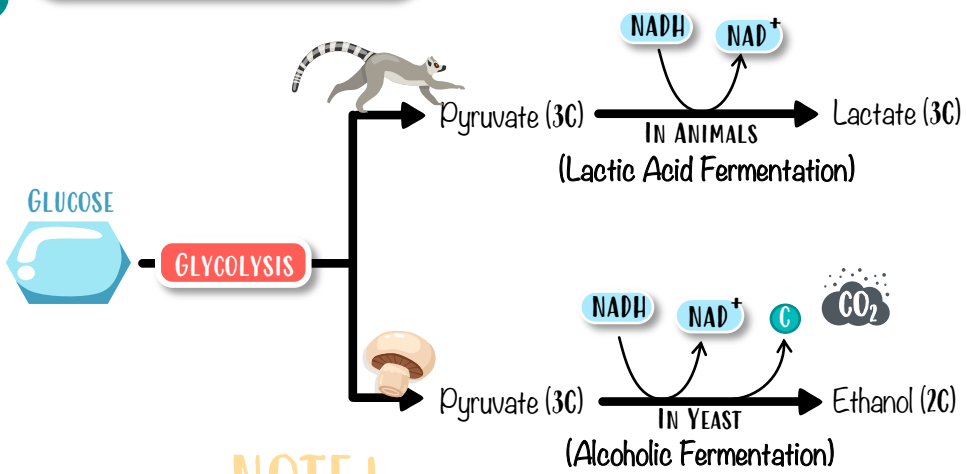
Final products for ONE molecule of Glucose

C1.2

Cellular Respiration (HL)

Anaerobic Respiration

Notice NADH is being used rather than produced and NAD^+ is being recycled for aerobic respiration.



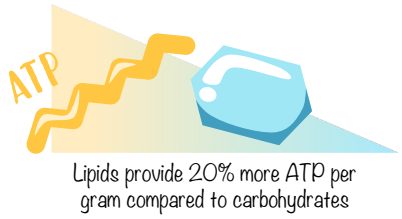
Anaerobic respiration allows for muscles to work vigorously for a short period of time. Muscle burn during intense exercise occurs because of lactic acid accumulation. Burn goes away when enough oxygen is provided so that aerobic cell respiration can occur.

Performed by yeast (a unicellular organism), it is useful for baker's yeast in bread (helps it rise because of the formation of CO_2), as well as for alcohol production.

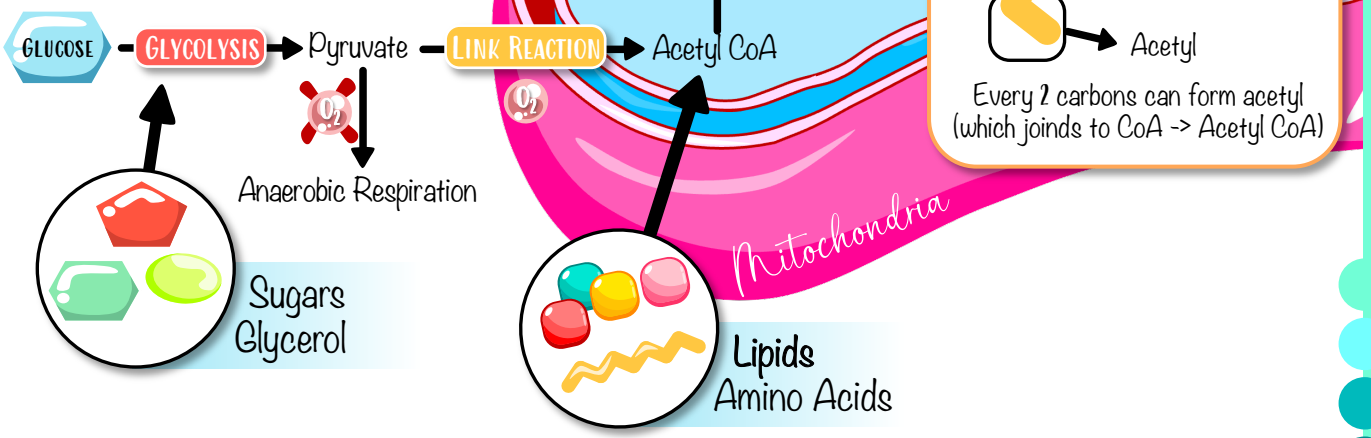
NOTE!

ONLY happens if CARBOHYDRATE is the substrate! (doesn't work with lipids or amino acids)

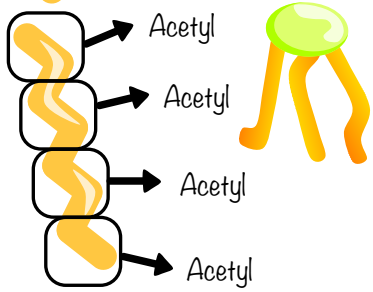
Other Respiratory Substrates



Lipids provide 20% more ATP per gram compared to carbohydrates



Lipids as a source of energy



Every 2 carbons can form acetyl (which joinds to CoA -> Acetyl CoA)

At various steps of cellular respiration, different substrates such as other SUGARS, GLYCEROL, LIPIDS or AMINO ACIDS may be used to generate ATP.

notes