Respiration

$$C_6H_{12}O_6 + 6O_2$$
$$\downarrow$$
$$6CO_2 + 6H_2O + e^- + 36\text{-}38\,ATP$$
$$+ \text{heat}$$

ATP is used for:

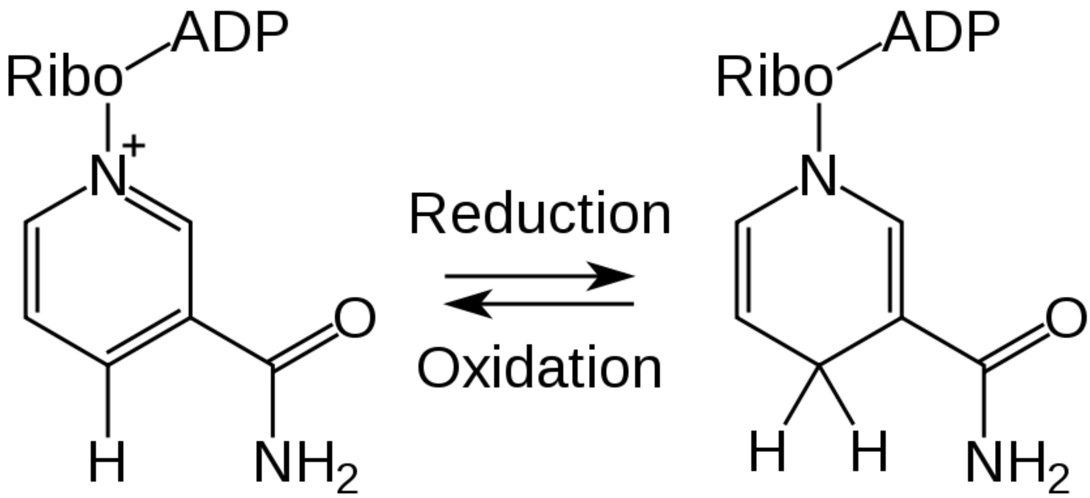
- active transport, e.g. Na^+/K^+ pump
- movement of vesicles from the Golgi to around the cell
- Enzyme activity, eg. DNA Polymerase
- Protein synthesis
- Muscle contraction

Aerobic respiration - uses oxygen, produces 32-38 ATP per glucose

Anaerobic respiration - does not need oxygen, produces 2 ATP per glucose

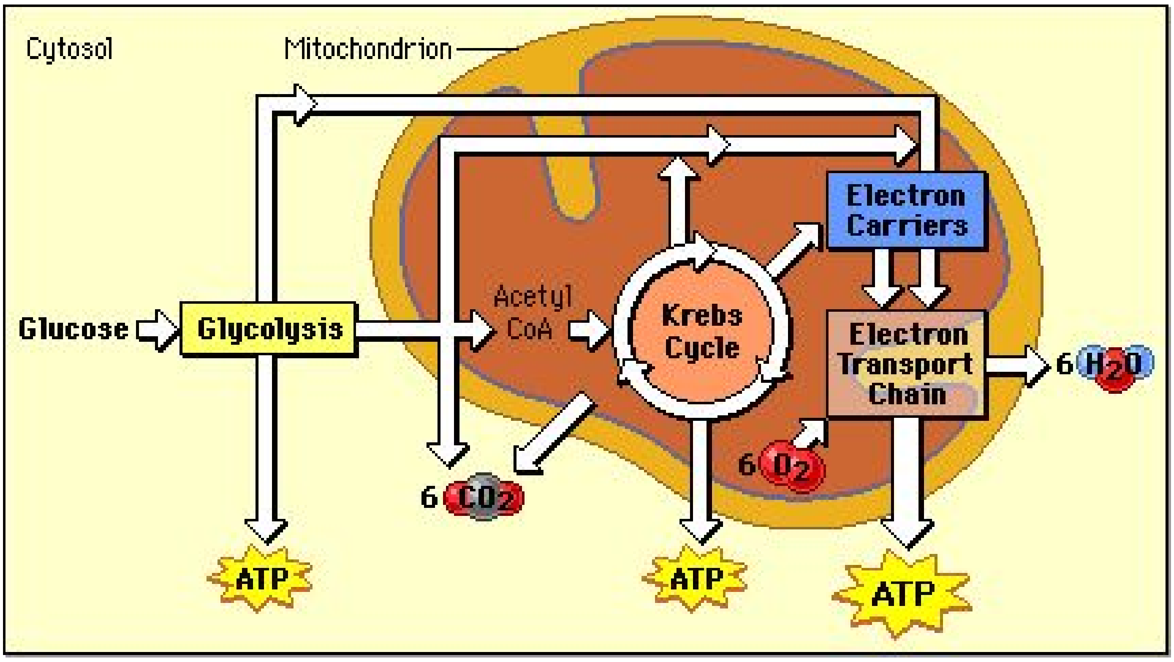
Coenzymes in Respiration (and Photosynthesis)

Coenzymes are molecules that help enzymes catalyse certain reactions. (pg 287)

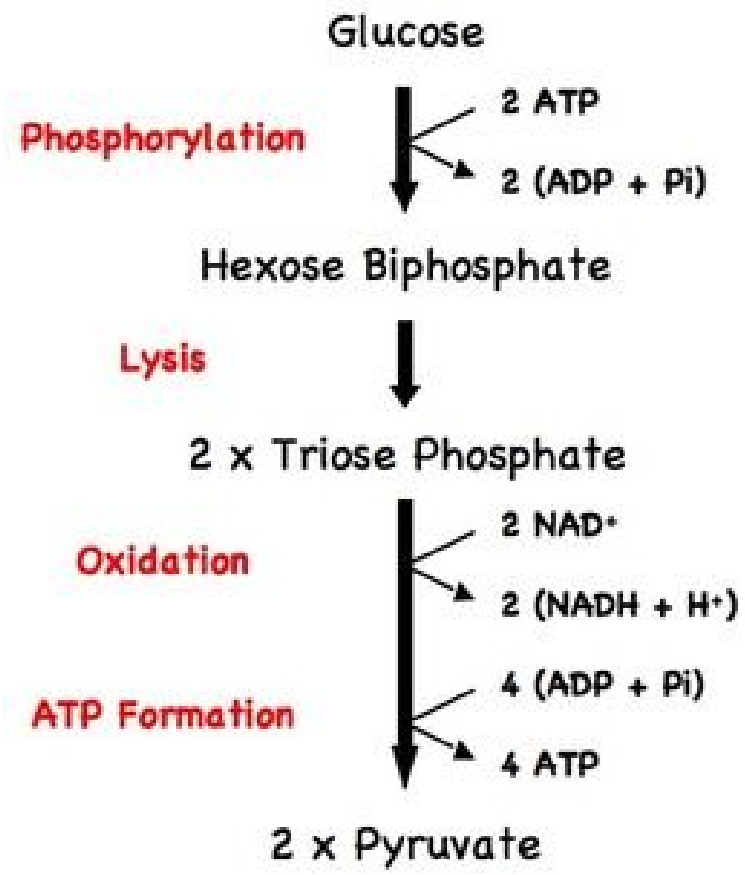


$$NAD^+ + H^+ + 2e^- \longrightarrow NADH$$

Overview of Respiration (pg 283)



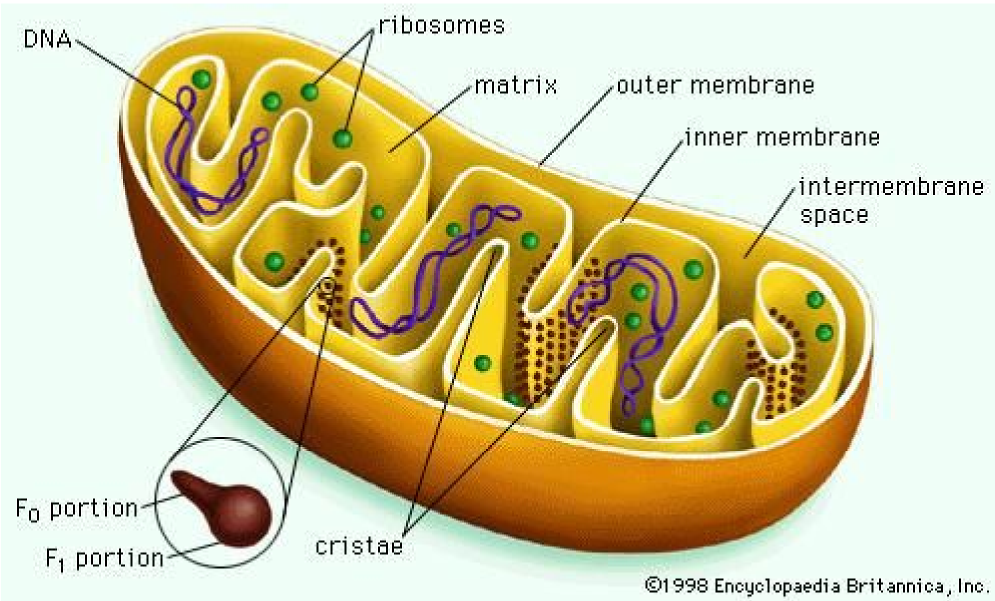
Step 1 - Glycolysis (cytoplasm) (pg 284)



Read summary on page 284.

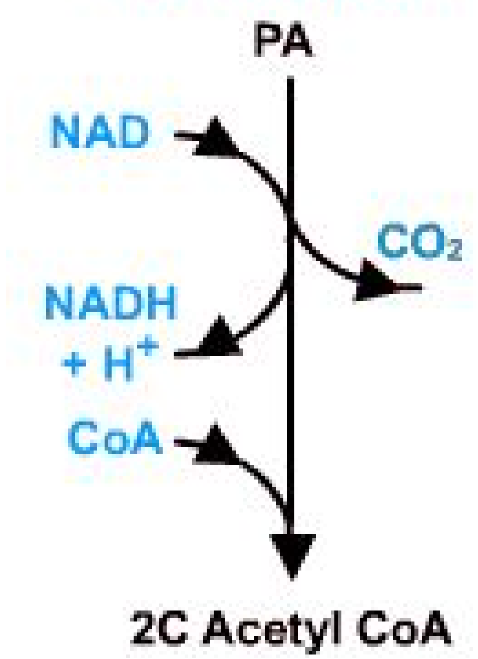
Net gain per glucose = 2 ATP, 2 reduced NAD (substrate-level phosphorylation)

Structure of the Mitochondria (Fig 1, pg 289)



Link Reaction

Pyruvate is actively transported into the mitochondrial matrix, using carrier proteins on the inner membrane.



Pyruvate is oxidised into acetate.

Coenzyme A is added to pyruvate to make acetyl coA.

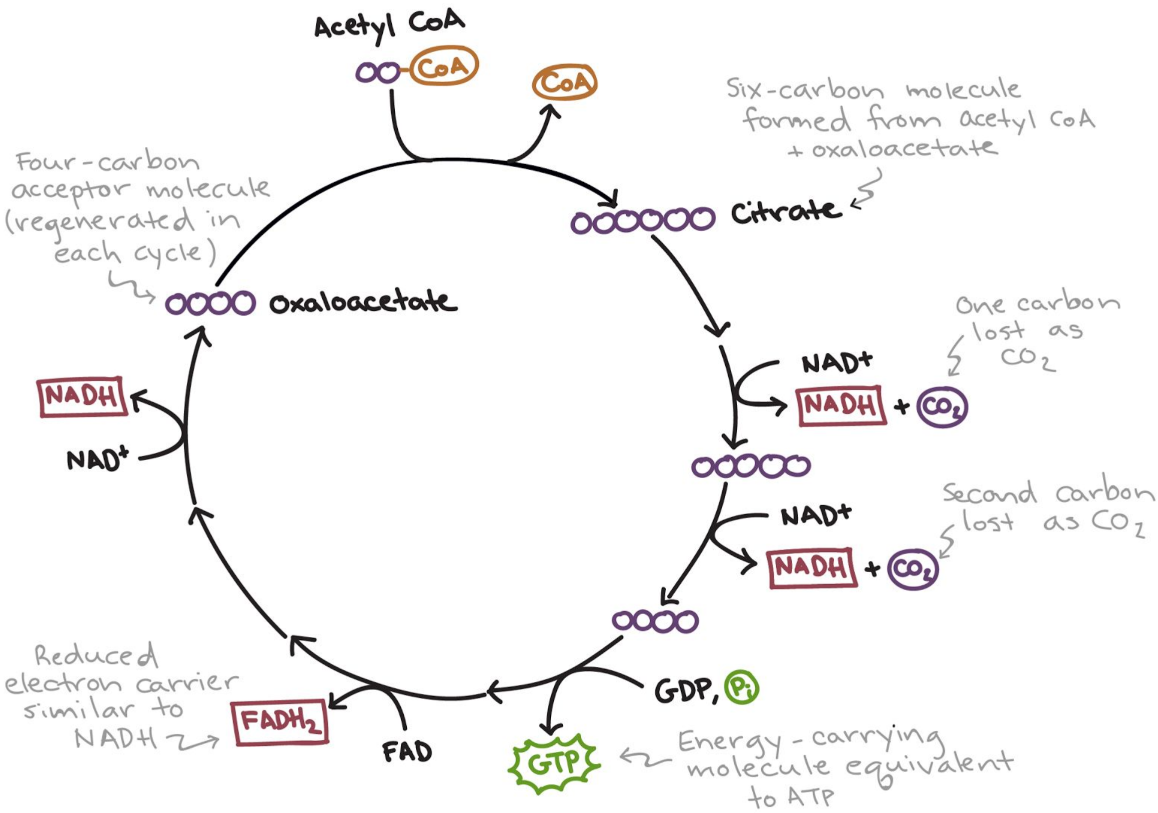
Net gain per glucose:
2 NADH

Enzymes that remove hydrogen = dehydrogenase
(e.g. pyruvate dehydrogenase)

Enzymes that remove CO_2 = decarboxylase
(e.g. pyruvate decarboxylase)

Kreb's cycle

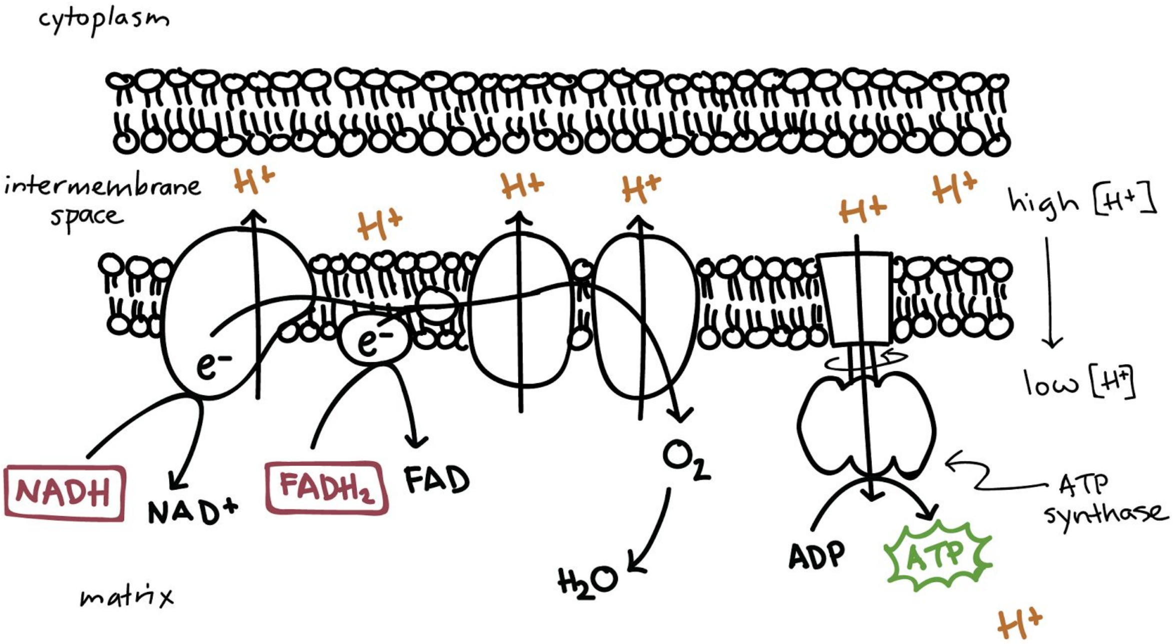
The goal of the Kreb's cycle is to make reduced NAD and reduced FAD. In matrix of mitochondria. (pg 286)



Net gain per glucose: 6 NADH, 2 $FADH_2$, 2 ATP (substrate-level phosphorylation)

Oxidative phosphorylation

Last step in aerobic respiration. The H and electrons from the reduced coenzymes are used to make large amounts of ATP. Uses the electron carriers and ATP synthase located on the cristae. (pg 289 -90)



https://www.youtube.com/watch?v=IRlTBRPv6xM

https://www.youtube.com/watch?v=b_cp8MsnZFA&t=44s

Steps in oxidative phosphorylation:

1. NADH and FADH are oxidised by the electron carriers of the Electron Transport Chain, releasing H^+ and e^-

2. The e^- is picked by the first electron carrier in the ETC

3. e^- flow down the ETC is a series of oxidation-reduction reactions, releasing energy

4. Some energy is used for the active transport of H^+ (protons) from the matrix into the intermembrane space

5. The rest of the energy is lost as heat

6. The concentration of H^+ builds up in the intermembrane space, resulting in a concentration gradient for H^+ across the inner mitochondrial membrane

7. The H^+ diffuse back into the matrix via proton channels located within ATP synthase, which is embedded in the crista (CHEMIOSMOSIS)

8. The potential energy stored within the H^+ is used to drive a shaft, that allows the enzyme to turn, and catalyse the joining of ADP and Pi to form ATP

9. The electrons combine with oxygen and H^+ to form water. This ‘neutralises’ the H^+ and ensures that a conc gradient is maintained across the membrane

Oxygen acts as the terminal electron acceptor in oxidative phosphorylation

Some animals, like the kangaroo rat, can use this water for metabolic reactions. Humans tend to lose a lot of this water as sweat or during exhalation.

Alternative respiratory substrates (pg 291)

Fatty acids

FA are broken down into 2C Acetyl-coA, which enters the Kreb's cycle.

Gram per gram, fats release 3X more energy than glucose

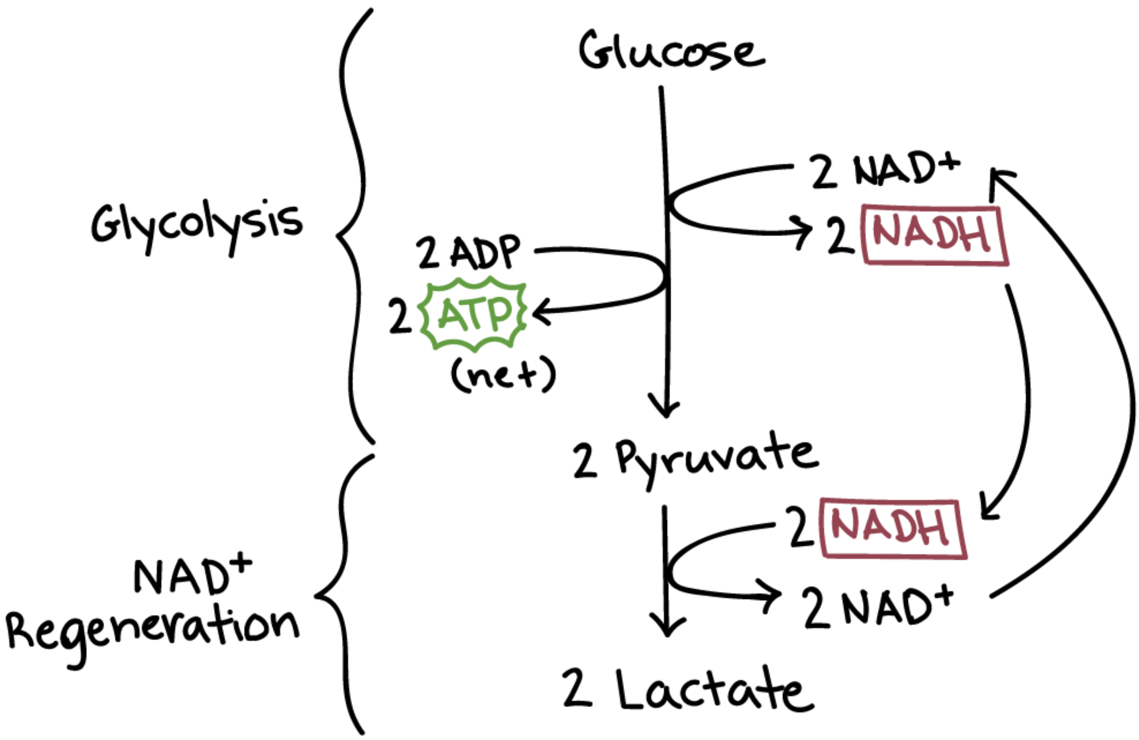
Amino acids

Amino acids are first deaminated (removal of nitrogen group) before entering the respiratory pathway.

3C amino acids are converted to pyruvate, whereas amino acids with 4 or 5 carbons are converted to intermediates of the Krebs cycles.

Proteins release similar amounts of energy to glucose

Anaerobic Respiration (pg 293)



Net gain per glucose = 2 ATP

Why might lactic acid cause muscle cramps?

When oxygen levels are low, the cell uses the anaerobic pathway to generate ATP. This is a modification of glycolysis.

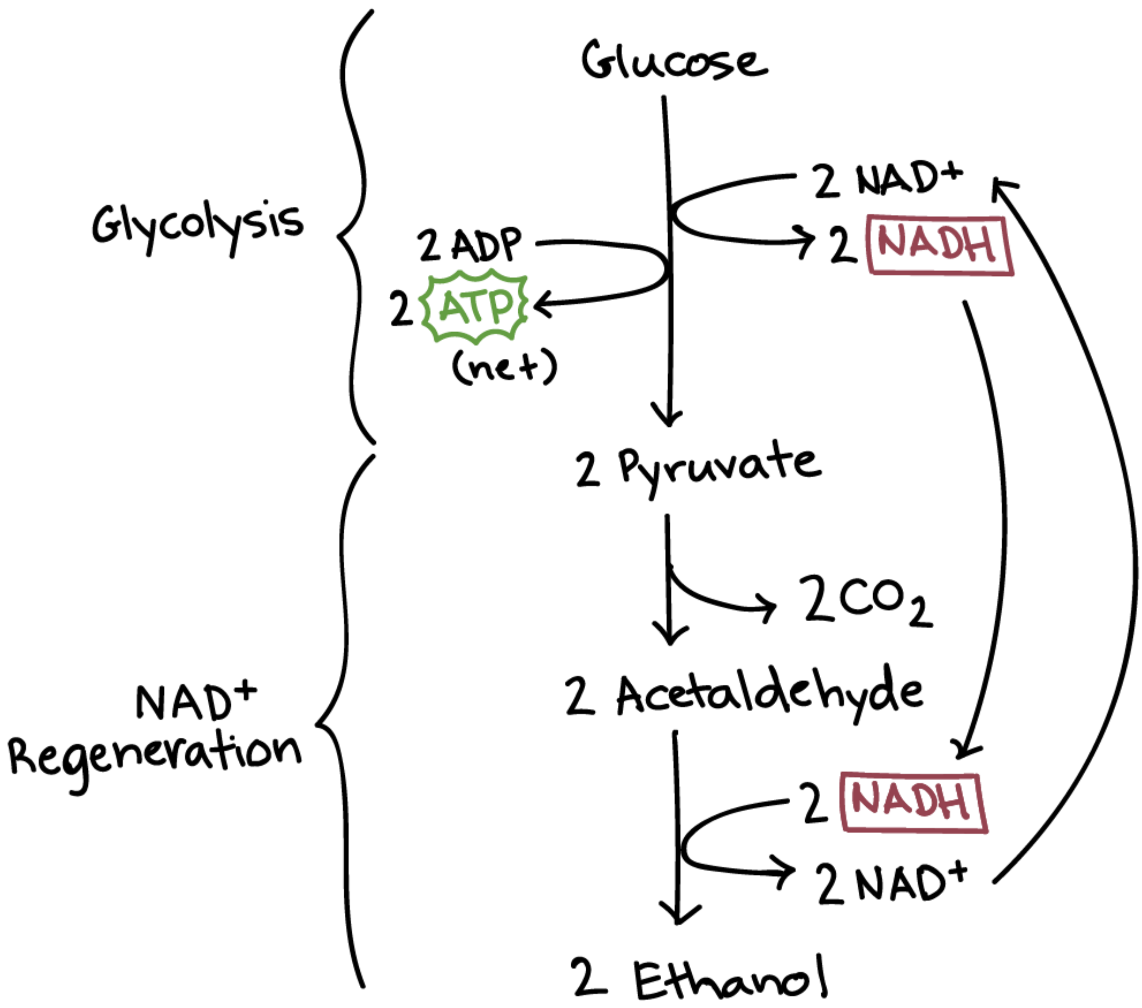
During glycolysis, glucose is oxidised to pyruvate. This produces 2 ATP (net gain) and 2 reduced NAD.

ATP is hydrolysed by ATPase during metabolic reactions, regenerating ADP and Pi.

However, the pathway for oxidising NADH does not function is the absence of oxygen.

Therefore, NAD becomes a limiting factor. To overcome this, pyruvate is reduced to lactate, using up the hydrogens from NADH, regenerating NAD

Anaerobic respiration in yeast



This pathway is not reversible, and produces CO_2 and ethanol = fermentation