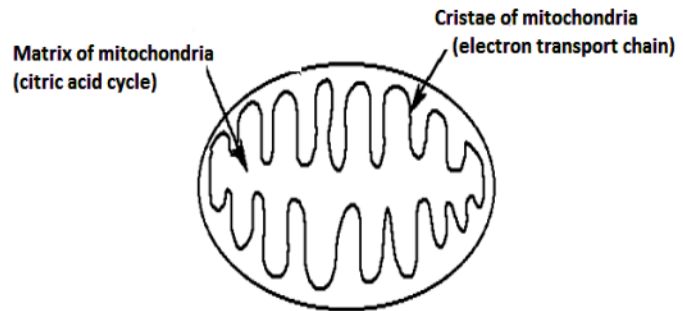


Respiration

Stages of respiration

1. **Glycolysis** (cytoplasm)
2. **Citric Acid Cycle** (Kreb Cycle)
(matrix of mitochondria)
3. **Electron Transport Chain**
(cristae/inner mitochondria membrane)



ATP production

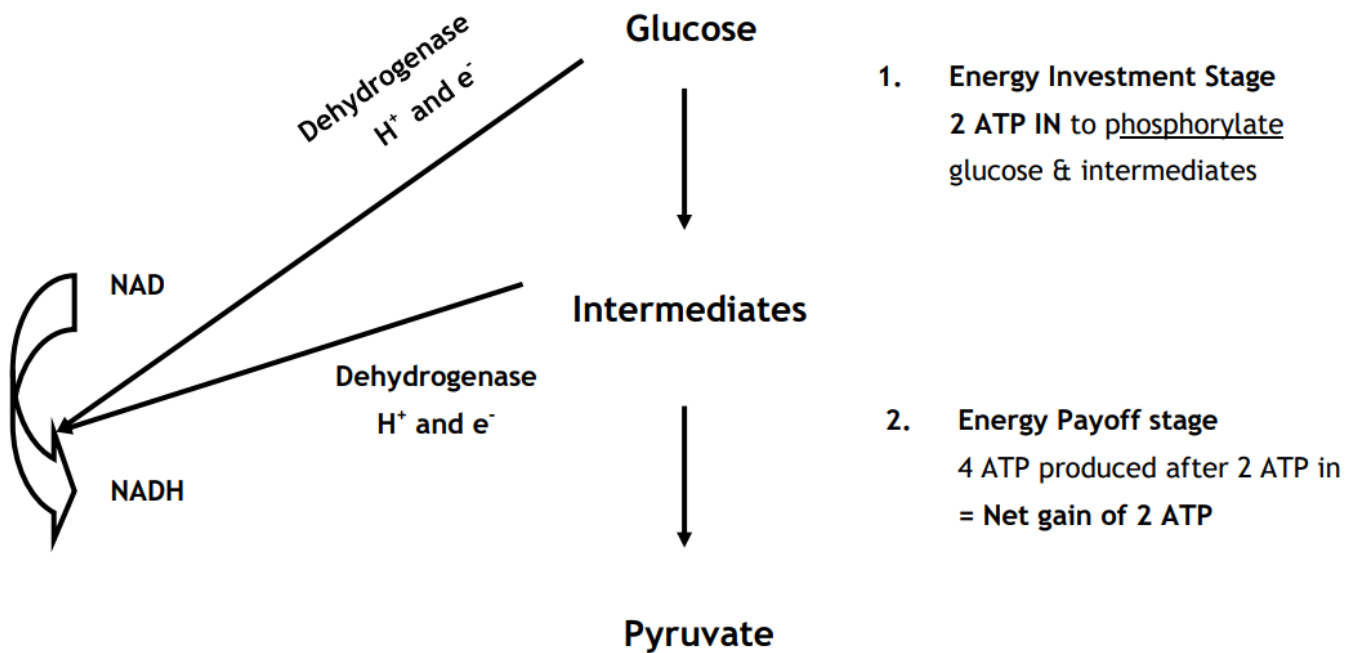
The **majority** of the ATP is produced during the **electron transport chain** although **ALL stages** generate some ATP.

Glycolysis

Location—cytoplasm

Process does not require oxygen

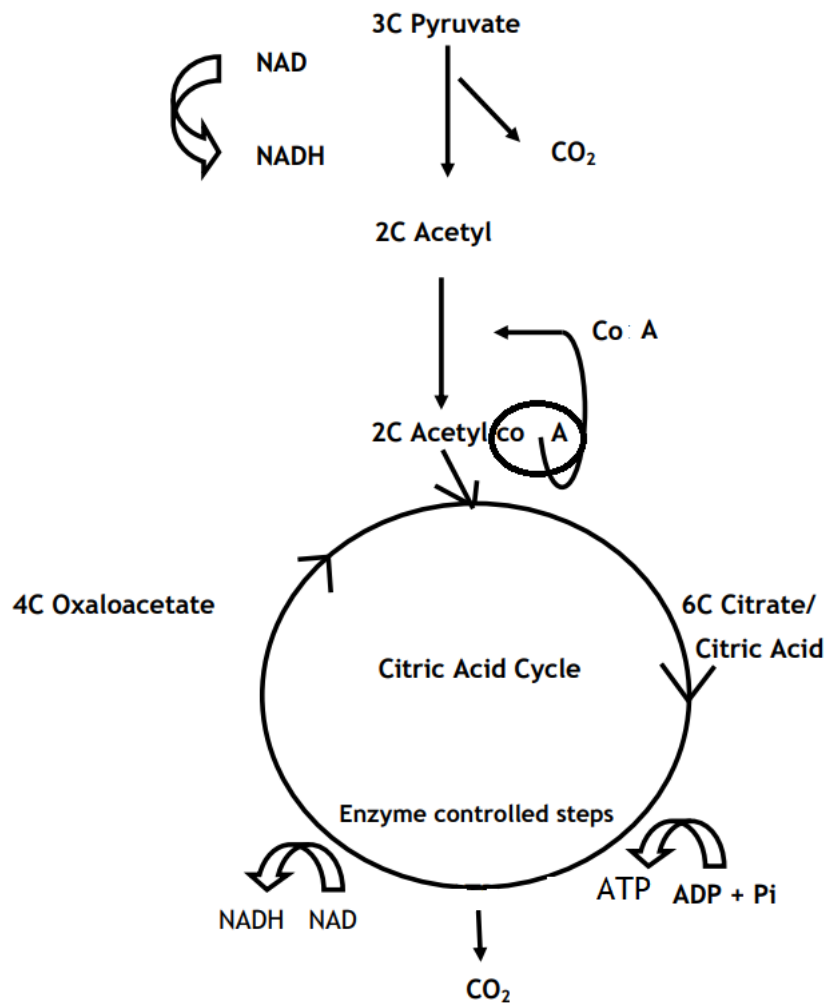
Net gain of 2ATP



Respiration

Aerobic Stage of Respiration

Process **requires oxygen** to move beyond pyruvate and is controlled by **enzymes** called dehydrogenases.



Summary of steps

1. In aerobic conditions, pyruvate is broken down to an acetyl group.
2. Acetyl combines with recycled coenzyme A forming acetyl coenzyme A.
3. In the citric acid cycle, the acetyl group from acetyl coenzyme A combines with oxaloacetate to form citrate.
4. During a series of enzyme-controlled steps, citrate is gradually regenerated back into oxaloacetate.
5. ATP, NADH and CO₂ are all produced during these enzyme-controlled steps.

7. Dehydrogenases and Co enzymes

Role of dehydrogenase

Removes hydrogen ions and electrons from substances and passes to coenzyme NAD to form NADH.

Location—Glycolysis and Citric Acid Cycle.

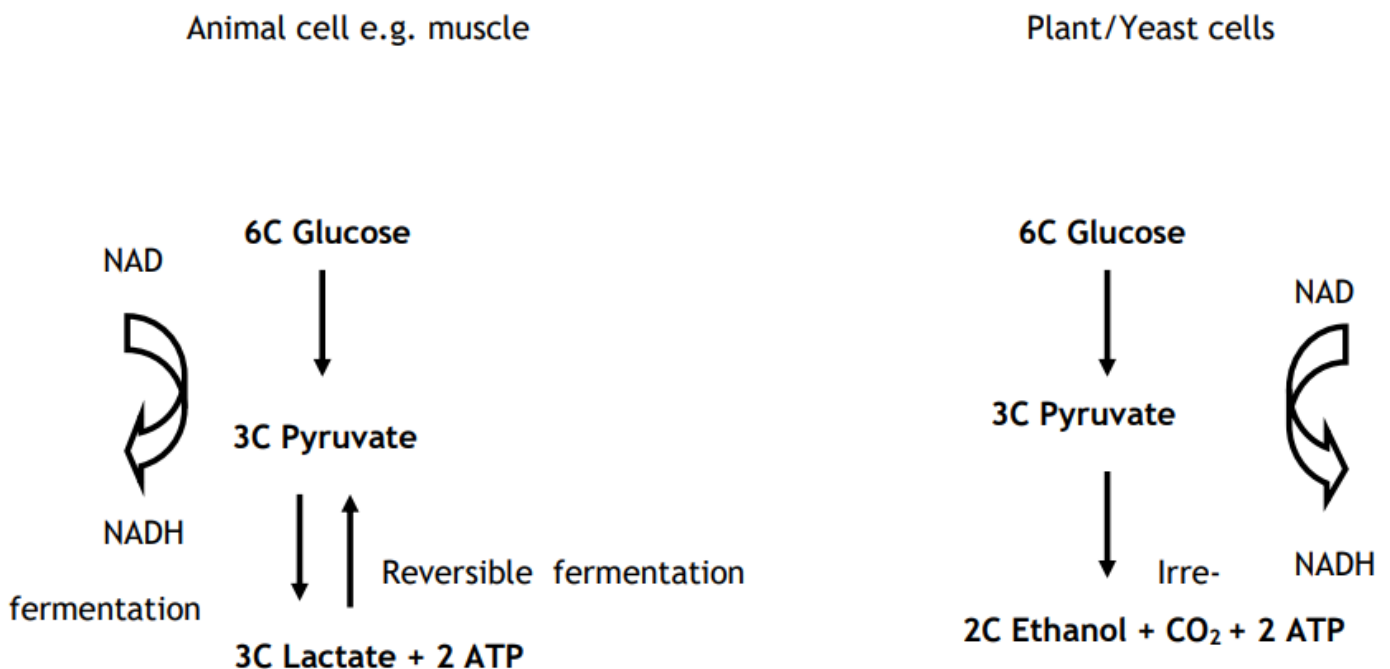
Role of Co enzymes

Accepts hydrogen ions and electrons and takes them to the electron transport chain on inner mitochondrial membrane.

Location—Glycolysis, Citric Acid Cycle and Electron Transport Chain

Fermentation

In absence of oxygen **fermentation** occurs in the cytoplasm.



Fermentation in animals (muscle) cells

Reversible process. Once oxygen is present again (repaying the oxygen debt) lactate is broken down into pyruvate which can now be made into acetyl in aerobic respiration.

Fermentation in yeast/plants

Irreversible process due to loss of CO₂ into air, ethanol builds up and kills plant/yeast.

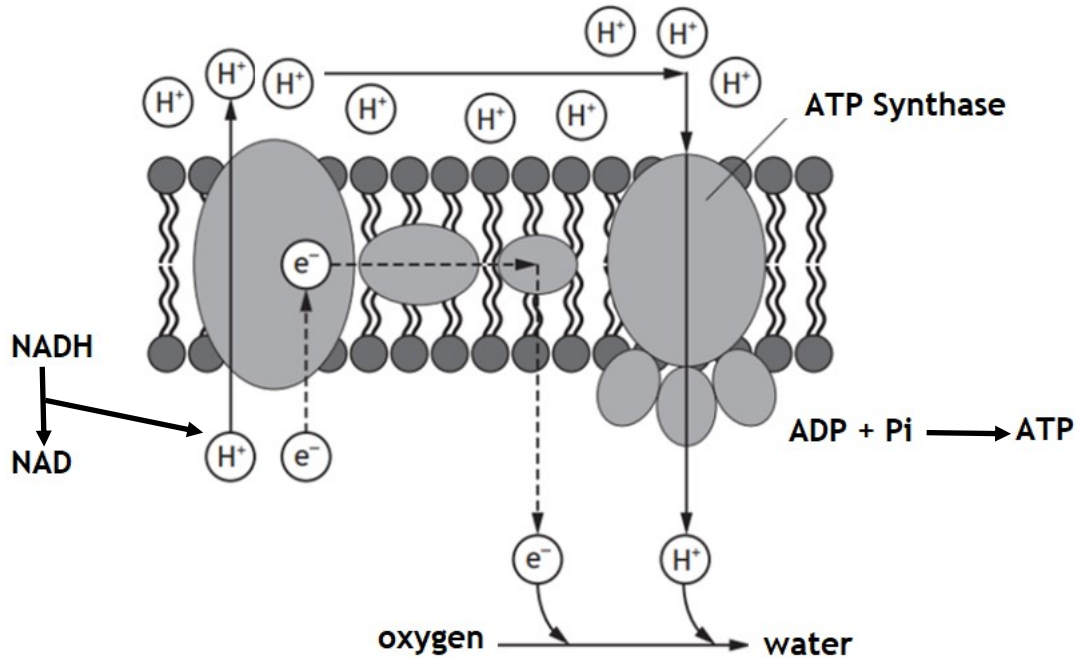
Fermentation results in much less ATP (2 ATP) being produced than in aerobic respiration.

Electron Transport Chain

Electron Transport Chain

The electron transport is a series of **carrier proteins** attached to the **inner mitochondrial membrane**.

Location—Inner membrane of mitochondria (Cristae).



1. The co enzyme NADH releases electrons and hydrogen ions in the inner mitochondrial membrane.
2. Electrons pass along the electron transport chain and release energy.
3. The energy released by electrons pumps H^+ ions across the membrane by active transport.
4. H^+ diffuses back across ATP synthase causing it to rotate to make ATP from ADP + P_i .
5. Oxygen is the final hydrogen ions and electron acceptor forming water.
6. Most of the ATP produced occurs during this stage.

High/Low Cristae

Lots of folds in the inner mitochondrial membrane are needed for active cells as they need lots of ATP e.g. muscle/brain/sperm cells.

More folds/cristae mean more electrons pass down chain/more H^+ is released & more ATP is produced by ATP synthase.

