

9-2 The Krebs Cycle and Electron Transport



The Krebs Cycle

In the presence of oxygen, pyruvic acid produced in glycolysis passes to the second stage of cellular respiration, the **Krebs cycle**.



During the Krebs cycle, pyruvic acid is broken down into carbon dioxide in a series of energy-extracting reactions.

9-2 The Krebs Cycle and The Krebs Cycle

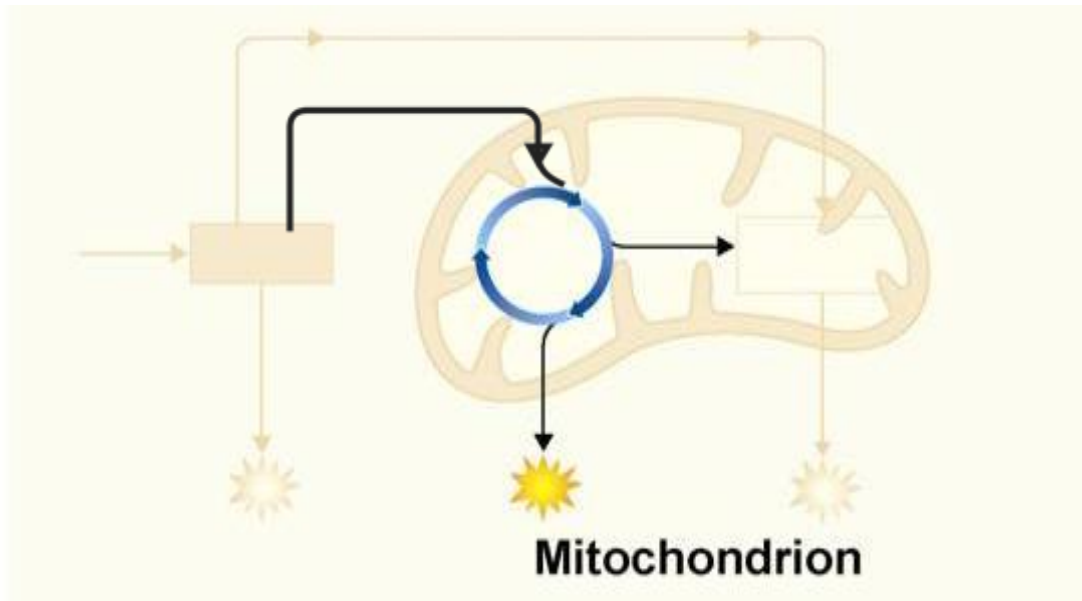
Electron Transport

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 Pyruvic acid

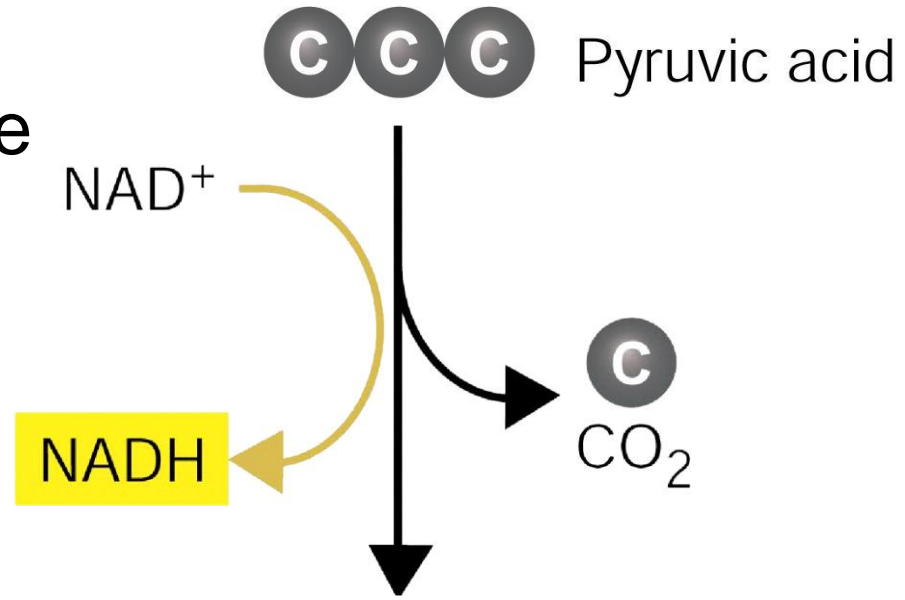
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The Krebs cycle begins when pyruvic acid produced by glycolysis enters the mitochondrion.



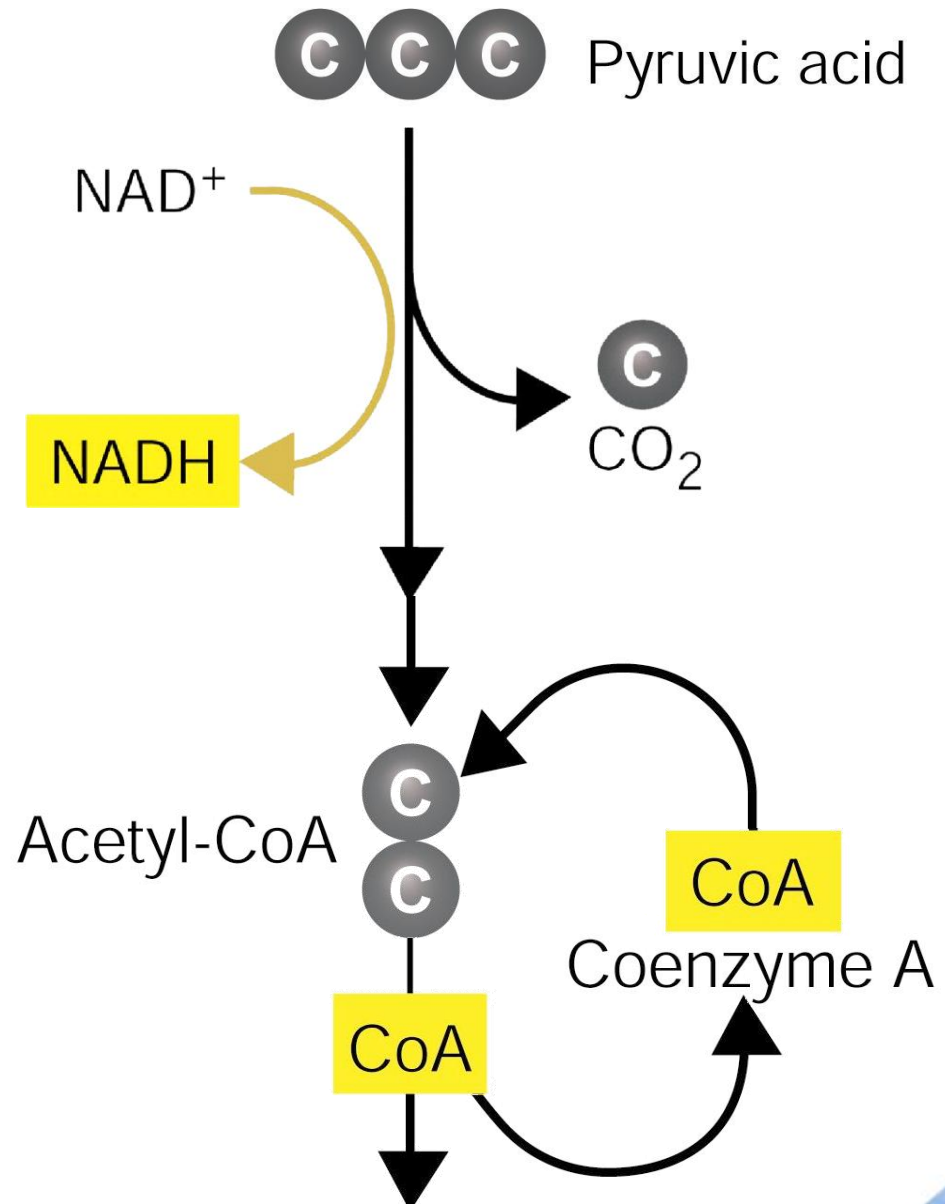
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One carbon molecule is removed, forming CO_2 , and electrons are removed, changing NAD^+ to NADH .



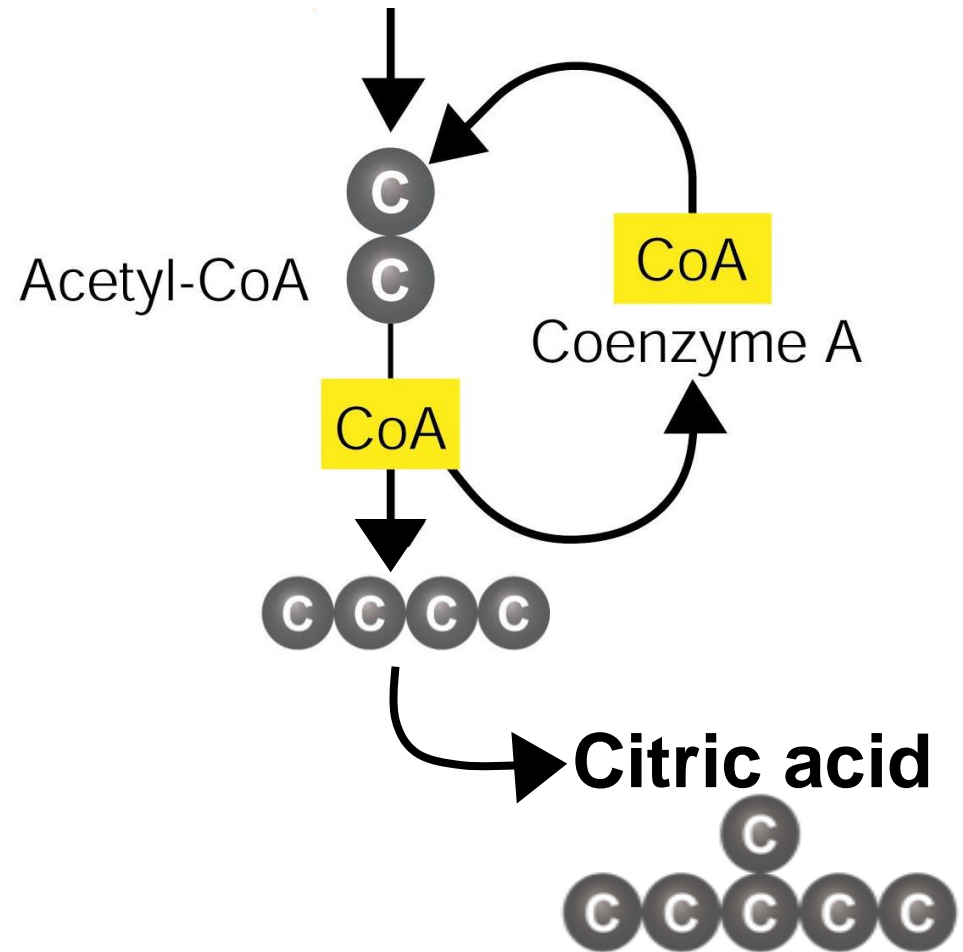
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Coenzyme A joins the 2-carbon molecule, forming acetyl-CoA.



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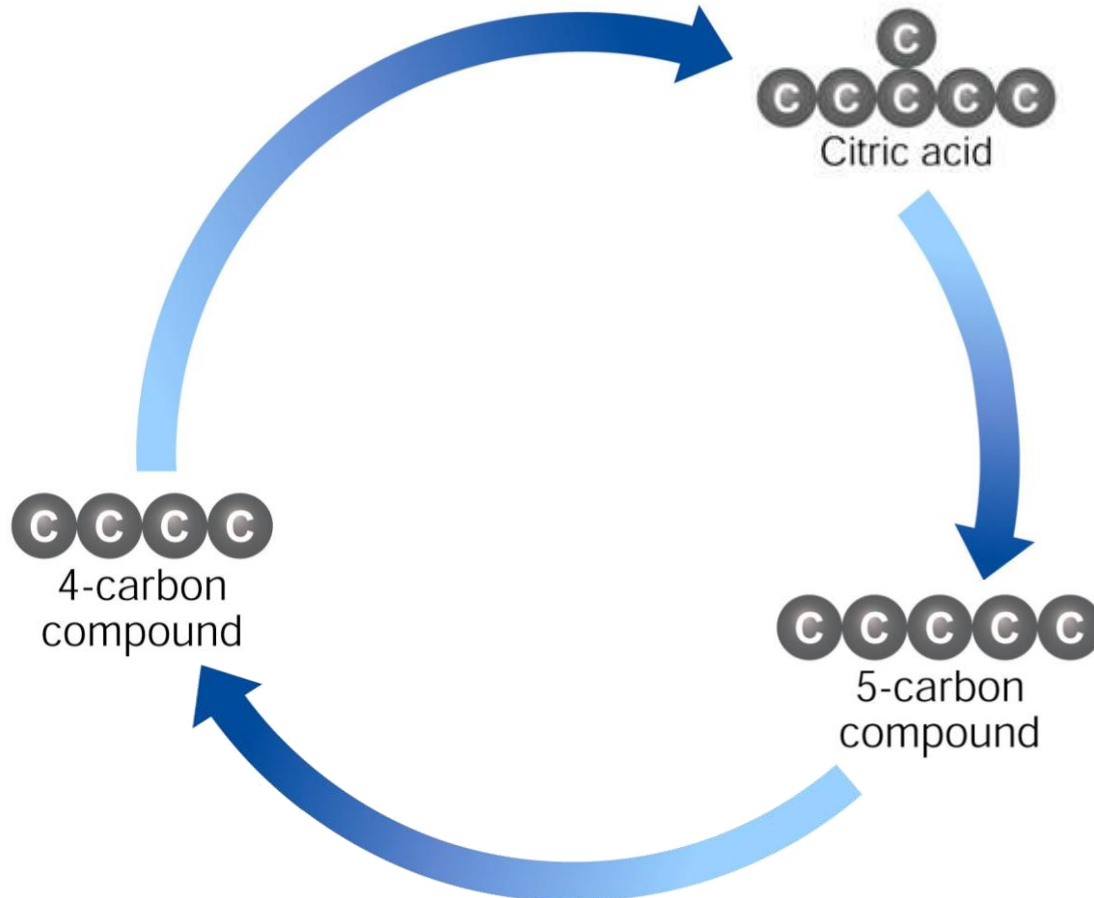
Acetyl-CoA then adds the 2-carbon acetyl group to a 4-carbon compound, forming citric acid.



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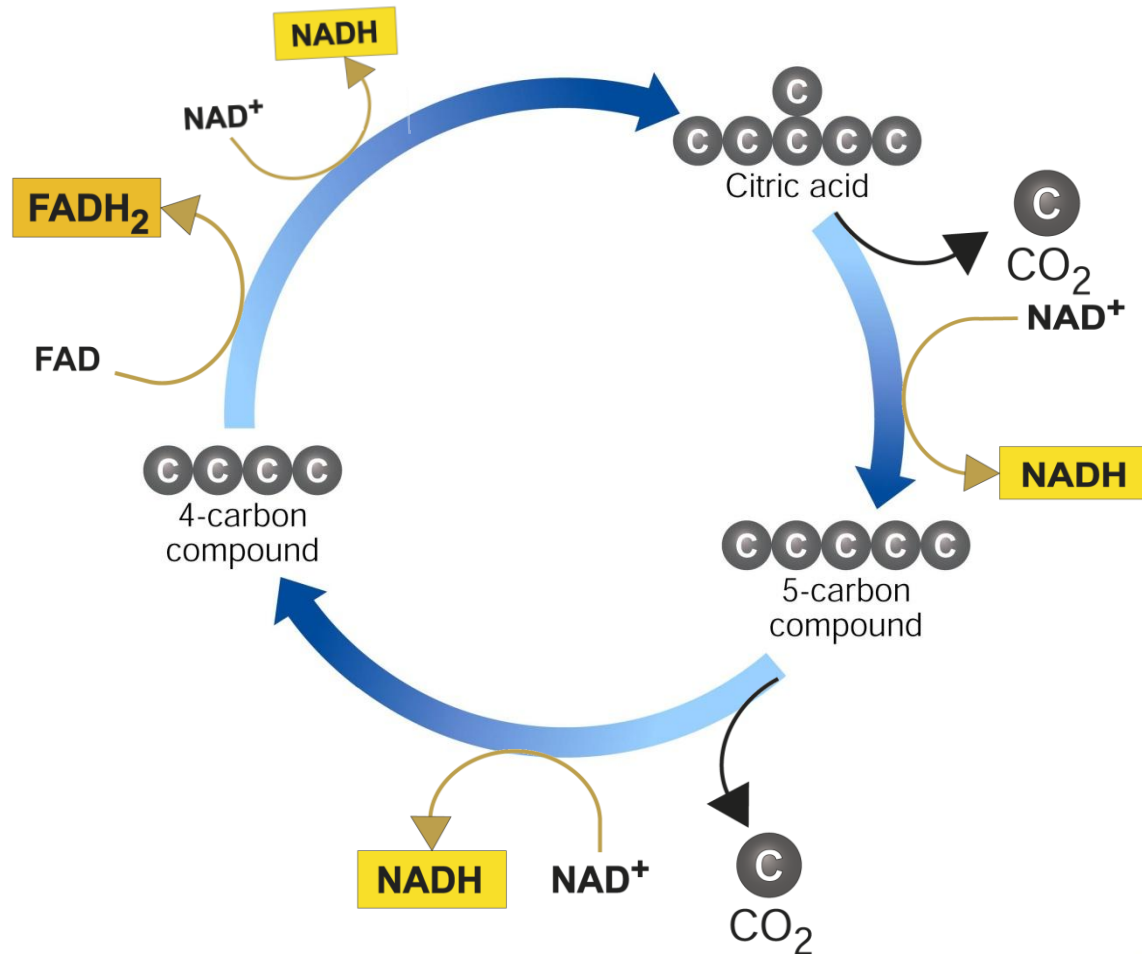
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Citric acid is broken down into a 5-carbon compound, then into a 4-carbon compound.



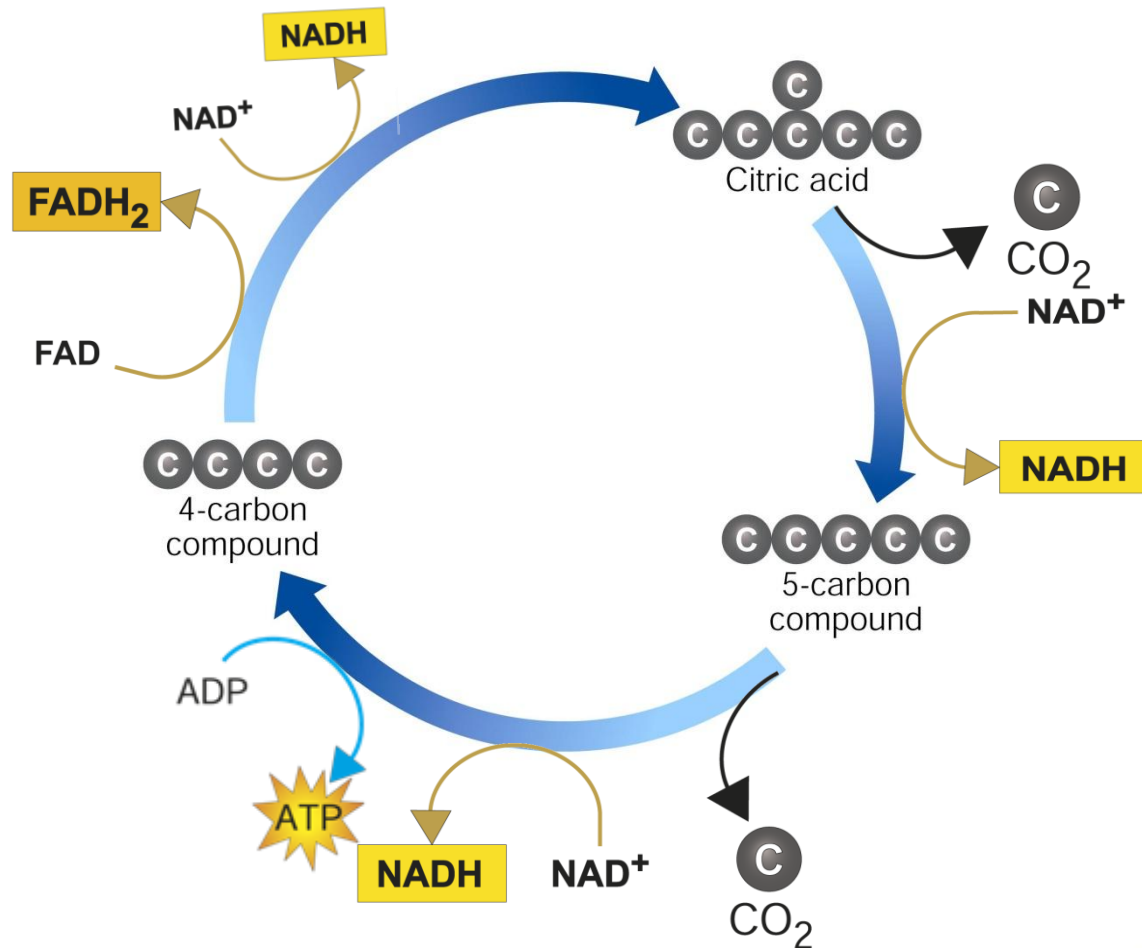
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Two more molecules of CO_2 are released and electrons join NAD^+ and FAD , forming NADH and FADH_2 .



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In addition, one molecule of ATP is generated.



9-2 The Krebs Cycle and The Krebs Cycle Electron Transport

The energy tally from 1 molecule of pyruvic acid is

- 4 NADH
- 1 FADH₂
- 1 ATP

9-2 The Krebs Cycle and The Krebs Cycle Electron Transport

What does the cell do with all those high-energy electrons in carriers like NADH?

In the presence of oxygen, those high-energy electrons can be used to generate huge amounts of ATP.

Electron Transport

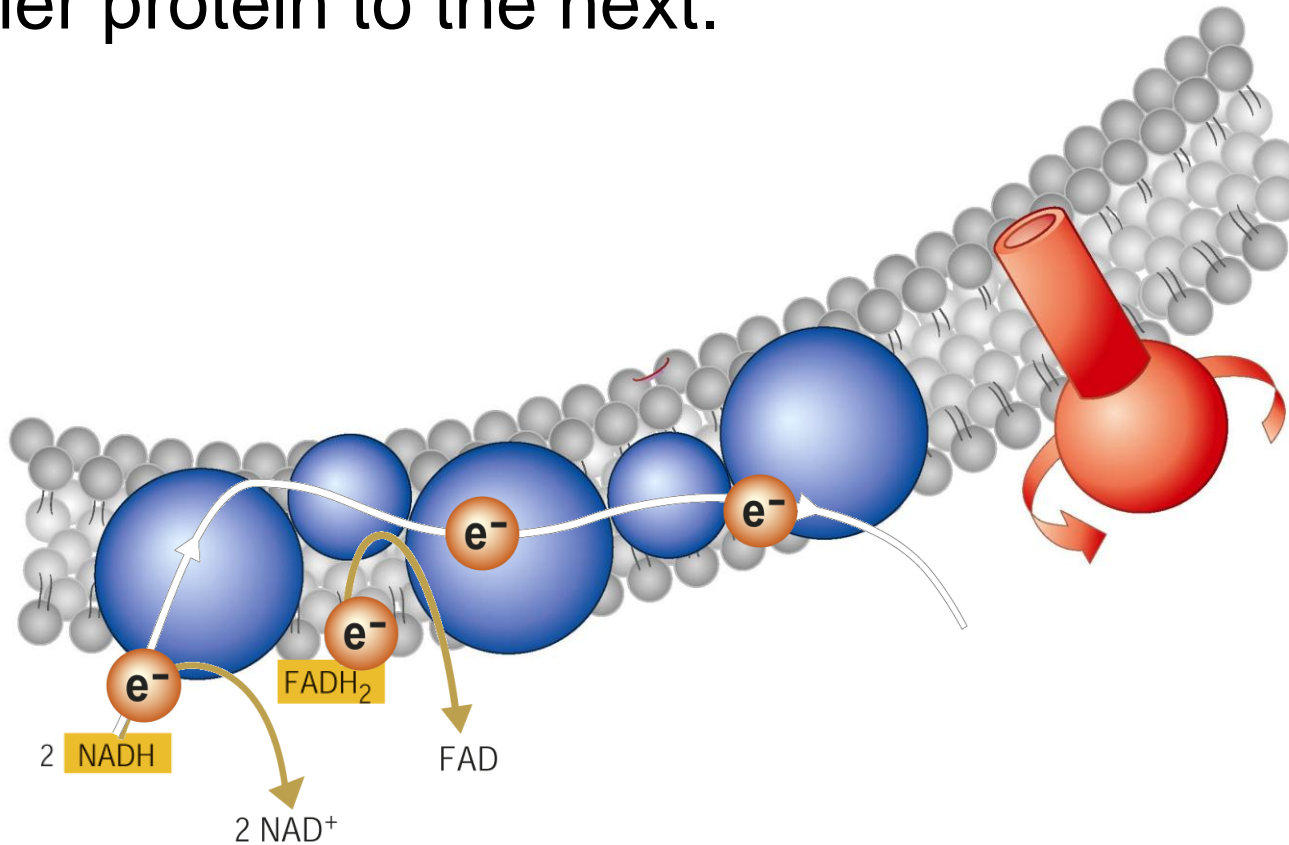


The electron transport chain uses the high-energy electrons from the Krebs cycle to convert ADP into ATP.

9-2 The Krebs Cycle and Electron Transport Electron Transport

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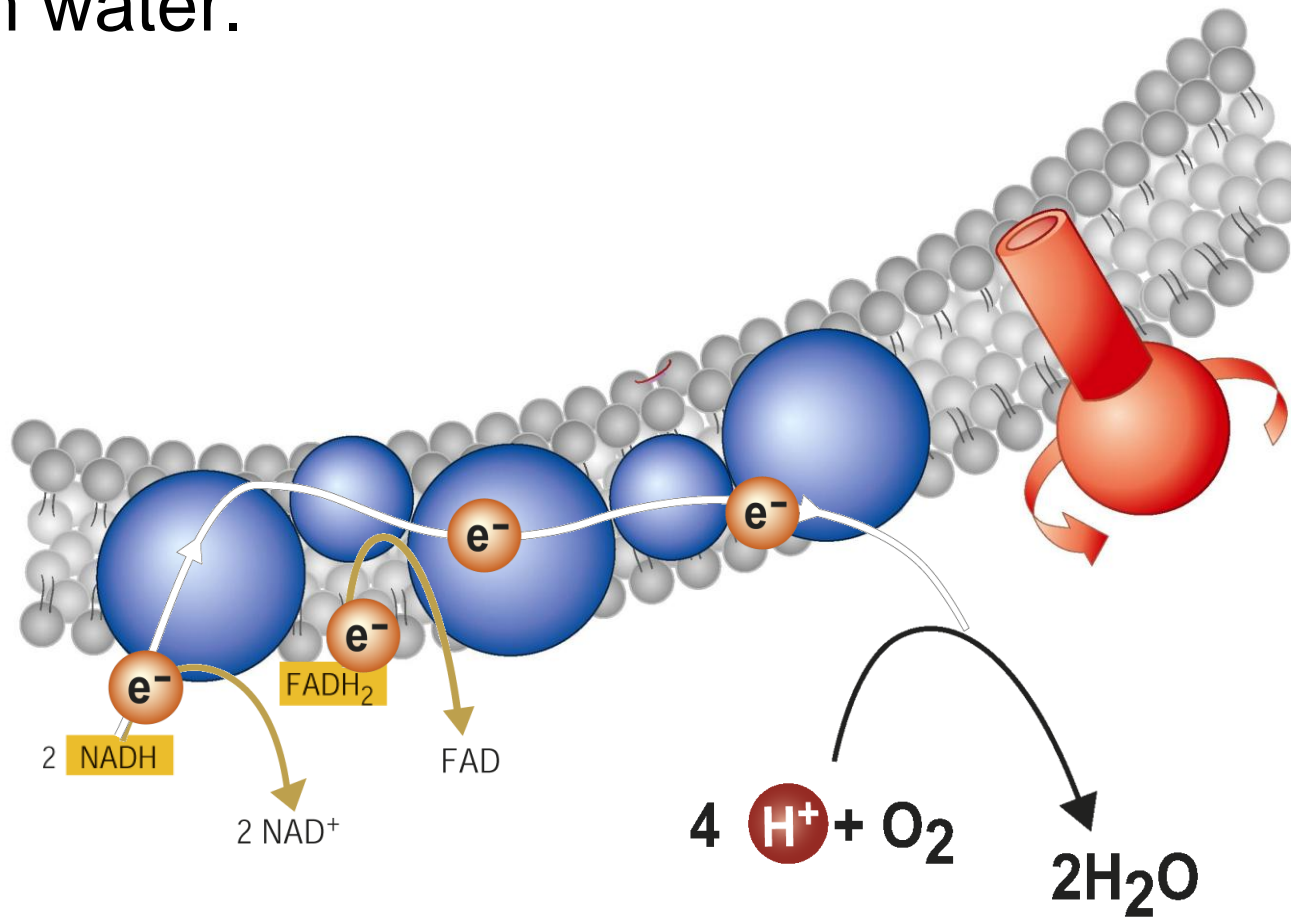
High-energy electrons from NADH and FADH_2 are passed along the electron transport chain from one carrier protein to the next.



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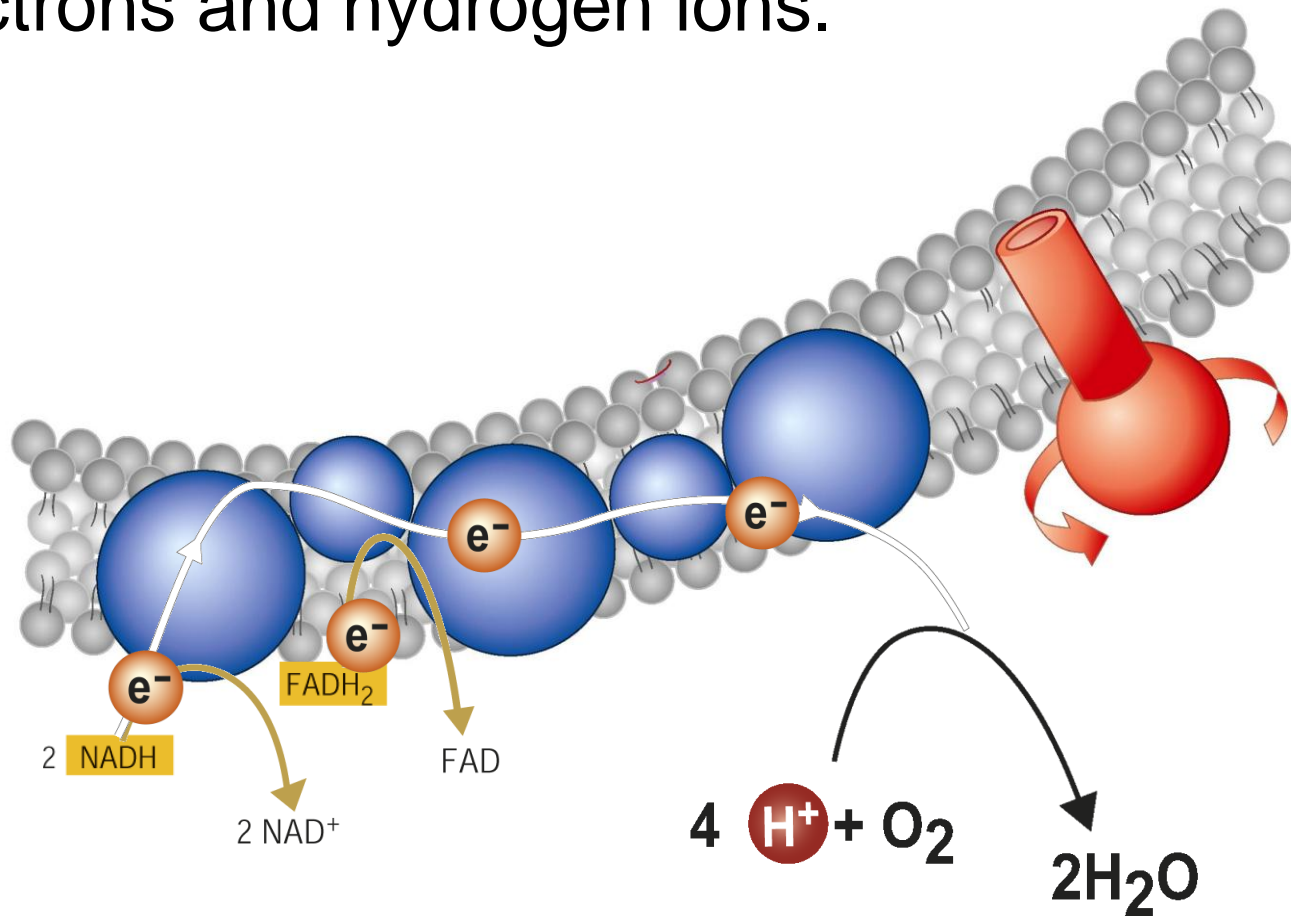
Electron Transport

At the end of the chain, an enzyme combines these electrons with hydrogen ions and oxygen to form water.



9-2 The Krebs Cycle and Electron Transport Electron Transport

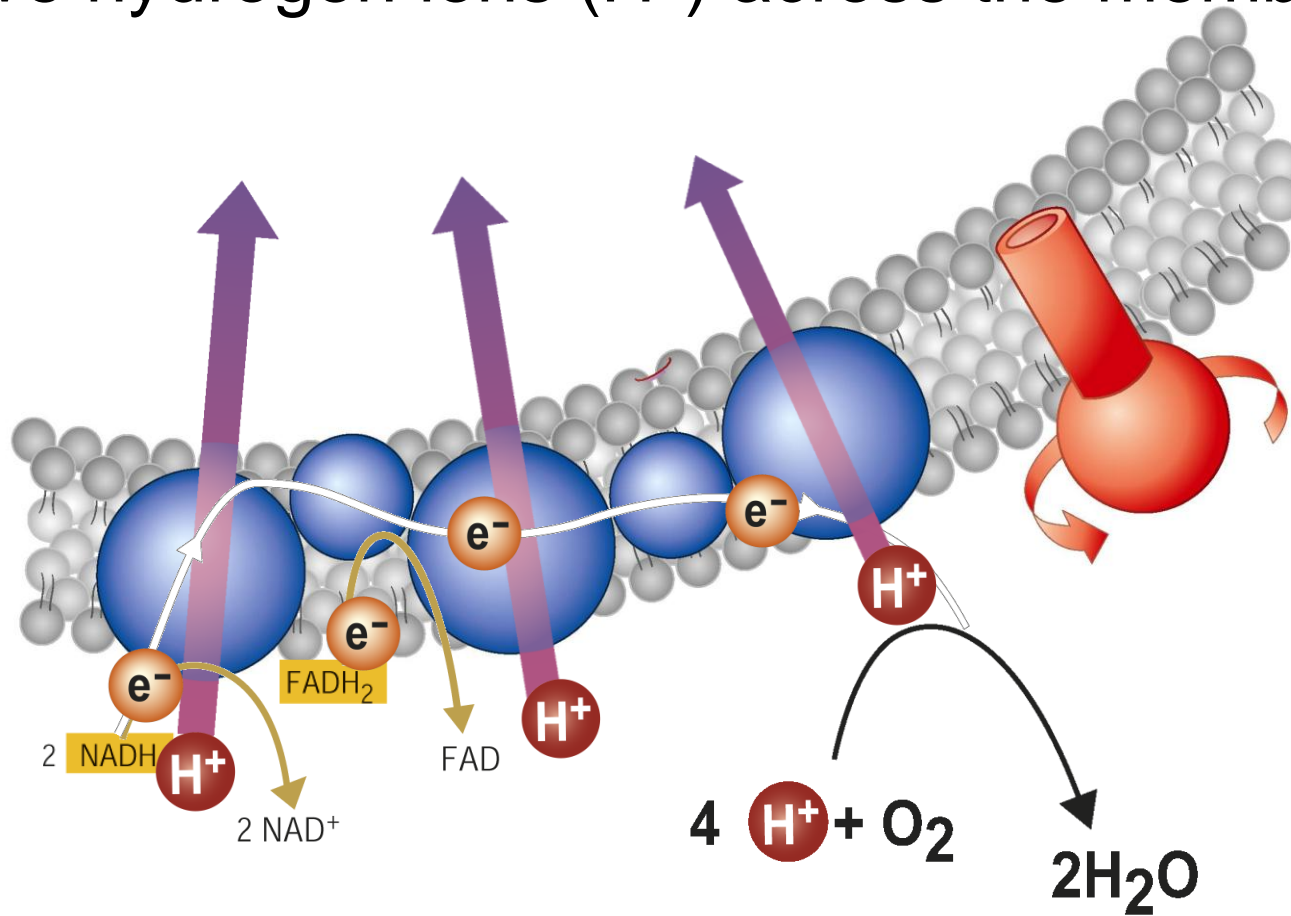
As the final electron acceptor of the electron transport chain, oxygen gets rid of the low-energy electrons and hydrogen ions.



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Electron Transport

When 2 high-energy electrons move down the electron transport chain, their energy is used to move hydrogen ions (H^+) across the membrane.

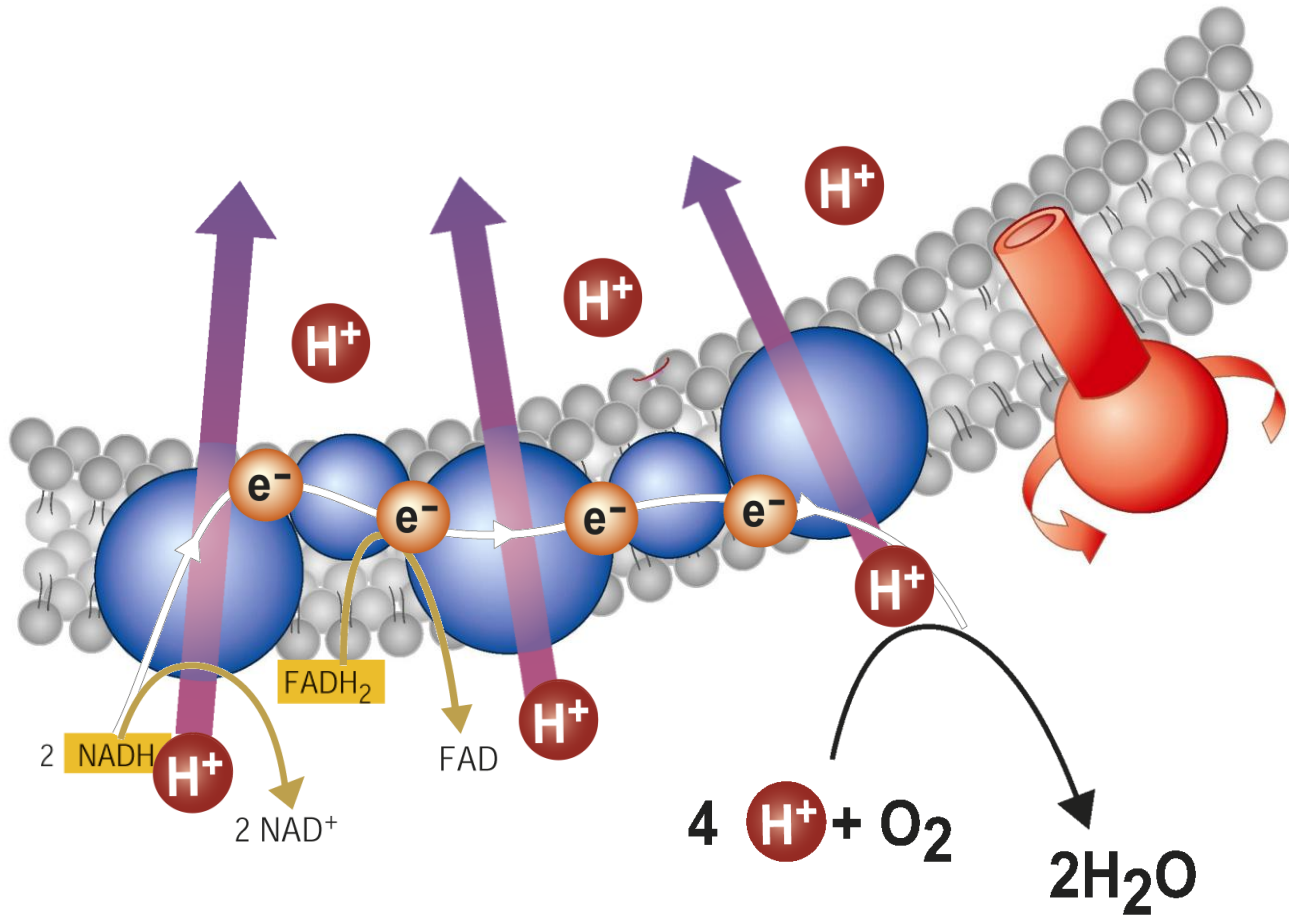


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Electron Transport

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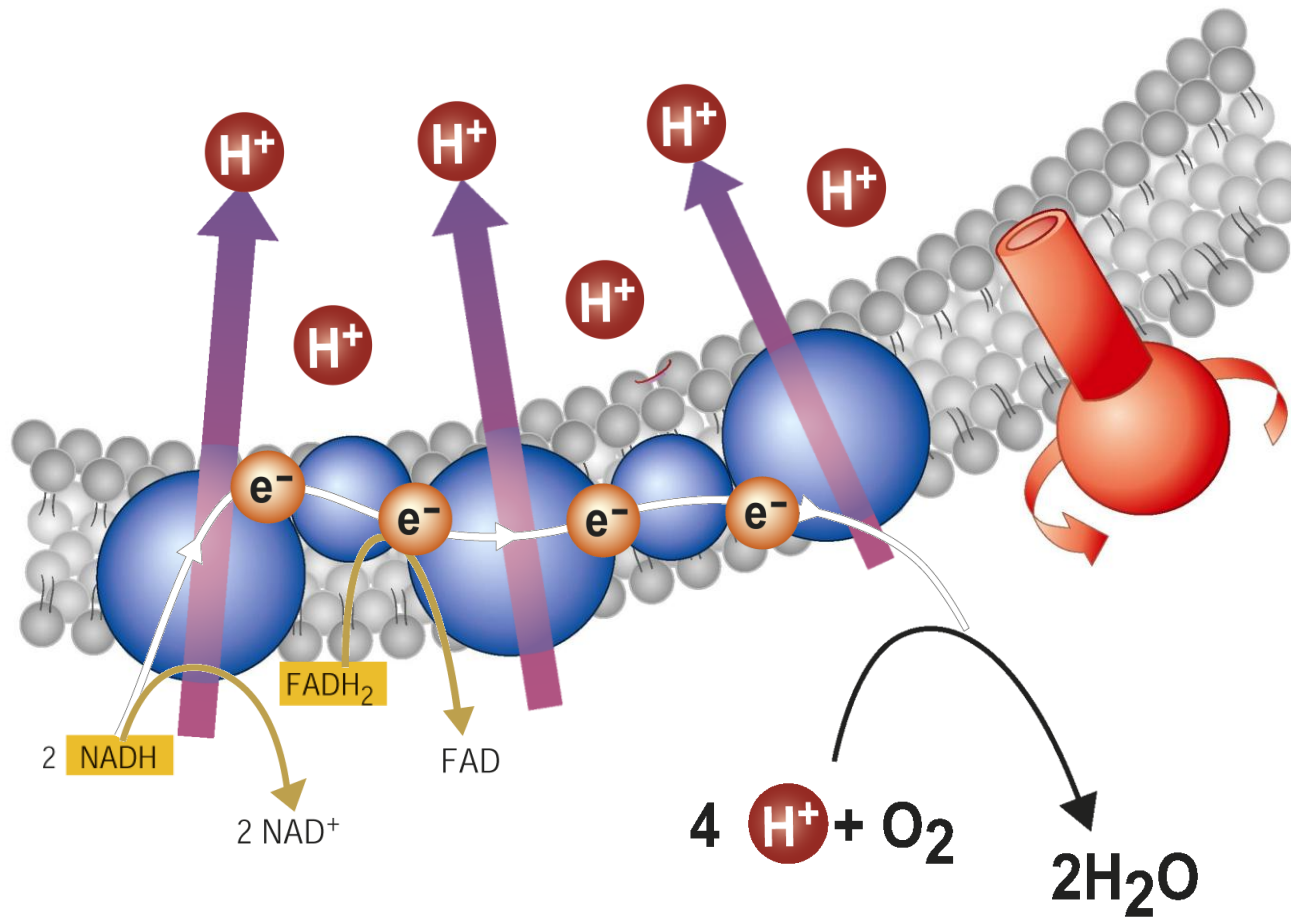
During electron transport, H^+ ions build up in the intermembrane space, so it is positively charged.



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Electron Transport

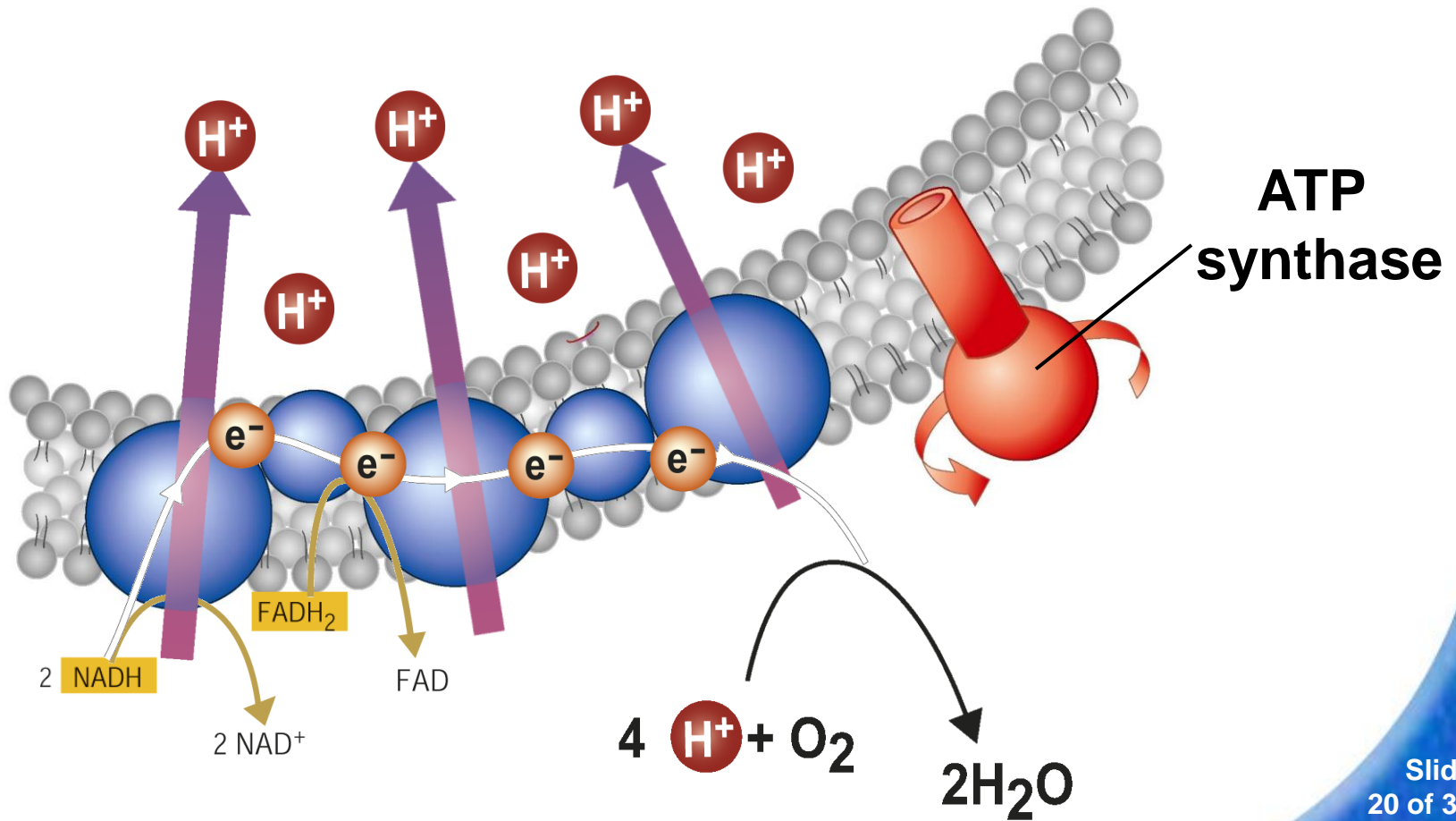
The other side of the membrane, from which those H^+ ions are taken, is now negatively charged.



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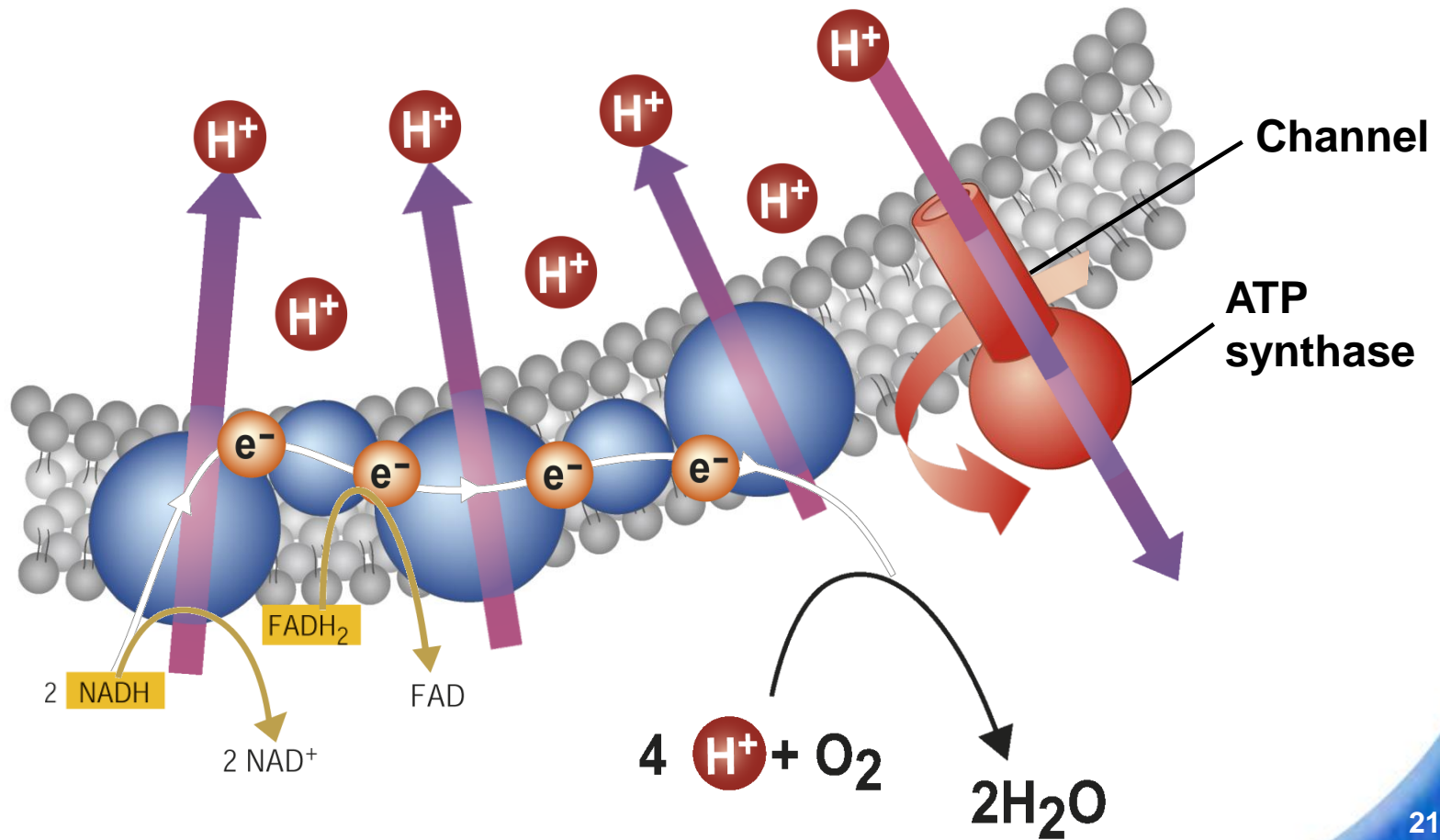
Electron Transport

The inner membranes of the mitochondria contain protein spheres called ATP synthases.



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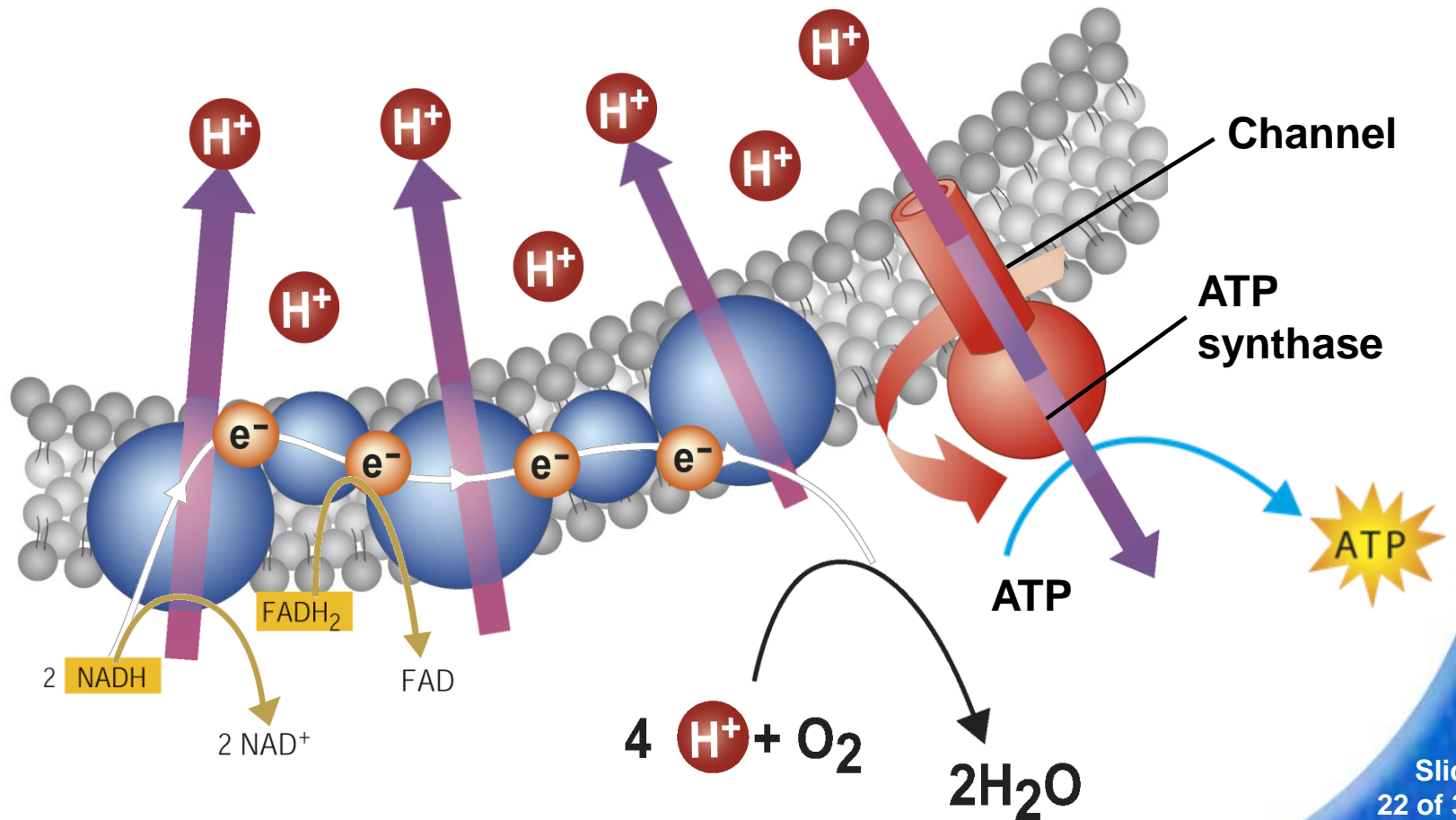
As H^+ ions escape through channels into these proteins, the ATP synthase spins.



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Electron Transport

As it rotates, the enzyme grabs a low-energy ADP, attaching a phosphate, forming high-energy ATP.



9-2 The Krebs Cycle and Electron Transport Electron Transport

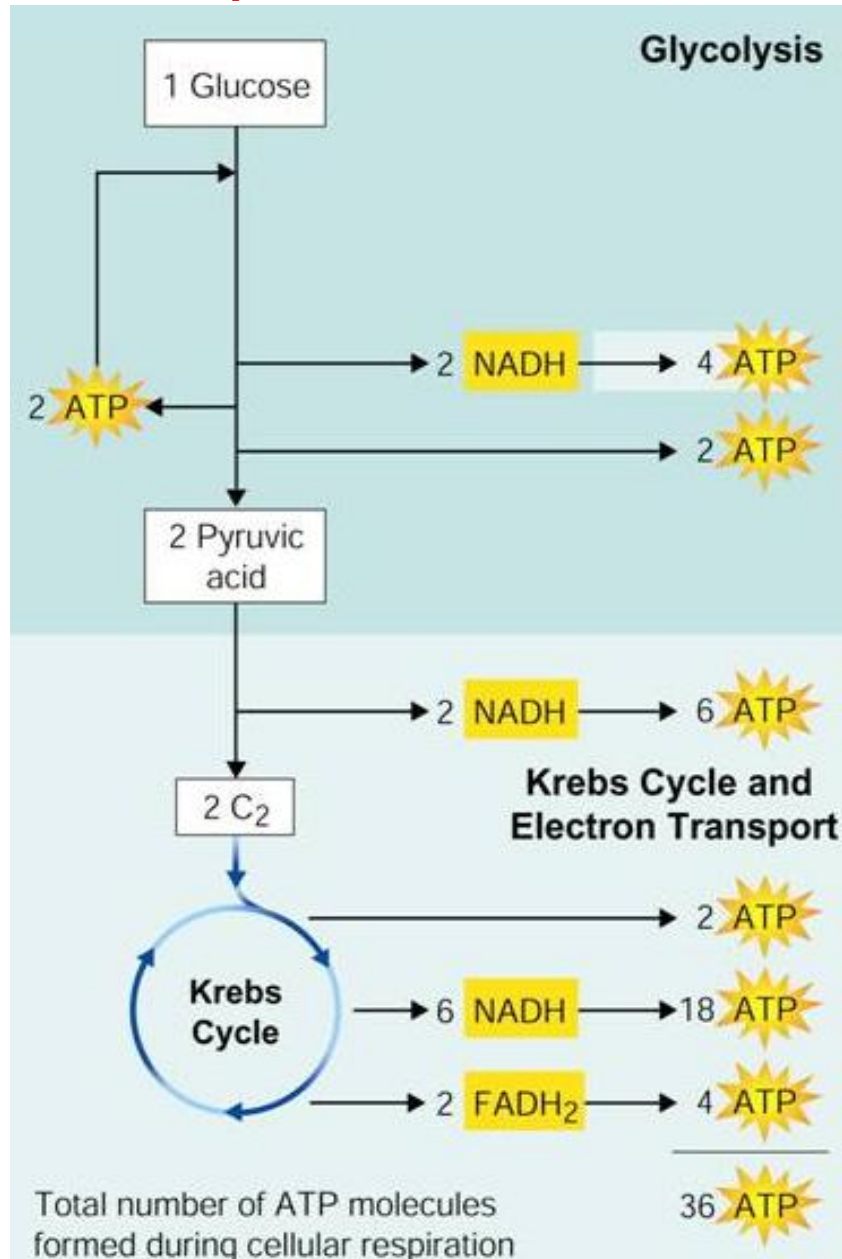
On average, each pair of high-energy electrons that moves down the electron transport chain provides enough energy to produce three molecules of ATP from ADP.

The Totals

Glycolysis produces just 2 ATP molecules per molecule of glucose.

The complete breakdown of glucose through cellular respiration, including glycolysis, results in the production of 36 molecules of ATP.

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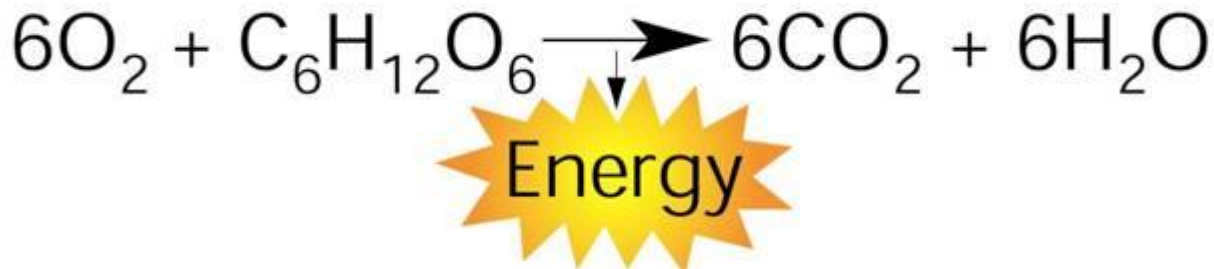
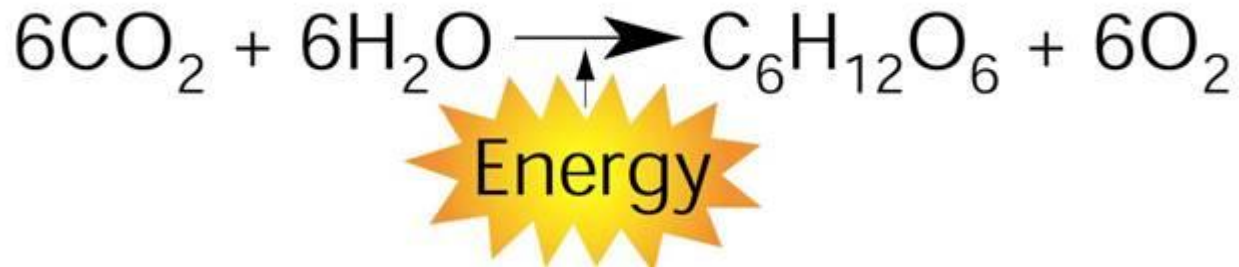


Total number of ATP molecules
formed during cellular respiration

36 ATP

Comparing Photosynthesis and Cellular Respiration

The energy flows in photosynthesis and cellular respiration take place in opposite directions.



On a global level, photosynthesis and cellular respiration are also opposites.

- Photosynthesis removes carbon dioxide from the atmosphere and cellular respiration puts it back.
- Photosynthesis releases oxygen into the atmosphere and cellular respiration uses that oxygen to release energy from food.

9-2 Section QUIZ

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Section QUIZ

- or -

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9-2 Section QUIZ

- 1 The Krebs cycle breaks pyruvic acid down into
- a. oxygen.
 - b. NADH.
 - A** c. carbon dioxide.
 - d. alcohol.

9-2 Section QUIZ

2 What role does the Krebs cycle play in the cell?

a. It breaks down glucose and releases its stored energy.

A b. It releases energy from molecules formed during glycolysis.

c. It combines carbon dioxide and water into high-energy molecules.

d. It breaks down ATP and NADH, releasing stored energy.

9-2 Section QUIZ

3 In eukaryotes, the electron transport chain is located in the

a. cell membrane.

A b. inner mitochondrial membrane.

c. cytoplasm.

d. outer mitochondrial membrane.

9-2 Section QUIZ

4 To generate energy over long periods, the body must use

- a. stored ATP.
- b. lactic acid fermentation.

A c. cellular respiration.

- d. glycolysis.

9-2 Section QUIZ

5 Which statement correctly describes photosynthesis and cellular respiration?

- a. Photosynthesis releases energy, while cellular respiration stores energy.
- b. Photosynthesis and cellular respiration use the same raw materials.

A c. Cellular respiration releases energy, while photosynthesis stores energy.

- d. Cellular respiration and photosynthesis produce the same products.

END OF SECTION