Summarize the KREBS cycle and its preliminary step by
(a) explaining the role of coenzyme A,
(b) explaining what happens to the carbon originally present in the pyruvic acid,
(c) listing the number of ATP molecules produced,
(d) listing the number and type of coenzyme utilized, and
(e) indicating where in the cell the process occurs.
Explain the difference between terminal electron transport and oxidative phosphorylation.
Explain the key steps in chemiosmotic coupling, including the role played by the inner mitochondrial membrane.
Account for the maximum number of ATP molecules produced by glycolysis and respiration.
Contents

The Preparatory Reaction

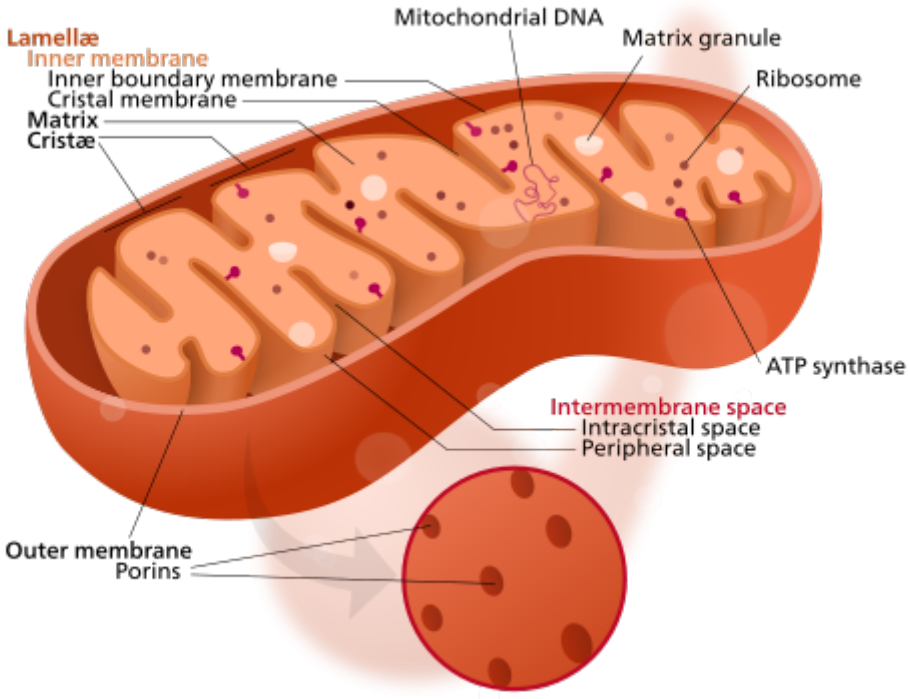
In the presence of O_2, aerobic organisms will use a reaction of pyruvate decarboxylation in the cytosol. This reaction generates a molecule of **Acetyl-CoA** from the Coenzyme A which can enter the mitochondria.

Coenzyme A (CoA) is charged with an Acetyl group (2 carbon compound) to generate Acetyl-CoA and a CO_2.

When there is an excess of carbohydrates, the Acetyl-CoA is used as a starting point for long-term energy storage in lipid synthesis.

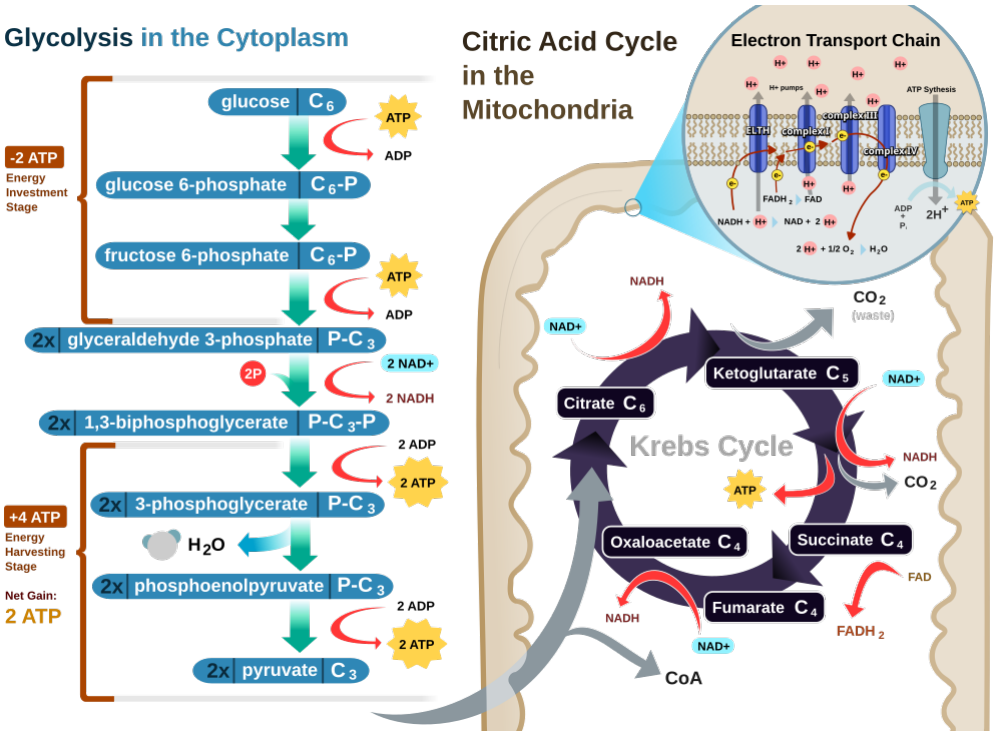
Mitochondria

Mitochondria are the power station of eukaryotic cells. They are derived from a process described by the **endosymbiotic theory** whereby aerobic prokaryotes were engulfed by a protoeukaryote. In this mutualistic arrangement, the prokaryote detoxified the deadly O_2 gas in the environment and used it to fully break down glucose to yield many ATP molecules. Evidence for this theory comes from the independent replication of the mitochondria, the bacterial-like mitochondrial DNA, the bacterial-like mitochondrial ribosomes, the bacterial lipids found in the inner membrane and the eukaryotic nature of the outer membrane. Mitochondria are genomically similar to bacteria of the order Rickettsiales. Some bacteria of this order are still free-living and some are intracellular pathogens.



Credit: Kelvinsong (CC-BY-SA 3.0)

Aerobic Respiration



Cellular Respiration. Left side is glycolysis (anaerobic). The Right side is what occurs in the presence of oxygen in eukaryotes. The aerobic reactions occur inside the mitochondria after being fed Acetyl-CoA molecules from the cytoplasmic preparatory reaction. Credit: RegisFrey (CC-BY-SA 3.0)

Acetyl-CoA enters the mitochondrial matrix where it is used in the **Krebs Cycle** (aka Tricarboxylic acid cycle (TCA), aka Citric acid cycle). For each pyruvate, there are 2 turns of the cycle where additional NADH and another high energy electron carrier **$FADH_2$** (flavin adenine dinucleotide) are generated.

*Closeup of the **Electron Transport Chain** (ETC) that takes place on the inner membrane of mitochondria. This is where oxygen is utilized as the final electron acceptor. Reduction of 1/2 O_2 results in the generation of a water molecule (**chemiosmosis**). Credit: Jeremy Seto (CC-BY-NC-SA 3.0)*

Metabolic Pool

The catabolic pathways involved in the glycolysis and the Krebs cycle constitute the **metabolic pool** that supplies building blocks for other anabolic reactions in the cell. An excess of carbohydrates can result in an accumulation of Acetyl-CoA molecules. If there is a great excess of Acetyl-CoA, the acetyl groups can be committed to fatty acid synthesis for long-term energy storage. Glycolytic products can also be the starting point for amino acid synthesis. 3-phosphoglycerate can be used to synthesize glycine, cysteine and serine. Pyruvate can be used to generate alanine, valine and leucine. Oxaloacetate from the Krebs cycle can be used as a starting point for aspartate, lysine, asparagine, methionine, threonine and isoleucine. Glutamate and glutamine are synthesized from α-ketoglutarate formed during the Krebs cycle. While most of the 20 amino acids can be synthesized *de novo*, there are 9 **essential amino acids** in humans that can not be synthesized in sufficient quantity and therefore must be gained from the diet. These essential amino acids include: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine.