Text transcript of TCA Cycle Animation

Cells break down food molecules, such as glucose, through multi-step pathways. For example, in the process of glycolysis, breakdown of glucose molecules releases energy that is captured by the energy carrier molecules, such as ATP and NADH. A breakdown intermediate, pyruvate, is imported into mitochondria, where it is converted into acetyl CoA and fed into the citric acid cycle. Acetyl CoA can also be generated by breakdown of fats or amino acids.

In this circular reaction path of the citric acid cycle, carbon atoms are “burned”—that is, oxidized—and released one-by-one as the waste product carbon dioxide. In this way, energy is released stepwise and captured by energy carriers, including NADH. NADH funnels energy to the electron transport chain in the inner mitochondrial membrane. This fuels the proton gradient that is then used for the production of ATP, the cell's primary energy currency.

The molecule that enters the citric acid cycle is the 2-carbon compound acetyl CoA. Acetyl CoA joins with the 4-carbon oxaloacetate to create the 6-carbon citrate.

We'll track the carbons from acetyl CoA with a red color. The two carbon atoms from oxaloacetate marked in blue will be released during this cycle to form carbon dioxide.

In the next step of the cycle, citrate rearranges to form isocitrate. Note that the hydroxyl group is in a different position in these two molecules.

In the next step, energy is captured by an NADH molecule, and a molecule of carbon dioxide is released. In this reaction, isocitrate is converted to ketoglutarate. The hydroxyl-bound carbon is stripped of its hydrogen atoms, resulting in a carbonyl group. One of these hydrogen atoms is picked up by NAD^+ to form NADH, and another is released as a proton. The carbon and 2 oxygen atoms are then released as CO_2, creating the 5- carbon a-ketoglutarate.

The next reaction also produces NADH and releases CO_2. The a-ketoglutarate from the previous reaction is converted to succinyl CoA by the addition of the coenzyme A. The enzyme for this reaction adds a high-energy thioester bond to coenzyme A, releasing the carbon and 2 oxygen atoms and converting NAD^+ to NADH.

The next reaction releases enough energy to form GTP, an energy-carrying molecule related to ATP. In this reaction, succinyl CoA is converted into succinate. The release of the coenzyme A group provides the energy to combine GDP and inorganic phosphate into GTP. Note that succinate is symmetrical molecule. The two end carbons are chemically identical, and the two carbons in the middle are chemically identical. For convenience we will continue tracing only the 2 carbons depicted in the upper half of the molecule.

In the next step, a molecule of $FADH_2$ is produced. $FADH_2$, like NADH, is an energy carrier that feeds high-energy electrons to the electron transport chain. In this reaction, succinate is converted to fumarate. Hydrogen atoms from succinate are stripped off and donated to FAD to produce $FADH_2$.

In the next reaction, fumarate combines with a water molecule. The resulting molecule is malate, with the water molecule added across the two central carbons.

The next step produces the final NADH molecule. In this reaction, malate is converted to oxaloacetate. The carbon carrying the hydroxyl group is converted to a carbonyl group. This reaction releases hydrogen atoms and converts NAD^+ to NADH, releasing a proton, and producing the four-carbon oxaloacetate.

Oxaloacetate is thus replenished and can take part in another cycle, returning to step 1. Note the new position of the red carbon atoms, which originated from the acetyl CoA in the previous cycle. In subsequent cycles, these carbons will eventually be lost as CO_2. The green labels indicate the positions of the new carbons added during this new cycle.