8.3

CITRIC ACID CYCLE

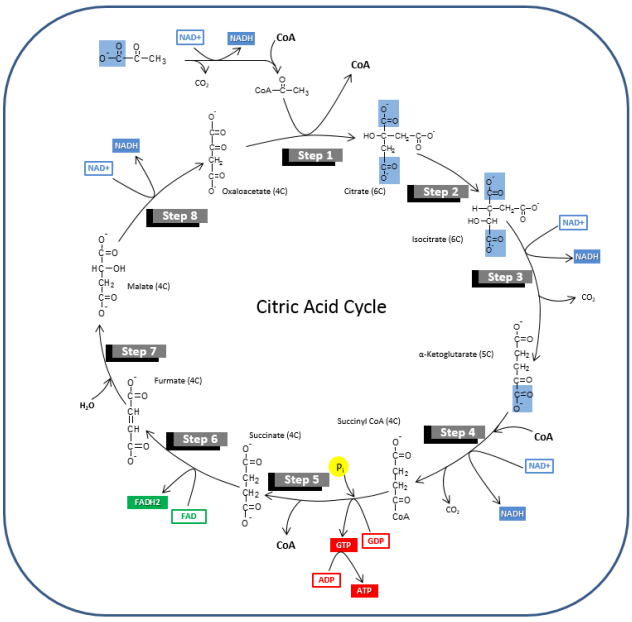
The Citric Acid Cycle is also called the "Tricarboxylic Acid Cycle (TCA) and the "Krebs Cycle." This cycle is a series of biochemical reactions that completes the catabolic pathway for the Glucose molecule that started glycolysis. Energy from the Citric Acid Cycle is captured by electron carriers (NAD and FAD). Also, ATP is generated at one of the steps in this cycle. Remember that you will be expected to understand the citric acid cycle at the level it is shown in the summary figure you have previously downloaded.

After the completion of this phase of metabolism, the following molecules and ATP are made as a byproduct:

Molecule	**Net Yield through Citric Acid Cycle**
ATP	2
NADH	6
FADH2	2

Below is a more detailed figure showing the citric acid cycle. Although it is more than you will need, it may serve as a good reference for you to understand more about the citric acid cycle. It helps to review this figure along with your summary figure to understand more about the citric acid cycle. This figure may help you understand the terminology that you come across in your online research to learn about the citric acid cycle.

FIGURE 9 - 8 STEPS OF THE CITRIC ACID CYCLE

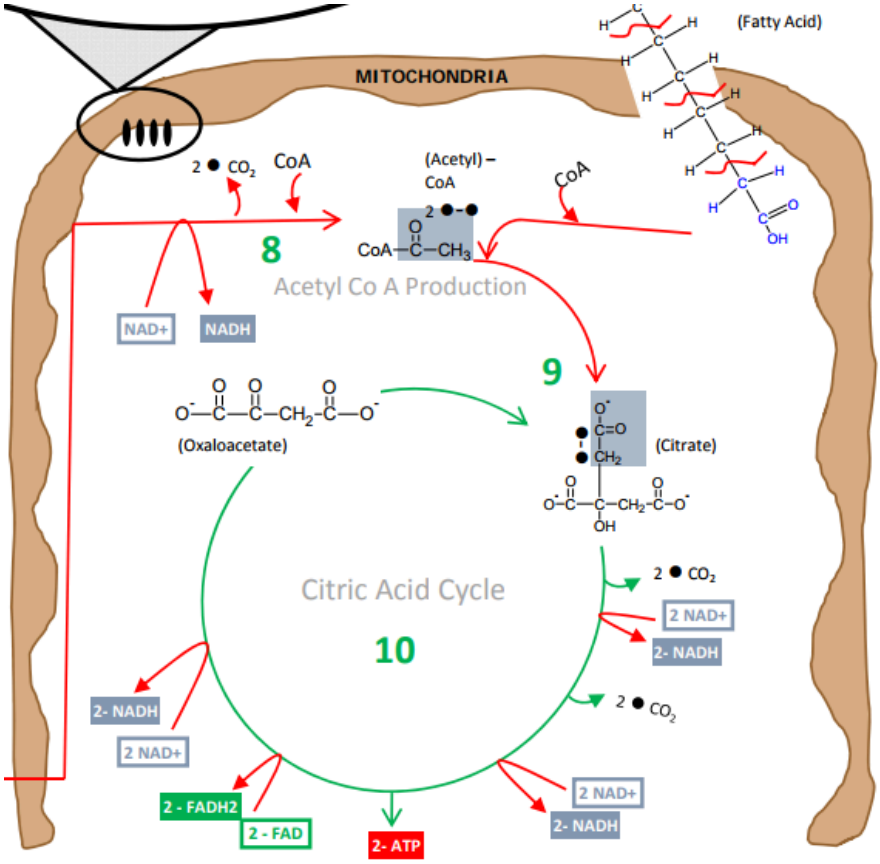


The figure above represents the Citric Acid Cycle (also called the "Krebs Cycle"). The part of the molecule that becomes carbon dioxide is highlighted in a blue box. Notice that a 4 carbon molecule called Oxaloacetate picks up 2 more carbons when it is joined with an acetyl group from Acetyl CoA. Through the beginning steps of the cycle, 2 carbons are lost as carbon dioxide and the molecule is again restored to a 4 carbon state, ready to pick up another acetyl group.

The details of the eight steps above are shown in the following pages. This time, the part of the molecule that undergoes a change is highlighted in blue and the name of the enzyme that catalyzes the reaction is in a green box.

Metabolism Summary Part 2: Citric Acid Cycle

Below is an image of the process of the Citric Acid (Krebs) Cycle magnified from the Metabolism Summary image you saw in 8.1. A continuation of our summary on metabolism follows below for the Citric Acid Cycle up until we reach the Electron Transport Chain where we will return to get the detailed information on this process first before continuing with our summary on all of the processes of metabolism. The green numbers in the image correlate with each of the steps listed below:



Citric Acid (Krebs) Cycle, from the "Big Picture" of Metabolism: Glycolysis, Citric Acid (Krebs) Cycle, Electron Transport Chain, Beta Oxidation and Lipolysis. *Image created at BYU-Idaho by JS 2010*

8 Steps 8-12 complete the story of aerobic metabolism of glucose. After pyruvate is transported into the mitochondria, another dehydrogenase enzyme (actually a very large enzyme complex) will accomplish several things. It will remove 2 protons and 2 electrons from pyruvate. This creates NADH (actually 2 NADHs because there are 2 pyruvates). Also, the reaction results in the loss of a carbon and two oxygen atoms (released as CO_2). Finally, the remaining 2 carbon molecule is attached to Coenzyme A.

Coenzyme A (often referred to as simply CoA) is derived from pantothenic acid (Vitamin B5). **Acetyl CoA** is the name used for the product of the reaction in step 8. The "Acetyl" prefix specifically refers to the 2 carbon group that is being transported by the CoA. Black dots in the summary figure help us keep track of the carbons that originated from the glucose molecule way back at the beginning of glycolysis. Notice that ultimately all the black dots are released as CO_2 so that the metabolism of glucose leaves us with no accumulation of carbons in the cell. Acetyl CoA will enter and participate in the reactions of the Citric Acid Cycle.

9 Step 9 represents the activities of the **Citric Acid (or Krebs) Cycle**. The Citric Acid Cycle involves a lot of steps. The intent for our level of understanding will not involve details of all the reactions.

10 The important things to remember about the Citric Acid Cycle are…

1. A 4 carbon molecule called oxaloacetate combines with the acetyl (2 carbon) group of Acetyl CoA (which came from glucose or fatty acids or possibly even some of the amino acids). This will yield a 6 carbon molecule called citric acid. Citric acid will be changed and manipulated as this 6 carbon molecule ends up recycled back to oxaloacetate – thus the term “Citric Acid Cycle”.
2. During the reactions of the citric acid cycle, CO_2 will be lost twice. This means that if you are counting, you will realize that every carbon of the original Glucose or Fat is ultimately lost as CO_2. This is the reason we have to breathe continuously as we do.
3. Hydrogens with electrons are transferred to NAD^+. This creates 6 NADH molecules.
4. FAD is reduced to $FADH_2$. This yields 2 $FADH_2$ molecules.
5. Substrate-Level Phosphorylation will yield an ATP for each turn of the Citric Acid Cycle (or 2 total for each glucose).