Glyoxylate Cycle

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Anaplerotic Reactions

- There is a heavy demand upon the TCA cycle to supply carbon for biosynthesis, and cycle intermediates could be depleted if nothing were done to maintain their levels.
- However, microorganisms have reactions that replenish cycle intermediates so that the TCA cycle can continue to function when active biosynthesis is taking place.
- Reactions that replace cycle intermediates are called **anaplerotic reactions.**
- Anaplerotic CO2 fixation reactions simply replace TCA cycle intermediates and maintain metabolic balance.
- Usually CO_2 is added to an acceptor molecule, either pyruvate or phosphoenolpyruvate, to form the cycle intermediate oxaloacetate.
- Some microorganisms (e.g., *Arthrobacter globiformis*, yeasts) use pyruvate carboxylase in this role.

$$\text{Pyruvate} + CO_2 + \text{ATP} + H_2O \xrightarrow{\text{biotin}} \text{oxaloacetate} + \text{ADP} + P_i$$

- Other microorganisms, such as the bacteria *Escherichia coli* and *Salmonella typhimurium,* have the enzyme phosphoenolpyruvate carboxylase, which catalyzes the following reaction.

$$\text{Phosphoenolpyruvate} + CO_2 \longrightarrow \text{oxaloacetate} + P_i$$

Glyoxylate cycle

- Some bacteria, algae, fungi, and protozoa can grow with acetate as the sole carbon source by using it to synthesize TCA cycle intermediates in the **glyoxylate cycle (figure 1).**
- This cycle is made possible by two unique enzymes, isocitrate lyase and malate synthase, that catalyze the following reactions.

$$\text{Isocitrate} \xrightarrow{\text{isocitrate lyase}} \text{succinate} + \text{glyoxylate}$$

$$\text{Glyoxylate} + \text{acetyl-CoA} \xrightarrow{\text{malate synthase}} \text{malate} + \text{CoA}$$

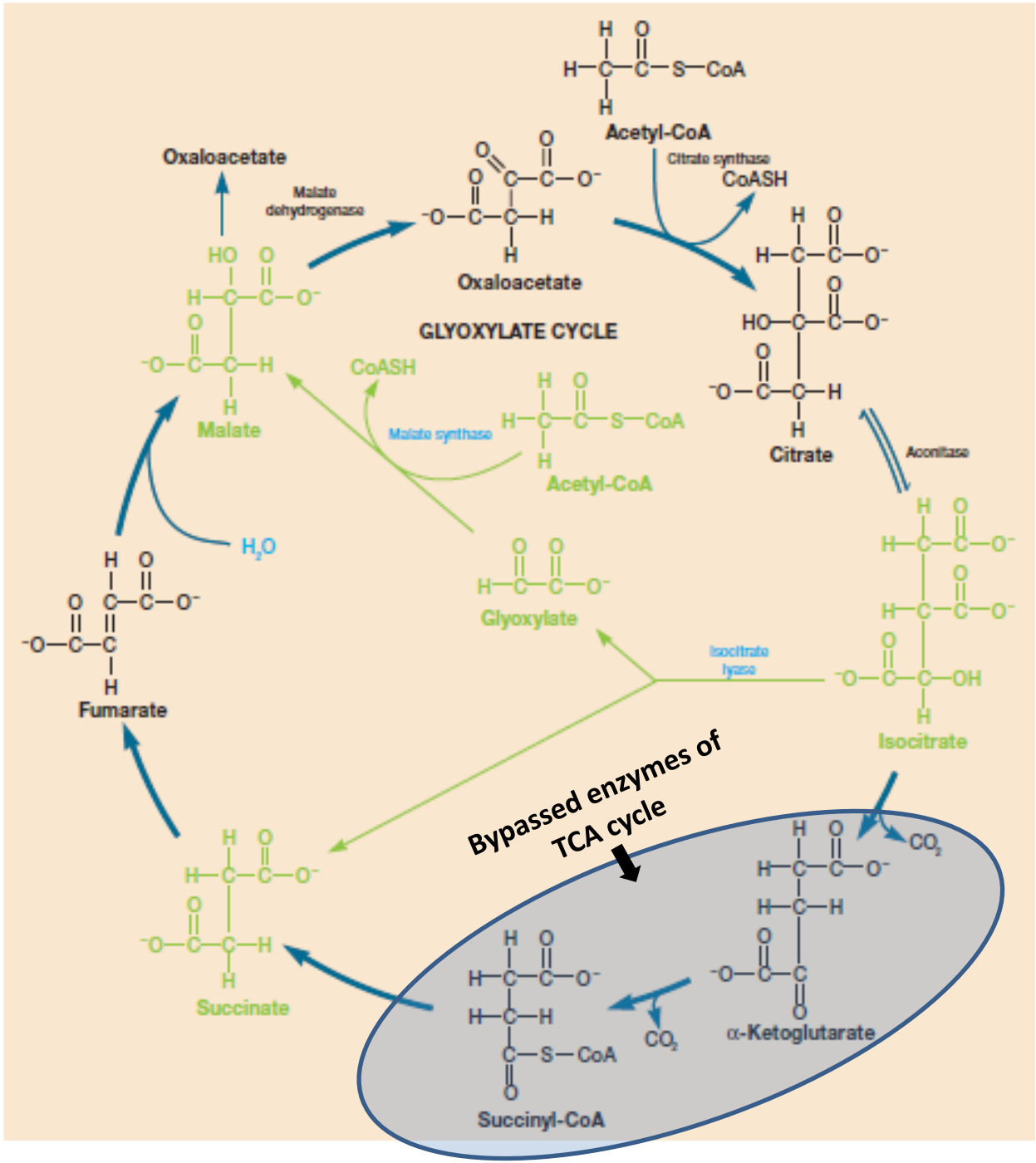
- The glyoxylate cycle is actually a modified TCA cycle.
- The two decarboxylations of the latter pathway (the isocitrate dehydrogenase and α-ketoglutarate dehydrogenase steps) are bypassed, making possible the conversion of acetyl-CoA to form oxaloacetate without loss of acetyl-CoA carbon as CO_2.
- In this fashion acetate and any molecules that give rise to it can contribute carbon to the cycle and support microbial growth.

Overall equation:

$$2\ \text{Acetyl-CoA} + \text{FAD} + 2\text{NAD}^+ + 3\text{H}_2\text{O} \longrightarrow \text{Oxaloacetate} + 2\text{CoA} + \text{FADH}_2 + 2\text{NADH} + 2\text{H}^+$$

Figure 1. The Glyoxylate Cycle. The reactions and enzymes unique to the cycle are shown in color.

The TCA cycle enzymes that have been bypassed are at the bottom.



Questions

- Write a short note on glyoxyate cycle.
- Diagrammatically explain glyoxylate cycle.
- What special enzymes are used in glyoxylate cycle. Give in detail.