

6.6 Connections to Other Metabolic Pathways

Learning objectives

By the end of this section, you will be able to:

- Discuss how the metabolic pathways, such as glycolysis and the citric acid cycle, can use sugars other than glucose to generate ATP
- Discuss how proteins and lipids can be used to generate ATP by entering glycolysis, pyruvate oxidation, and citric acid cycle as intermediates
- Be able to define and explain all bolded terms

You have learned about the catabolism of glucose, which provides energy to living cells. However, living things consume more than just glucose for food. How does a turkey sandwich, which contains protein, provide energy to your cells? This happens because all the catabolic pathways for carbohydrates, proteins, and lipids eventually feed into glycolysis, pyruvate oxidation, and the citric acid cycle pathways (Figure 6.28).

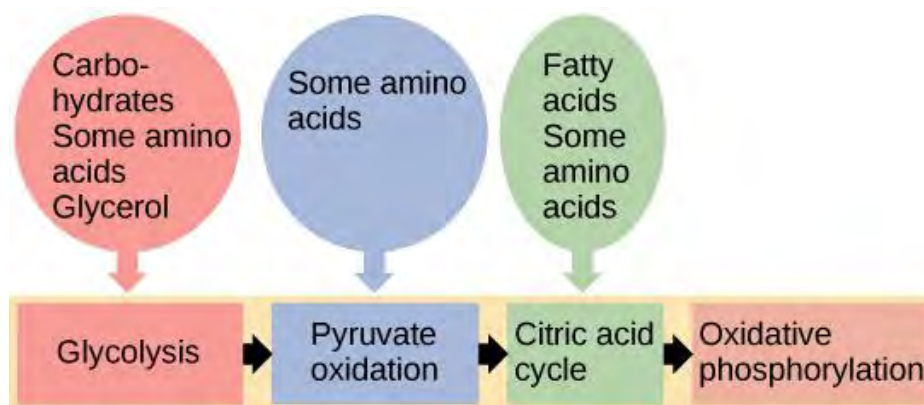


Figure 6.28 Different organic food molecules can feed into the catabolic pathways for carbohydrates. (credit: Fowler et al. / [Concepts of Biology OpenStax](#))

Connections of Other Sugars to Glucose Metabolism

Sucrose and lactose are both disaccharides that can be used during aerobic cellular respiration. Both sugars must be hydrolyzed before they can be utilized. Sucrose, commonly referred to as table sugar, is broken down into glucose and fructose with the help of the enzyme sucrase. Lactose, a sugar found in milk, is hydrolyzed into glucose and galactose with the help of the enzyme lactase. Both fructose and galactose can be used during glycolysis; however, they cannot begin the process as glucose does. Both sugars can enter glycolysis as intermediates and produce the same amount of ATP molecules as glucose.

Connections of Proteins to Glucose Metabolism

In cells, proteins are broken down by a variety of enzymes called proteases. Most of the time, amino acids are recycled into new proteins. If there are excess amino acids or if the body is in a state of starvation, some amino acids will be shunted into the citric acid cycle to generate ATP. Other amino acids are used to create intermediates of glycolysis or generate acetyl CoA (Figure 6.29). Each amino acid must have its amino group removed before entering into these metabolic pathways. The amino group is converted into ammonia and along with carbon dioxide forms urea, the main waste product found in mammalian urine.

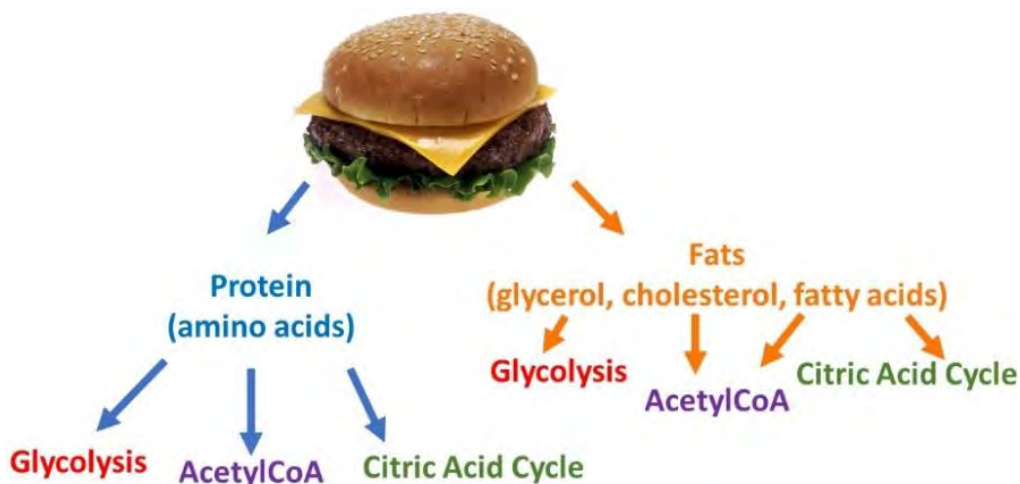


Figure 6.29 shows a cheeseburger that contains carbohydrates, lipids, and protein.
(credit: Elizabeth O'Grady / cheeseburger image original work by National Cancer Institute
[Wikimedia commons](https://commons.wikimedia.org/wiki/File:Cheeseburger.jpg))

Connections of Lipids to Glucose Metabolism

Cholesterol and triglycerides are the most common lipids used to generate ATP. Cholesterol is a lipid that contributes to the flexibility of the cell membrane and is a precursor of steroid hormones. The synthesis of cholesterol starts with acetyl CoA (Figure 6.28). Remember that acetyl CoA is a necessary reactant in the citric acid cycle. The citric acid cycle can be used to generate ATP, NADH, and FADH₂.

Triglycerides are used long-term to store energy in animals. Triglycerides store about twice as much energy as carbohydrates and are made of glycerol and three fatty acids. Glycerol can be phosphorylated and enter as an intermediate of glycolysis. Fatty acids are broken into two-carbon units that enter the citric acid cycle as acetyl CoA.

Section Summary

The breakdown and synthesis of carbohydrates, proteins, and lipids can be used to generate ATP. Galactose and fructose are additional carbohydrates that can feed into glycolysis. The amino acids from proteins can be used to generate pyruvate, acetyl CoA, and components of the citric acid cycle. Cholesterol, glycerol, and fatty acids can be used in the citric acid cycle.

Exercises

1. Which of the following is generated during cholesterol synthesis?
 - a. glucose
 - b. acetyl CoA
 - c. pyruvate
 - d. carbon dioxide
2. Which of the following cannot be used to generate ATP in eukaryotic animal cells?
 - a. lipids
 - b. carbohydrates
 - c. proteins
 - d. water
 - e. all of the above are used in the catabolism of energy
3. True or False Galactose can start the process of glycolysis

Answers

1. (b)
2. (d)
3. False