INTRODUCTION

Metabolism is the sum of all chemical reactions in a cell. Some of these reactions are **catabolic:** They break large molecules, like sugars, into smaller molecules, like carbon dioxide (CO_2) and water (H_2O). Catabolic reactions release energy. Other metabolic reactions are **anabolic:** They join small molecules together to make a large molecule. One example of this is protein synthesis in which amino acids are linked together to make a protein. Anabolic reactions require energy. All reactions in a cell are catalyzed by **enzymes.** That means that enzymes control whether or not a reaction occurs and how fast it goes. In this laboratory, you will study fermentation, a catabolic reaction, and photosynthesis, an anabolic reaction. Both are types of metabolism.

Fermentation is a way that cells can make ATP without oxygen, or **anaerobically.** In fermentation, a sugar molecule is broken a little bit. When chemical bonds are broken, energy is released. Cells can capture some of this energy and use it to make ATP (adenosine triphosphate), the energy molecule of the cell. In fermentation in yeast, a glucose molecule ($C_6H_{12}O_6$) is broken into two ethanol molecules (C_2H_5OH), and two molecules of CO_2 and two molecules of ATP are made:

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + 2ATP.$$

The amount of CO_2 produced is a way to measure the amount of fermentation occurring. The amount of CO_2 produced when the yeast are given different sugars is a way to measure the effectiveness of different sugars as energy sources. Glucose and fructose are monosaccharides or simple sugars. Sucrose is a disaccharide made of glucose and fructose linked together. In order to use fructose or sucrose, the yeast must first rearrange fructose and sucrose into glucose.

In **photosynthesis,** organisms such as plants are able to capture **light** energy and make ATP, which is then used to link together CO_2 and H_2O to make carbohydrates such as glucose.

$$6CO_2 + 6H_2O \xrightarrow{light} C_6H_{12}O_6 + 6O_2$$

In plants, these reactions occur in **chloroplasts.** Within chloroplasts, there are disk-shaped structures called **thylakoids.** The pigment molecules that capture light energy are in the thylakoid membranes. There is also a cytoplasm-like component within chloroplasts called **stroma.** This is where the carbon-fixation reactions called the Calvin cycle occur. During the Calvin cycle, molecules of CO_2 are incorporated into other sugar molecules so that the final product is glucose.

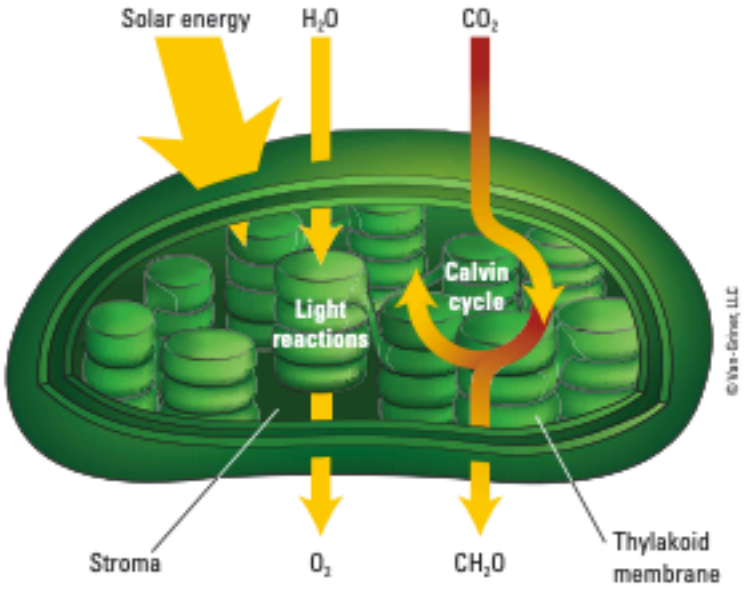

Figure 4.1 Overview of Photosynthesis. Photosynthesis includes the light reactions when energy is collected and O_2 is released, and the Calvin cycle reactions when carbohydrate (CH_2O) is formed.

In this part of the lab, you will separate the different photosynthetic pigments from spinach. You will also observe the uptake of CO_2 by the aquatic plant *Elodea* by measuring the pH change using phenol red.