

**EVALUATING
ACADEMIC READINESS
FOR APPRENTICESHIP TRAINING**
Revised for
ACCESS TO APPRENTICESHIP

**SCIENCE SKILLS
CELL RESPIRATION AND PHOTOSYNTHESIS**

**AN ACADEMIC SKILLS MANUAL
for
The Horticulture Trades**

This trade group includes the following trades:
Arborist, and
Horticulturist

*Workplace Support Services Branch
Ontario Ministry of Training, Colleges and Universities*

Revised 2011

In preparing these Academic Skills Manuals we have used passages, diagrams and questions similar to those an apprentice might find in a text, guide or trade manual.

This trade related material is not intended to instruct you in your trade. It is used only to demonstrate how understanding an academic skill will help you find and use the information you need.

SCIENCE SKILLS

CELL RESPIRATION AND PHOTOSYNTHESIS

*An academic skill required for the study of the
Horticulture Trades*

INTRODUCTION

Most plants develop from a germinating seed. Once the seed has germinated, the plant must continue to grow. The plant takes in resources such as light, carbon dioxide and water from the outside, and uses them for its own development. Through the process of *photosynthesis*, plants manufacture simple sugars from these materials. Through the process of *respiration*, the plant then utilizes the sugars to release energy needed for plant growth and development.

Every plant must carry out the processes of photosynthesis and respiration to survive. They also need to use some of their energy to ensure that they reproduce and create another generation of plants. But, different plants have developed slightly different ways of using the raw materials from the outside environment in these processes. This has led to the development of the many fascinating and beautiful plant species that we enjoy in our gardens. However, despite the different environments that plants have learned to exploit, the basic processes of photosynthesis and respiration are the same.

This skills manual looks at these essential processes. It covers the following topics:

- ◆ Review of plant cell structure
- ◆ Photosynthesis
- ◆ Respiration

REVIEW OF PLANT CELL STRUCTURE

The basic organizing unit of a plant is the cell.

- ◆ Plant cells are surrounded by a rigid *cell wall* that defines the boundaries of the cell. This wall gives the plant overall support to stand up.
- ◆ Cells also contain a cell *membrane* that helps control what goes into and out of the cell.
- ◆ Inside the cell membrane is a jelly-like substance called *cytoplasm*, which consists of water, food, proteins, minerals and enzymes.
- ◆ Floating in the cytoplasm are many specialized *organelles* that carry out special tasks.

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Below is a diagram of a typical plant cell:

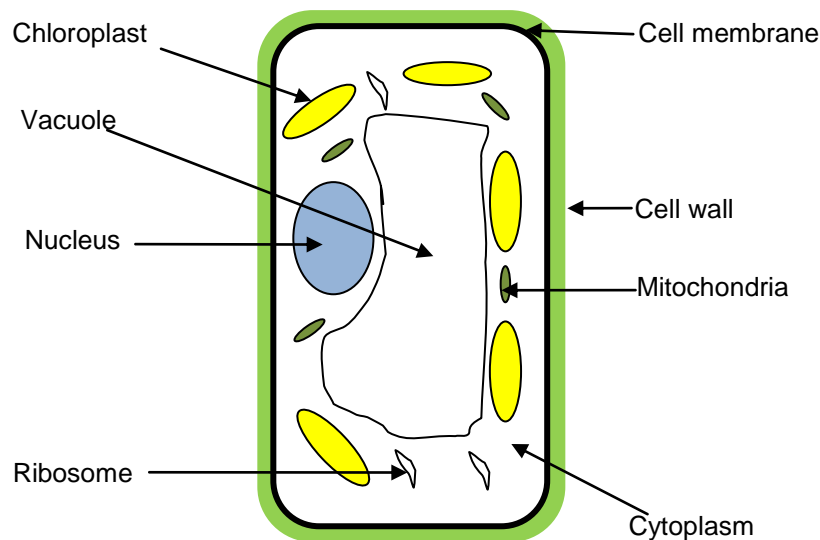


FIGURE 1: Structure of a Plant Cell

The control centre of the cell is called the **nucleus**.

- ◆ The DNA in the nucleus contains the genetic information that directs the activities of the cell.
 - This genetic material is passed on to both cells whenever an original cell divides into two cells.
 - It is also passed on in the reproductive seeds that a plant produces.

A plant cell contains a special organelle called a **chloroplast** that uses the energy from the sun to create food through the process of **photosynthesis**.

- ◆ The chloroplast contains molecules of **chlorophyll** that can capture the energy in sunlight.
- ◆ The sun energy enables the chloroplast to produce sugar molecules.

The cell uses this food to get the energy it needs to maintain itself. The food is converted into energy in the **mitochondria** through the process of **respiration**.

- ◆ The cell uses this energy, along with molecules of plant food, water and minerals, to produce new plant components.

An organelle called a **ribosome** produces protein substances for the plant.

- ◆ Proteins help direct the complex functions of the cell.

The plant cell has a large storage area called a **vacuole**.

- ◆ Because it is filled with watery cell sap, the vacuole helps a plant maintain its shape.

PHOTOSYNTHESIS

All living organisms, both plant and animal, need energy in order to function and survive. This energy ultimately comes from sunlight. Through the process of **photosynthesis**, the sun's energy is absorbed by plants and held in the food molecules that the plant produces. When the plant food is later broken down, this energy becomes available to power the growth and development of plant cells. It is also used by the animals that eat plants to fuel their own growth, development and reproduction.

For photosynthesis to occur, there must be several systems in place:

1. The plant needs a site where the incoming energy from the sun can be captured and used to manufacture raw materials into simple sugars.
2. It needs a transport system to gather the water, soil nutrients and gases used as raw materials in the photosynthetic process.
3. It needs a molecule that can absorb the energy and transform it into the bonds that hold sugar molecules together.

Once these systems are in place, the sugar molecules synthesized through photosynthesis are used to provide energy for all the other functions that the plant must carry out in order to grow and flourish.

Trapping the energy from the sun

The plant cell contains the raw materials and the apparatus needed to capture energy from the sun. Photosynthesis takes place in the chloroplast. See Figure 1. Most chloroplasts are found in cells in the leaves. Inside the chloroplast are chlorophyll molecules. Chlorophyll has the ability to convert sunlight into energy-rich sugar molecules.

There is competition for access to sunlight. Trees grow tall and send out wide branches to capture as much sunlight as possible. Other plants such as hostas have adapted to growing in shade where there is less light.

The transport system

Before chlorophyll can be converted to sugars, the plant needs a source of water and carbon dioxide nearby. Water is taken up from the soil by cells in the roots. From there it moves into the hollow, tubular cells called **xylem**. The xylem transports the water up the stem to the leaves where sunlight is most abundant. Carbon dioxide enters the plant through tiny pores located on the surface of leaves. These openings are called **stomata**. Once inside the leaf, the carbon dioxide diffuses into cells where photosynthesis takes place.

Absorbing the energy

Plants cannot store energy as light, heat or electricity. Instead they store energy within chemical bonds that hold sugar molecules together. Each chemical bond is a little storehouse of energy that can later be broken open. The stored energy is then released to do other work such as making new plant materials.

In photosynthesis, light energy is absorbed by chlorophyll molecules. This energy splits water molecules which results in electrons being transferred along with hydrogen ions from the water. The hydrogen ions bond to carbon dioxide molecules that are present in the chloroplast. This changes the carbon dioxide to a simple sugar. The energy from the transferred electrons is stored as potential energy in the bonds holding the sugar together.

The Two Stages of Photosynthesis

In the first stage of photosynthesis, called the **light reaction**, chlorophyll absorbs light energy. This light reaction converts solar energy to chemical energy. Chemical energy is created when electrons and hydrogen from water are transferred to an acceptor called NADP. Because the hydrogen molecules now have extra electrons, they are called hydrogen ions. NADP stores the hydrogen ions until they are used in creating chemical bonds in sugar molecules. Water molecules are split when the electrons and hydrogen are transferred to NADP. The oxygen that was part of the water escapes into the atmosphere while the hydrogen, along with its extra electrons, remains to be used in the second stage.

In the second phase of photosynthesis, called **carbon dioxide fixation**, carbon dioxide from the atmosphere combines with the hydrogen ions carried by NADP to form the building blocks of different sugars such as glucose, sucrose, starch and cellulose. The energy needed to bond the sugars together comes from the energy stored in the extra electrons in the hydrogen ions. These are the hydrogen ions that were created when light was absorbed by chlorophyll. This process requires the help of an already-present sugar molecule which brings together the carbon dioxide and hydrogen.

Figure 2 illustrates the two stages of photosynthesis

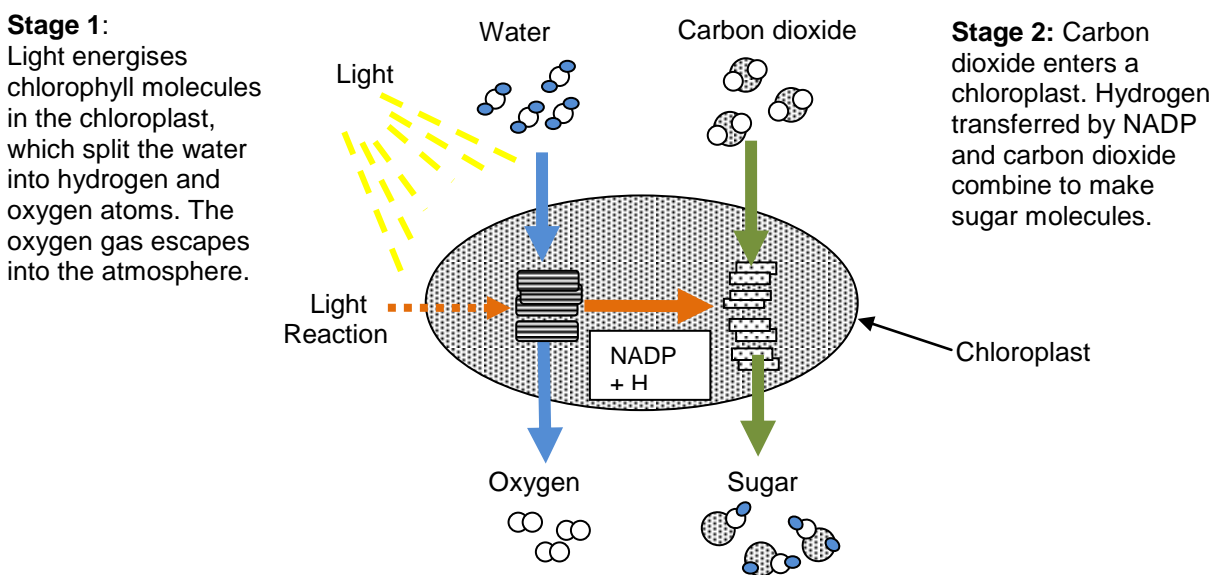


FIGURE 2: Photosynthesis

The sugars manufactured through photosynthesis are used by the plant for many different functions. Cellulose is used in strengthening cell walls. Starch is the principal form of sugar that the cell stores for future use, to be converted into other plant products or to be used in plant respiration.

The plant needs other substances besides sugars. With the addition of mineral elements from the soil such as nitrogen, calcium, sulphur and potassium, it can make other essential molecules. These include proteins, which are vital in coordinating the different activities of the cell. Fats are needed in building cell membranes. Nucleic acids are required for the formation of DNA and RNA molecules. DNA carries the genetic information that directs the functions of cells and that enables this information to be passed to future generations.

The manufacture of these cell products requires energy. This energy comes from breaking apart the sugar molecules that were made in the process of photosynthesis. The release of the stored energy occurs through the process of respiration.

RESPIRATION

Plants need energy to organize their many functions, to grow new cells, to transport water, nutrients and food, and to reproduce, passing on their genetic information through seeds. The process of extracting energy from food molecules is called ***cellular respiration***. Respiration takes place in cell organelles called mitochondria.

Respiration in plants requires oxygen from the atmosphere. Oxygen gas enters through the stomata in the leaves. The oxygen released through photosynthesis is also available for respiration.

During respiration, the sugar glucose is broken down in the mitochondria into carbon dioxide and water. The energy stored in the glucose bonds is released, to be stored and transported where it is needed.

The products of photosynthesis and respiration move around the cell, allowing plants to carry out all the functions required for them to flourish in our gardens. Figure 3 shows how the two processes are interrelated.

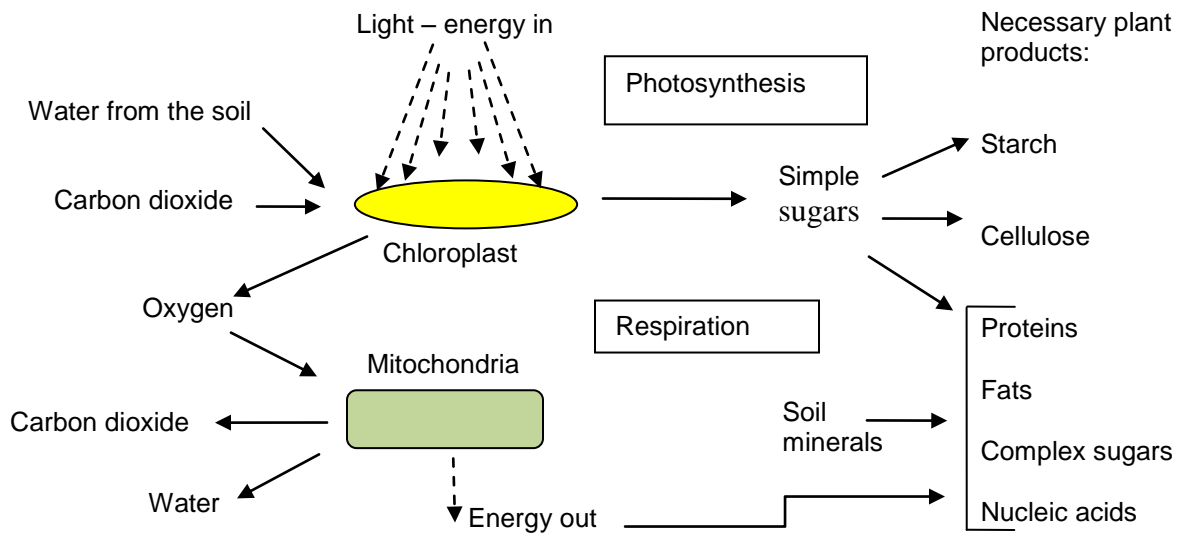


FIGURE 3: The Interconnected Processes of Photosynthesis and Respiration

CONCLUSION

Every plant attempts to survive and eventually reproduce, and to do so they all need to be able to convert light, air and moisture into energy through photosynthesis. The energy is stored as different types of sugars and converted through respiration into the plant products that the plant uses for growth and reproduction.

Not only plants, but every living thing depends on the processes of photosynthesis and respiration for survival. Animals which eat plants convert their sugars into energy which allow them to also grow and reproduce. Humans directly benefit from the energy produced by plants when we eat them and then again from the more complex energies that animals make from plant products.

Without the processes of photosynthesis and respiration, life as we know it could not exist.

Answer the following questions by putting the correct word in the blank spaces. Answers are on the next page.

1. The energy needed by plants ultimately comes from the _____ .
2. The process of capturing the energy of the sun by creating sugar molecules is called _____ .
3. Photosynthesis takes place in cell organelles called _____ .
4. Gases enter a plant through openings in the leaf called _____ .
5. Water is transported to the leaves through _____ cells.
6. _____ is a molecule in the chloroplast that can capture the energy from the sun.
7. Energy is stored in a plant in the form of chemical _____ .
8. When bonds in a sugar molecule are broken, _____ is released to do work for the development of the plant.
9. In the _____ reaction of photosynthesis, the solar energy absorbed by chlorophyll splits water, releasing electrons to hydrogen ions in the process.
10. A water molecule is split into _____ and _____ atoms during the light reaction of photosynthesis.
11. In the second stage of photosynthesis, carbon dioxide and hydrogen combine to form the building blocks used to make _____ molecules.
12. The cell stores sugar in the form of _____ .
13. The release of stored energy through the process of breaking down sugar molecules is called _____ .
14. Respiration takes place in _____ .
15. During respiration, glucose is broken down into carbon dioxide and _____.
16. The gas _____ is required for respiration to take place.

ANSWER PAGE

1. sun
2. photosynthesis
3. chloroplasts
4. stomata
5. xylem
6. Chlorophyll
7. bonds
8. energy
9. light
10. hydrogen, oxygen
11. sugar
12. starch
13. respiration
14. mitochondria
15. water
16. oxygen