12.1 The Characteristics of Plants

Figure 1 The cup-like structure of this pitcher plant contains water and enzymes that digest any insects that get trapped inside.

carbohydrate a molecule that contains only atoms of carbon, hydrogen, and oxygen in a ratio of 1 : 2 : 1

All organisms face changes in their environment. For example, the temperature may change, or it may start to rain. Most organisms are able to move away from conditions that are not suitable. Plants, however, have unusual lives because they are immobile. They cannot move independently from one place to another and are therefore limited to the environment around them to meet their needs.

To cope with their immobility, each plant species has specific adaptations for a particular range of environmental conditions. For example, whereas most plants absorb nutrients from water in the soil, pitcher plants obtain nutrients by digesting other organisms (**Figure 1**). They have adapted this way because the soil in which they grow is very low in nitrogen.

Basic Needs of Plants

Plants need energy, nutrients, water, gas exchange, protection from herbivores and disease, and they need to reproduce. How do plants manage to meet all these needs while staying in one spot?

Plants capture energy from incoming solar radiation and convert it to chemical energy through photosynthesis, a complex process that uses carbon dioxide and water to form glucose and oxygen. The word equation for photosynthesis is

$$\text{carbon dioxide} + \text{water} \xrightarrow{\text{solar energy}} \text{glucose} + \text{oxygen}$$

Glucose is a carbohydrate. A **carbohydrate** is a molecule that consists only of carbon, hydrogen, and oxygen atoms. Carbohydrates are the main source of the chemical energy plants need for maintenance, growth, and development. Through photosynthesis, plants can meet their needs for chemical energy in any environment that has enough light, carbon dioxide, and water. Because light is so important for making carbohydrates, plant species have developed many different adaptations to capture as much light as possible. For example, some plants can adjust the position of their leaves to maximize their exposure to sunlight.

Since they are carbohydrate rich, and therefore energy rich, being eaten is an unfortunate fact of life for many plant species. Plants are a food source for a wide range of organisms. Since they cannot move away from herbivores, plants have developed other ways to protect themselves. Many plants produce toxic or bad-tasting substances to keep herbivores away. Others produce a tough, hairy, or prickly outer layer (**Figure 2**).

Figure 2 (a) Tree bark is an adaptation that protects the plant from herbivores and other damage. (b) Many plants have hairy surfaces that deter insects and other herbivores. (c) Thorns and spikes can also protect a plant from some herbivores.

Plants need specific nutrients, such as nitrogen, phosphorus, and potassium, in order to synthesize the proteins, lipids, and other compounds needed in their cells. Most plants absorb nutrients as dissolved substances in water. As you have learned, most plants are helped in this process by mycorrhizal fungi associated with their roots. Plants also need water for photosynthesis and many other processes, such as the growth and repair of cells. If a plant loses too much water it will wilt and may die; similarly, it may die if it is exposed to too much water.

Plants are living organisms and need to exchange gases with the environment during processes such as photosynthesis and cellular respiration. In vascular plants, most gas exchange happens in the leaves.

Like any organism, plants need to reproduce. They do so through both asexual and sexual reproduction—meaning that male and female gametes, usually from two individuals, have to meet and join. Since individual plants cannot move, plants have evolved some amazing adaptations to ensure that their gametes unite and that the resulting zygote has an appropriate environment in which to germinate and grow. You will explore reproduction in vascular plants in Chapter 13.

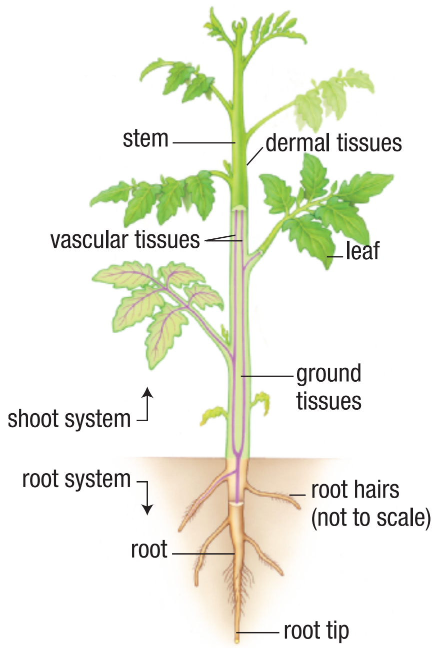

Figure 3 The general structure of a vascular plant. The shoot system includes the stems and leaves. The root system includes all the root material.

The Vascular Plant Body: Roots and Shoots

Even though vascular plants come in an incredible variety of shapes and sizes, the bodies of most vascular plants have the same basic design—they consist of an underground root system and an above-ground shoot system (**Figure 3**). (Some plants, called epiphytes, grow on other plants and live entirely above ground, however.) All cells in the plant body have cell walls composed mainly of cellulose molecules—linked chains of glucose (**Figure 4**).

Figure 4 Onion cells have thick cell walls composed of cellulose.

Vascular plants have three main non-reproductive organs: the leaf, the stem, and the root. These organs are primarily composed of three tissue types: dermal tissue, vascular tissue, and ground tissue (**Table 1**).

Table 1 Basic Tissue Types in Vascular Plants

Tissue	Description	Role
Dermal tissues	• two tissue types: epidermis and periderm • outermost cell layers • often have thicker cell walls • covered with a waxy cuticle	• protect against injury, herbivores, disease, and water loss
Vascular tissues	• two tissue types: xylem and phloem • xylem—thick-walled cells, dead at maturity • phloem—thin-walled cells, living at maturity	• transport water and nutrients • support the plant body
Ground tissues	• three tissue types: • parenchyma—thin-walled cells, living at maturity • collenchyma—thick-walled cells, living at maturity • sclerenchyma—cells with lignin in their cells walls, dead at maturity	• perform cellular processes to support growth and development (parenchyma and collenchyma) • store carbohydrate, especially starch (parenchyma) • support and protect plant body (collenchyma and sclerenchyma)

Vascular plants also contain meristematic tissue. **Meristematic tissue** (also called a **meristem**) is an area of actively dividing undifferentiated cells (meristematic cells). Meristematic cells are found in areas of the plant where growth occurs. They eventually develop into specialized cells and tissues.

meristematic tissue (meristem) tissue consisting of dividing undifferentiated cells (meristematic cells) found in areas of the plant where growth can take place

Updating the Phylogeny of Vascular Plants

Scientists constantly revise and update their theories as new information comes to light. The same is true in plant classification. Recall from the Diversity of Living Things unit (Unit 1) that there are three major groups of vascular plants: the lycophytes and pteridophytes (club mosses; ferns and their relatives), the gymnosperms (conifers), and the angiosperms (flowering plants). **Figure 5** outlines how these groups of vascular plants can be distinguished by key evolved traits.

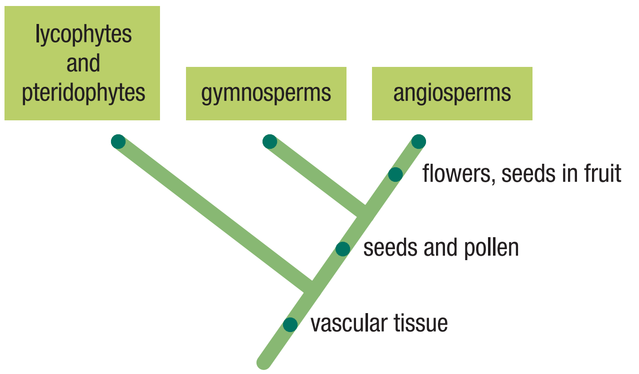

Figure 5 Evolutionary relationships of the three groups of vascular plants

cotyledon a structure in the seeds of flowering plants that stores nutrients

The seeds of angiosperm species may contain either one or two **cotyledons**, which are structures that supply nutrients to the plant embryo. Until recently, angiosperms were divided into only two groups: monocots, which have one cotyledon, and dicots, which have two cotyledons. However, recent DNA studies suggest that placing all dicot species into one group does not reflect the evolutionary relationships among these species. Dicots now fall into at least four groups: Amborellales (a group with one surviving species, *Amborella tricopoda*), Nymphaeales (water lilies), other early angiosperms, and eudicots ("true dicots"). Scientists think that Amborellales, water lilies, and the other early angiosperms evolved before monocots and eudicots (**Figure 6**). Monocots evolved most recently, about 100 million years ago.

WEB LINK

Angiosperms can be classified into many groups, depending on the number of characteristics that are compared. To learn more about how angiosperms can be classified,

GO TO NELSON SCIENCE

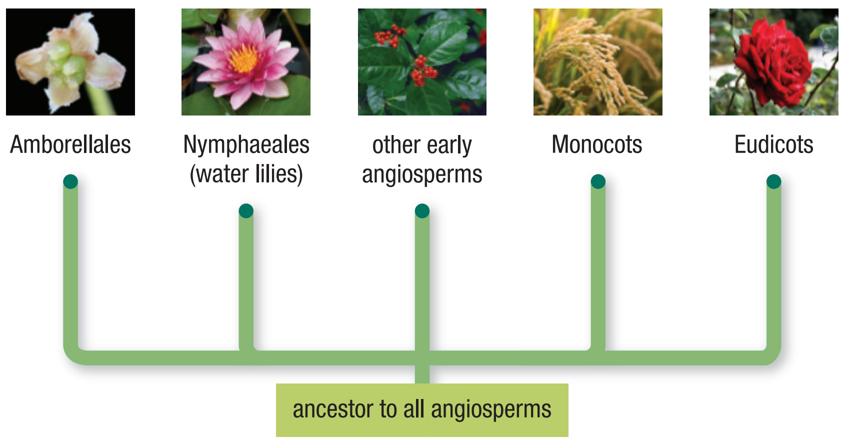

Figure 6 Evolutionary relationships among angiosperms

Monocots and eudicots are both very successful groups. Roughly one-quarter of all angiosperm species are monocots and more than two-thirds of angiosperms are eudicots. They are found in every environment that supports plant life and often live side by side in the same habitat. For example, a lawn of grasses (monocot plants) will often contain eudicots such as dandelions and clover.

Monocots and eudicots are vitally important to sustaining human life and supply most of our food, fibre, and building materials (**Figure 7**).

Figure 7 (a) Wheat, (b) flax, and (c) bamboo are monocot species that can be used for food, fibre, and building materials, respectively. (d) Soybeans, (e) cotton, and (f) oak are eudicots that can also be used for these purposes.

12.1 Summary

- Plants have adaptations to help them make food, exchange gases, obtain nutrients, defend themselves, and reproduce, even though they cannot move independently.
- The body plan of most vascular plants includes leaves, stems, and roots.
- Vascular plants include club mosses, ferns and their relatives, gymnosperms, and angiosperms.
- Angiosperms may be classified as Amborellales, water lilies, other early angiosperms, monocots, and eudicots.

12.1 Questions

1. Plants are unique in part because they are immobile. What other aspect of plants makes them unique? K/U
2. When we eat a balanced diet, all our nutritional needs are met. Compare and contrast this with how a plant meets all its nutritional needs. K/U A
3. Why do plants need to exchange gases with the environment? K/U
4. (a) Which two tissue types make up plant vascular tissues? What role(s) do these tissues play in the life of a plant?
   (b) Which type of tissue would you expect to be most commonly used as a food source? Why?
   (c) Which types of tissue play a protective role in the plant?
   (d) How are meristematic tissues uniquely different from all other tissue types? Where can meristematic tissues be found in a plant? K/U T/I A
5. Outline how scientists have changed the way they classify angiosperms. K/U
6. Which angiosperm groups are most useful to humans? Explain why. K/U
7. Suppose a robin and an oak tree share the same environment. One summer day is particularly hot and dry. Compare the ability of these two organisms to respond to this change in environmental conditions. K/U A
8. How might the fact that plants do not move influence their ability to adapt to climate change and other environmental changes? T/I