CHAPTER 13

Succession, Reproduction, and Sustainability

KEY CONCEPTS

After completing this chapter you will be able to

- discuss how different societies or cultures have used plants in a sustainable way
- design and conduct an inquiry to determine the factors that affect plant growth
- describe various techniques of plant propagation
- compare and contrast monocot and eudicot plant structures and evolutionary processes
- explain the reproductive mechanisms of plants in natural reproduction and artificial propagation
- describe the various factors that affect plant growth
- explain the process of ecological succession, including the role of plants in maintaining biodiversity

How Do Plants Respond to Changes in the Environment?

Imagine you and your friends are putting on a presentation to new Canadians about appropriate outdoor clothing for life in Canada. Some of your audience have never seen snow and do not know how to dress for a Canadian winter. Others might believe that Canada is cold year round. What seasonal changes in the outdoor environment would you need to consider?

The plants in Canada must also survive these seasonal changes. For example, the marvellous fall colours of deciduous trees in parts of Canada are due in part to a leaf-shedding adaptation that helps protect the plant from freezing damage and water loss during the winter. Non-deciduous trees, such as conifers, are adapted to cold winter weather in other ways. Conifers have needles that stay on the tree year round. These needles have a thick, waxy cuticle that helps prevent freezing damage. Plants in other parts of the world must also be able to respond to cyclical changes in their environments, such as wet and dry seasons. Plants also have to respond to sudden changes in the environment, such as the rain and temperature change of a sudden thundershower. Humans can usually run indoors or put on a coat when such changes occur, but plants must be able to respond to environmental changes while staying put.

Some environmental changes are so severe or rapid that much of the plant (and animal) life may die, such as during a forest fire. Some plants, however, have adaptations that allow them to benefit from such events. For example, jack pines are often the first trees to appear after a forest fire. Jack pine seeds are sealed in the pine cone by a resin that will release the seeds only when it is heated above 50 °C. This temperature is often reached during a forest fire. Since most other living things have died and begun to decompose after a forest fire, jack pine seeds germinate in an environment with very little competition and lots of nutrients.

Plants must also respond to environmental changes caused by human activity. We might wear a path in a grassy area by walking the same way every day. We might bulldoze all the plants in an area to construct a building. Some of our actions also contribute to climate change. How plants respond to climate change can dramatically alter an environment. For example, the Athabasca Glacier in Jasper National Park has receded substantially over many decades because of global warming. As the glacier recedes, it exposes bare rock below. Land that was once under ice several metres thick is starting a gradual transformation into a forest.

STARTING **POINTS**

Answer the following questions using your current knowledge. You will have a chance to revisit these questions later, applying concepts and skills from the chapter.

1. Suppose that the yard of a house is left undisturbed for 20 years after the family moves away. There was grass in the yard but no trees or bushes. Predict how the yard would change over this time.
2. What factors in the environment do you think are most important to plant growth and development? Why?
3. Plants can reproduce asexually, which produces individuals that are genetically identical.
   (a) When might asexual reproduction be beneficial to a plant?
   (b) Give an example of how asexual reproduction is of economic value to people.
4. Suggest one way in which the sexual reproduction of plants is related to sustainable agricultural practices.

Mini **Investigation**

Which Way Is Up?

Skills: Researching, Controlling Variables, Performing, Observing, Analyzing, Communicating

SKILLS HANDBOOK A2.1

Unlike animals, plants do not have obvious sense organs. Can plants detect and respond to light, chemicals, and other stimuli in their environment? In this investigation you will examine the response of germinating seeds to the force of gravity. Later in this chapter you will learn how plants are able to respond to other environmental stimuli.

Equipment and Materials: Petri dish; filter paper; cotton batting; 4 pre-soaked seeds; tape; aluminum foil or dark paper

1. Arrange four pre-soaked seeds on the bottom of a Petri dish as shown in **Figure 1**. Each seed should be oriented toward the centre of the dish.
2. Cover the seeds with two layers of wet filter paper, being careful not to move the seeds.
3. Fill the Petri dish with enough dampened cotton batting to hold the seeds in position.
4. Place the lid on the Petri dish and tape it shut.
5. Stand the Petri dish on its edge, and tape it in position (**Figure 1**). Cover the Petri dish with foil or dark paper to keep out light.
6. Check on the seeds each day and record the growth patterns of the roots and shoots, using labelled sketches.

A. Describe the overall growth patterns of your germinating seedlings. Did the roots and shoots respond to gravity in the same way? T/I

B. Why was it necessary to keep light out of the Petri dish? T/I A

C. Conduct online research to learn more about how plants detect and respond to the force of gravity. T/I A

(i) How are plants able to detect the force of gravity?

(ii) Can plants be grown in the "zero gravity" of space? If so, how?

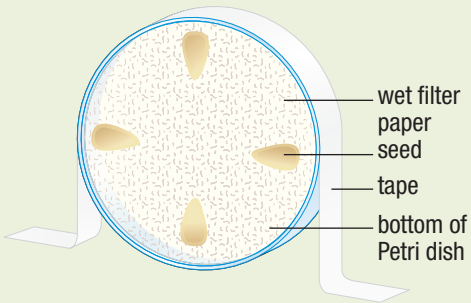

Figure 1

GO TO NELSON SCIENCE

13.1 Succession

Figure 1 The ash and thermal energy released by the eruption of Mount St. Helens destroyed all life in some regions.

succession the gradual change over time in the species that form a community

primary succession succession in an area that has no plants, animals, or soil

pioneer species the first species to colonize an area during succession

On May 18, 1980, Mount St. Helens, a volcano in the U.S. state of Washington, suddenly erupted, releasing huge plumes of volcanic ash (**Figure 1**). The thermal energy and ash from the eruption destroyed all life on the mountainside. Lava from the volcano eventually cooled to form a dome of new rock. Over the decades since the eruption, the bare rock and ash have slowly been colonized by plant and animal life. The changes in the community that are happening on Mount St. Helens are a dramatic example of succession. **Succession** is the gradual change in the species composition of a community over time. The change can be a result of shifts in the population sizes of some of the species and by the appearance and disappearance of species.

Primary Succession

Primary succession is succession that takes place on completely barren rock or mineral deposits. The thermal energy, ash, and lava of a volcanic eruption destroy all living things and cover any existing soil, creating a site for primary succession. Primary succession may also occur on lifeless surfaces exposed by retreating glaciers and explosions. Primary succession begins when organisms first colonize the bare surface. These first colonizers are called **pioneer species**. **Figure 2** shows the overall steps in primary succession that could occur at the edge of a receding glacier. Notice how, as succession proceeds, the biodiversity of the community increases.

Figure 2 Primary succession at a glacier's edge begins with bare rock, which is slowly colonized by an increasing number of species. The final result is a diverse community of organisms. Primary succession after a glacier retreats takes roughly 200 years.

Bare rock is revealed at the edge of a retreating glacier. There are no plants.

There are no animals.

There is no soil, no shade, and no shelter.

Pioneer organisms, usually lichens, colonize the rock. They do not need soil to get nutrients. Lichens secrete acids that erode rock, forming soil, and add organic matter when they decompose.

Animals such as caribou and mountain goats eat the lichen. Their droppings add organic nutrients to the developing soil layer.

The very thin soil layer cannot retain moisture and is very low in nutrients. There is no shade or shelter.

Mosses and other very small plants colonize the area. They help keep water in the soil and reduce erosion, stabilizing the soil. Lichens decline because they require bare rock, which is now covered by soil.

Insects, birds, and some small animals feed on the plants. Plant and animal decomposition builds soil.

The soil is thicker, has more nutrients, and can retain some moisture. Plants provide shelter to protists, insects, and spiders.

Small herbaceous plants outcompete the mosses. These species survive in dry, windy areas with relatively nutrient-poor soil. Their roots continue to break up the rock below. They add nutrients to the soil when they decompose.

Plants provide food and shelter for more species: worms, insects, birds, and small mammals.

Soil formation continues. Plants moderate temperature, wind, and moisture in the area.

As succession proceeds, the organisms in a community slowly change the biotic and abiotic factors of the ecosystem. The biotic factors are usually most noticeable, since they include the species present in the community and their population sizes. Abiotic factors that may change during succession include the acidity, type, and temperature of soil, and the availability of sunlight and water. As the biotic and abiotic factors change, the environment becomes less favourable for some organisms and more favourable for others. Which species colonize an area during succession depends on the geographic location. For example, temperate forest trees would never successfully colonize the tundra.

secondary succession succession in an ecosystem that has been disturbed by a natural event or human activity

Eventually, the shifts in plant populations slow down and a stable community is formed. Although it is stable, the community still responds to environmental changes. For example, an increase in the average temperature (such as from global warming) might make a region warmer and dryer, which would cause an increase in the number of drought-resistant species. We still have a lot to learn about primary succession, and several studies are ongoing around the world.

CAREER **LINK**

Freshwater Biologist

Freshwater biologists may monitor the changes in freshwater communities or be involved in re-establishing damaged ones, such as lakes in which all life was killed by acid rain. To learn more about a career as a freshwater biologist,

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Secondary Succession

Secondary succession is succession that occurs after an existing community has been disturbed by natural events or by human activity. Natural events include forest fires, floods, and violent storms such as tornadoes and hurricanes. Human activities include forest harvesting as well as clearing land for agriculture or for construction. Unlike primary succession, secondary succession takes place where soil containing organic matter and sometimes a few plants may remain after the disturbance. The plant populations in the community therefore establish more quickly than in primary succession. **Figure 3** shows how succession might occur on farmland that was abandoned and left undisturbed. Although our example is of a terrestrial community, secondary succession also occurs in aquatic environments.

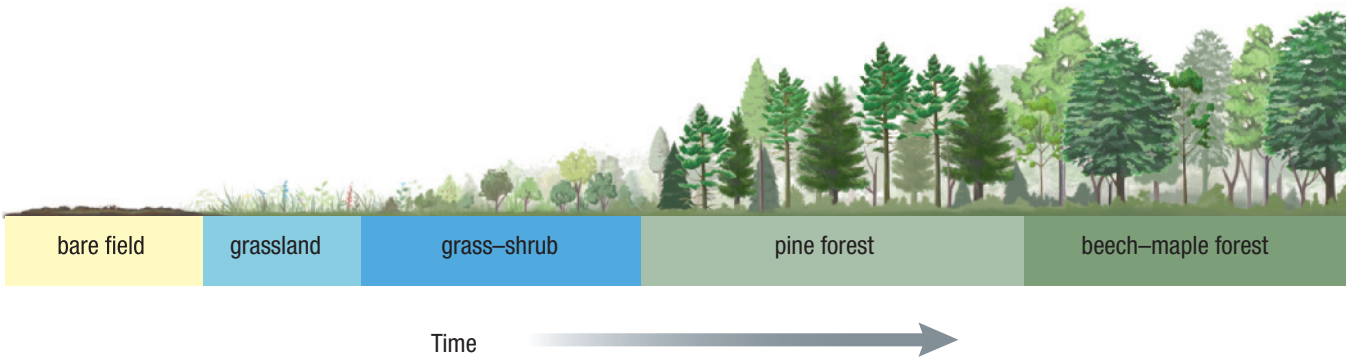

Figure 3 As with primary succession, biodiversity increases as secondary succession progresses.

Human Activity and Succession

Figure 4 In this schoolyard, plants that would have arisen by succession in a natural environment have been planted in a previously grassed area.

Succession creates stable, diverse communities. The more diverse a community is, the better it can withstand environmental change. Unfortunately, many human activities get in the way of succession. For example, traditional suburban yards are dominated by a monoculture of grass. Some people ensure that succession does not proceed by actively destroying any non-grass species that colonize their lawns, either by weeding or by using herbicides. Such actions can reduce plant and animal biodiversity. However, people are modifying their actions in ways that allow us to meet our needs and wants while minimizing negative effects on succession and biodiversity. For example, some gardeners allow native plants to colonize their gardens. When forestry companies switch from clear-cutting to selectively cutting trees of a particular size, the plant community remains at a later stage of succession and is more stable.

Human actions can also help to advance the stages of succession, increasing biodiversity and stability in communities. For example, some schoolyards and parks are planted with species that would eventually arise naturally by succession (**Figure 4**). It is important to plant species that are only one or two stages ahead in succession. This helps ensure that the plants are in a community with biotic and abiotic factors that can support their growth and development.

Research This

The Greening of Sudbury

Skills: Researching, Analyzing, Communicating, Identifying Alternatives

SKILLS HANDBOOK A5.1

Sudbury is a greening city. As you can see in **Figure 5(a)**, the environment in and around the city was once severely degraded by industries operating in the area. Emissions from nickel smelting caused acid rain, which acidified the soil in and around Sudbury until virtually all plant life was killed off.

Although the environment has not yet completely recovered from the negative effects of industry, it has slowly undergone succession and recovery (**Figure 5(b)**). However, this succession has been possible only because of the intervention of environmental groups. In the case of Sudbury, it was not sufficient to simply plant species that would occur eventually by succession. The environmental conditions in damaged areas had to be changed before any plant species could survive. In fact, some areas near Sudbury remain barren of life.

Figure 5 (a) Degraded land near Sudbury, 1977 (b) Reclaimed land near Sudbury

1. Use the Internet and other sources to find out more about the work involved in greening Sudbury. Find out what was done to begin the process of succession and what is continuing to help it occur more quickly.

A. Create a flow chart, timeline, or other graphic organizer to show how people in Sudbury worked with succession to help rehabilitate damaged environments. T/I C

B. Some areas have yet to be rehabilitated. Why? T/I

C. Using what you know about succession and biodiversity, suggest further steps that groups and governments in the Sudbury area could take. T/I A

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13.1 Summary

- Succession is the gradual change in a community brought about by shifts in population sizes of various species and/or loss or gain of particular species.
- Primary succession occurs in an area in which there is no existing life.
- Secondary succession occurs after a community has been disturbed; soil with organic nutrients and some plant species remain after the disturbance.
- At each successional stage, biotic and abiotic conditions change; each species may be more or less successful in the new conditions. Eventually, succession results in a stable community with relatively small changes in populations.
- Biodiversity increases at every stage of succession.
- Human action can affect the process of succession positively or negatively.

13.1 Questions

1. Explain how succession and biodiversity are related. K/U T/I
2. Distinguish between primary succession and secondary succession. K/U
3. Give an example of how human activity can cause primary succession and secondary succession. Which type of succession is more often affected by human actions? K/U
4. Does a stable community remain the same? Explain. K/U
5. Suppose there is a weedy section of grass in your schoolyard. Using what you know about succession, how could you improve the biodiversity of this area? T/I A
6. Some plants produce large numbers of very small seeds while others produce a few large seeds. Predict which type of plants are more likely to be found in early successional stages. Explain your reasoning. T/I A