2.1 Primary Succession

Figure D2.2: Steaming lava runs into the Pacific Ocean from Hawaii.

Figure D2.3: Ferns manage to grow through cracks in volcanic lava.

A popular destination for people visiting the Hawaiian Islands is Volcanoes National Park. The park features two active volcanoes, Mauna Loa and Kilauea, that regularly erupt. The eruptions are rarely violent, and the lava produced flows slowly. This allows tourists to get close to this 1000°C molasses-like fluid. As molten rock reaches the Pacific Ocean shore, it transfers its thermal energy upon contacting the water. This produces steam and new rock. Each year, with the continual eruption of these volcanoes, Hawaii's Big Island gets bigger. New rock formed from solidified lava is exposed to seeds and spores of simple, tough plants, such as ferns. These seeds and spores are carried to the new rock by wind, insects, or on the feet and bodies of birds. The germination of seeds and spores on the new rock—as shown in Figure D2.3—demonstrates that the process of **primary succession** has begun.

primary succession: the process of changing—in successive stages—an environment from an area of bare rock and few species to a complex community

DID YOU KNOW?

Molten rock—from 50 km to 250 km deep within Earth—can rise through cracks in the outer crust. When this molten rock reaches the surface it is called lava. Since molten rock has a temperature between 800°C and 1000°C, a lava flow can completely destroy nearly everything in its path. Things can get knocked over, surrounded, buried, or ignited. If lava encounters a body of water, the water may start to boil suddenly—this can result in an explosive splatter of extremely hot material.

Succession Begins

Primary succession occurs in places where soil has been removed or where it never existed. Examples include bare land—such as cooled lava, sand dunes, and mountain slopes. Primary succession is a slow process because few plants are able to grow on bare rock without soil, with little water, or without protection from the sun and wind. Tough plants first invade or colonize this new territory. Lichens growing on these rocks exposed by a retreating glacier or ferns that can grow on lava rock, described in Figure D2.4, are called **pioneer species**.

Pioneer species—ferns, lichens, mosses, and some bacteria, etc.—pave the way for more complex organisms as their life processes change the original habitat. For example, bacteria and lichens produce acids that break down the rock. Minerals are released to provide areas that trap water. Mosses can then grow in the sparse soil made by lichens and they trap dust and water against the rock. The dead bodies of lichens and mosses add material to the soil when they decay and become the organic component of soil called **humus**.

Figure D2.4: Lichens thrive while growing on glacial rocks.

- **pioneer species:** simple and hardy plants that first invade or colonize barren ground and change the environment to support more complex life forms
- **humus:** the organic component of soil created from the decomposed bodies of organisms

Investigation

Succession on Land

Purpose

You will determine if there is a difference in the characteristics of plant seedlings grown in potting materials exposed to succession (and that have humus), compared to seedlings grown in pre-succession potting materials.

Science Skills

- ✓ Performing and Recording
- ✓ Analyzing and Interpreting

Prediction

Read though the entire procedure.

1. List the variables, in addition to the amount of potting material and water, that you will need to ensure accurate results.
2. State the substrate—potting mix—you think will produce seedlings with the best appearance. Support your answer.

Materials

- 4 equal potting containers
- approximately 15 tomato seeds (or other garden seeds)
- potting materials—garden soil, clay, sand, and rock chips
- water
- bright, well-lit location

Procedure: Setting Up Your Succession Garden

step 1: Fill four containers with equal amounts of different types of potting materials—sand, clay, garden soil, and rock chips.

step 2: Plant three tomato seeds (or other garden seeds) in each container.

step 3: Water each planted container with an equal amount of water that sufficiently wets the potting material. Continue to water the containers in equal amounts at consistent intervals throughout the experiment's length.

TIP: For the purpose of this investigation, consider complete germination to be two visible and completely open leaves on a seedling.

step 4: Make an observation table and, if possible, daily observe and record any germination (sprouting) of seeds for about two weeks. Make notes on your table about the quality of seedlings, including the relative height of seedlings and the number of leaves. Your table will require approximately 14 rows.

Date	Sand	Clay	Garden Soil	Rock Chips

Analysis

3. Which potting material produced seedlings with the fastest germination?
4. Which potting material produced seedlings with the greatest height and vigour?

Evaluation

5. If you repeated this investigation with seeds from a hardier plant, how would you modify the design of this experiment to produce more reliable data? Identify the reasons for the changes you would make.

Succession Continues

Once enough humus-rich soil is produced by the pioneer species, the habitat is ideal for grasses to grow. Grass roots bind and protect the soil and work their way into cracks, breaking apart the underlying rock even further. The taller grass plants shade the moss that grows closer to soil level—this causes the mosses to die off and results in a meadow. In this progression, the grasses have replaced or succeeded the lichen and moss communities. The process of succession in northern Alberta's boreal forest continues as broad-leaved shrubs succeed grasses, deciduous trees follow shrubs, and coniferous trees succeed deciduous trees. The final, stable community produced through the process of succession is called a **climax community**. The change from bare rock to the end product of a climax community can take thousands of years. Once reached, a climax community remains stable until there is an ecosystem disturbance.

Different species make up the climax community in different climates. In an ecosystem like Alberta's southern prairies, grasses are the climax community. In an ecosystem like Arizona's Sonoran Desert, even the resilient and distinctively tall saguaro cactus needs to begin growing in the shade of a shrub.

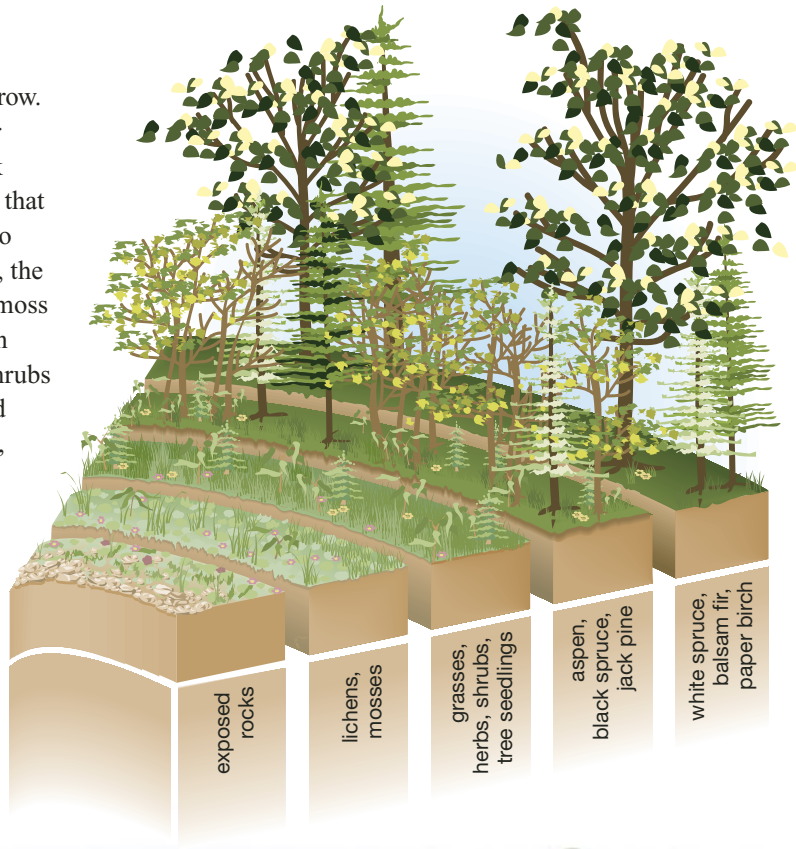

Figure D2.5: The process of boreal forest succession is continuous.

climax community: the stable community that results from the process of succession

Utilizing Technology

Researching Primary Succession on Mars

Background

Could people live on Mars one day? Some people have proposed that future missions to the red planet should include the introduction of hardy pioneer species so that these organisms can begin to change the planet's raw soil and prepare it for more complex organisms and, eventually, human colonization. One challenge to overcome is the unfavourable abiotic conditions that exist on Mars.

The process of transforming a planet to be more like Earth has been called **terraforming**. Some scientists are even researching what kind of bacteria would make good candidates for the first Earth life form to pioneer the colonization of Mars.

Science Skills

✓ Analyzing and Interpreting

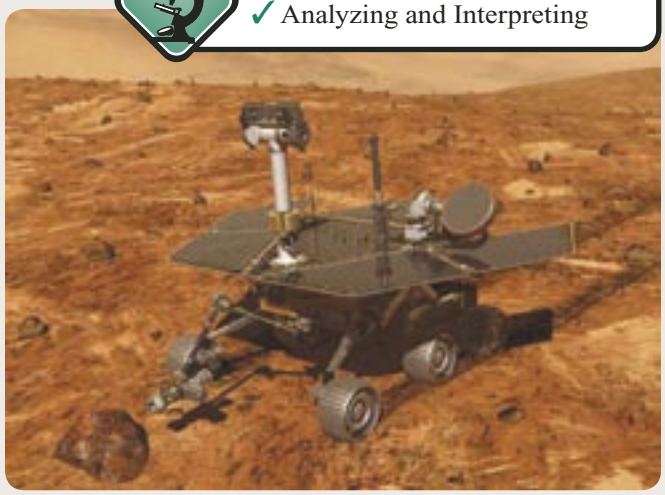

Figure D2.6: A robotic probe gathers data from Mars.

Research Activity

Using the Internet and/or other resources, determine answers to the following questions.

1. What are some of the major obstacles to the terraforming of Mars?
2. What would be some of the particular challenges these first species would have to overcome in terms of abiotic conditions on Mars?
3. Are there some ethical, societal, or scientific concerns with the idea of terraforming? If so, what are they?
4. After completing your research, perform a risk-benefit analysis to determine if terraforming Mars is worth the investment of time, money, and other resources.
5. Use the results of your risk-benefit analysis to decide if terraforming Mars is a project you would support.

terraforming: the process of transforming a planet to be more Earth-like

Aquatic Succession

Succession happens both on land and in aquatic ecosystems. When water from rain and run-off first collects in a ground depression, called a basin, it is poor in nutrients (e.g., nitrogen). A basin could be formed in many ways. For example, the crater left by the impact of an ancient meteorite fills with water, or a farmer digs a dugout for her cattle. The lifeless water of the dugout is soon colonized by algae, which will provide food for other organisms. Frogs, salamanders, and insects will lay their eggs in the dugout. Seeds and fish eggs might find their way to the dugout by being attached to body parts of a bird that visits the dugout.

Figure D2.7: Succession occurs in aquatic ecosystems.

The sediment from run-off that drains toward the dugout and the decomposing bodies of the dugout inhabitants will add to the dugout's bottom layer. This creates an aquatic soil that provides aquatic plants with a place to anchor and grow. As the sediment continues to be created, the dugout slowly gets smaller in diameter and becomes shallower.

Later, along the water's edge, you will see plants, like cattails and reeds, begin to grow. Increased vegetation could turn the area into a marshy bog. At this stage, the transition from an aquatic ecosystem to a terrestrial ecosystem has begun. Plants from the surrounding ecosystem will begin to grow in the bog and increasingly transform the aquatic environment into surroundings that look more terrestrial.

Investigation

Aquatic Succession

Background

Primary succession happens very slowly. It would be impossible to carry out an experiment to observe all the succession stages from bare rock to a climax community and get the results during the span of one science course. However, you can simulate some succession stages by using a small experimental model.

Science Skills

- ✓ Performing and Recording
- ✓ Analyzing and Interpreting

Purpose

You will determine the changes in population and the stages of succession that can be observed in a body of water over a short time period.

Prediction

1. Read though the entire procedure. What differences do you think will be observed between the two flasks?

Materials

- 2 Erlenmeyer flasks with rubber stoppers
- distilled water
- plastic cling wrap or closed rubber stoppers
- latex gloves
- 2 eyedroppers
- compound microscope
- microscope slides and coverslips
- methylene blue stain
- quieting solution
- small amount of mud from a local pond, slough, or stream

Procedure

Your teacher may prepare steps 1 and 2 ahead of time.

step 1: Partially fill two small flasks with distilled water and cover them. Covering the flasks will prevent evaporation and the entry of unwanted pioneers into your microhabitats. You have now created two mini-ponds where succession is ready to begin.

step 2: Choose one flask to act as a control. In the other flask, simulate pond succession by adding a small amount of soil and vegetation, or even water from a local pond. Ensure you re-cover or re-stopper the container. Place both containers in a well-lit area (e.g., a window sill).

CAUTION!

It is important to wear latex gloves and to use proper techniques in the next steps because the succession flask may contain harmful bacteria such as *E. coli*.

step 3: Make an observation table and, if possible, daily observe and record any apparent overall changes in the two mini-ponds. Add as many rows as necessary.

Control Flask				Succession Flask		
Date	Physical Changes	Number of Types of Organisms Observed	Number of Organisms Observed	Physical Changes	Number of Types of Organisms Observed	Number of Organisms Observed

step 4: Once you have made your overall daily observation, remove a sample of water from each mini-pond by using an eyedropper. Prepare a microscope slide of each sample. Be careful to use a separate dropper for each flask to avoid cross-contamination. Add some methylene blue stain to the slide to better see any organisms. For better observations, a quieting solution may be used to slow down swimming micro-organisms.

step 5: View and compare the two slides using the compound microscope. Record on your observation table the sightings of any organisms that you find. You may even want to sketch the new inhabitants of your mini-pond on your table.

Analysis

2. Did you observe any physical changes in the mini-pond during the investigation?
3. Was there a noticeable change in the number of organisms present in your mini-pond? Describe the changes.
4. Were you able to notice a change in the types of species present?
5. Was there any invasion of species into your control flask? State a possible reason or explanation for the presence of organisms in your control.

Evaluation

6. Does this experiment accurately simulate the process of succession? Describe changes to the experimental design that could be incorporated if this experiment were to be repeated.

2.1 Summary

Primary succession occurs in places where soil has been removed or where it never existed. This process continues as one community succeeds another until a stable climax community is reached. Since primary succession is a very slow process, it can take thousands of years to go from bare rock to a climax community. The first group of hardy species to grow or live in an area is called a pioneer species. These species play a particularly important role because without them soil would not be created for more complex plants and the organisms that follow. Primary succession also occurs in aquatic ecosystems and produces its own distinctive climax community.

2.1 Questions

Knowledge

1. Why do you think scientists chose the term *pioneer species* for certain organisms? What characteristics do these pioneer plant species possess that allow them to be categorized as pioneer species?
2. List the benefits that a pioneer species would experience.
3. Place the following stages in the correct order in which they would be observed during primary succession: deciduous trees, bare rock, grasses, lichens, deep humus-rich soil, coniferous trees, mosses, shrubs, thin soil.

Applying Concepts

4. Examine the photo in Figure D2.8.
   - **a.** State an event that might have caused the soil to be removed in this habitat before primary succession began.
   - **b.** List the stages of succession that you can see in the photograph. Refer to the diagram of succession shown in Figure D2.5.
   - **c.** State a reason why the area in the rock cracks seems to be at a later stage of succession than the area on top of the flat rock.
   - **d.** Identify which organisms in this photo would be most productive in terms of capturing energy from the sun to carry out photosynthesis.

Figure D2.8: Stages of succession can be seen in this photograph.

Photo Credits and Acknowledgements

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Legend: t = top, m = middle, b = bottom, l = left, r = right

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