5.2 Asexual Reproduction

In asexual reproduction, only one parent is required. Asexually produced offspring, or clones, have identical genetic information to each other and to the parent. Asexually reproducing unicellular organisms reproduce quickly and in large numbers. Knowledge of asexual reproduction enables biotechnologists to clone both organisms and cells.

Words to Know

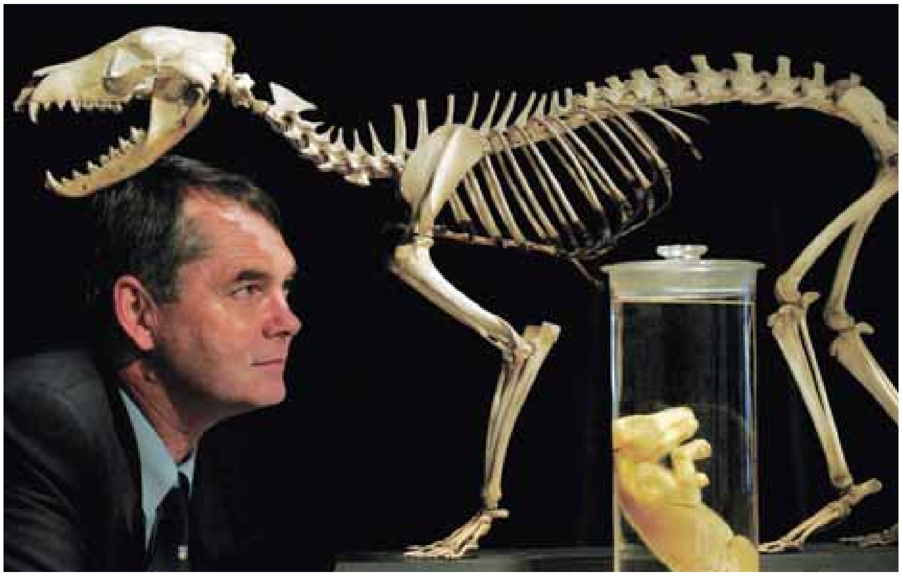
asexual reproduction
binary fission
budding
clone
fragmentation
spore
stem cell
vegetative reproduction

If you have heard anything about clones then you already know something about asexual reproduction. A **clone** is an identical genetic copy of its parent. You encounter clones every day. Bread mould is a group of clones that come from a single mould spore. A new duplicate tree growing up from the bottom of another tree is also a clone (Figure 5.15). A clone is produced through the process of **asexual reproduction**. In asexual reproduction, only one parent is required to produce offspring. They look identical to the parent and to each other.

Figure 5.15 The aspen is one of the most widely distributed trees in North America. In British Columbia, aspen trees are found mostly east of the Coast Ranges. Many of these trees grow in multistemmed groups of clones.

Bread mould and tree shoots are examples of clones that occur naturally. Other types of clones are artificially made in agricultural or horticultural industries and in biomedical laboratories. The cloning of animals such as sheep, pigs, cattle, and horses and of plants such as ornamental shrubs and trees has become more frequent as bioengineers seek to improve livestock breeds and increase plant production. Bioengineers also clone individual skin cells to grow new tissue for burn victims. Geneticists clone healthy genes to replace mutated ones.

In 1999, scientists successfully extracted DNA from an unborn Tasmanian tiger pup, which had been preserved in ethanol for 150 years (Figure 5.16 on the next page). Two years later, scientists extracted more DNA from the bone, teeth, and dried muscle of two other pups. They successfully duplicated individual genes of the Tasmanian tiger and hope to use cloning technology to reproduce all of the genes and gene sequences of this extinct animal.



Did You Know?

A clone bank is a collection of clones that make up the genome of a species. Clone banks enable biologists to preserve genetic information and to conduct research.

Figure 5.16 Scientists have succeeded in cloning the genes from an extinct Tasmanian tiger.

5-2A Examining Ideas about Cloning

Find Out ACTIVITY

In this activity, you will use a graphic organizer to help you link together ideas about cloning. Then you will examine your understanding about cloning to determine whether you are in favour of cloning or against it. Later in this chapter, you will learn more about the methods used to clone various organisms.

What to Do

1. Read the list of words, sentences, and phrases below, which all connect in some way to cloning.
   - Saves species close to extinction
   - A clone would be the same age as the donor
   - Reproductive cloning
   - Produces a copy of yourself so that you will be immortal
   - Possible applications of cloning
   - Produces organs for transplant
   - Misconceptions about cloning
   - Produces copies of Albert Einstein or other famous people
   - Produces copies of your skin cells to treat burns
   - Techniques of cloning
   - A clone would have feelings and emotions identical to those of the donor
   - Produces plants that produce high crop yields
   - Produces an animal that has become extinct
   - Produces another you so that there will be a supply of your organs in case any of your organs fail
   - Therapeutic cloning
2. Working in pairs, choose a graphic organizer to represent your understanding of these statements and how they fit together. Construct your graphic organizer.
3. After completing your graphic organizer, compare your work with that of other classmates. Identify similarities and differences between your graphic organizers.
4. Look again at the list above, which includes several possible applications of cloning. Put a star beside the possible future applications of cloning that you believe are good for society. Place an X beside the possible future applications of cloning that you believe are not good for society. Put a question mark beside the applications you are unsure about.
5. As a class, discuss the consequences of possible future applications of cloning.

What Did You Find Out?

1. Did you have misconceptions about cloning? If so, what were they?
2. For each possible future use of cloning that you marked with an X in step 4, give reasons for why you feel that that application would not be good for society.

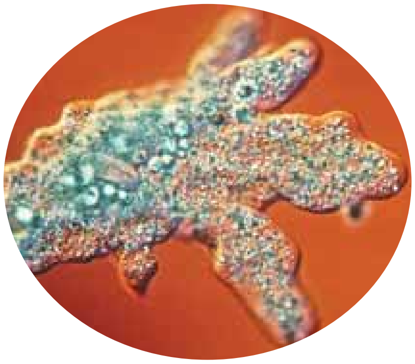


Figure 5.17 To survive, the amoeba must reproduce in great numbers.

Types of Asexual Reproduction

One-celled (unicellular) organisms, such as the amoeba (Figure 5.17), depend on asexual reproduction to reproduce themselves in great numbers. The amoeba and many other one-celled organisms are part of the food chain for more complex, multicellular organisms. Because of this role, it is important for their survival that they reproduce in large numbers.

Many species reproduce by asexual reproduction. Asexual reproduction occurs naturally in living things through a variety of methods, which include binary fission, budding, fragmentation, vegetative reproduction, and spore formation.

Binary fission

Small, one-celled eukaryotic organisms like the amoeba reproduce by **binary fission** (Figure 5.18). In binary fission, a single parent cell replicates its genetic material and divides into two equal parts. Amoebas have between 30 and 40 chromosomes depending on the species. *Amoeba dubia* has several hundred chromosomes! The chromosomes must be replicated and attached to the spindle fibres in mitosis to ensure that the exact number of chromosomes ends up in each daughter cell.

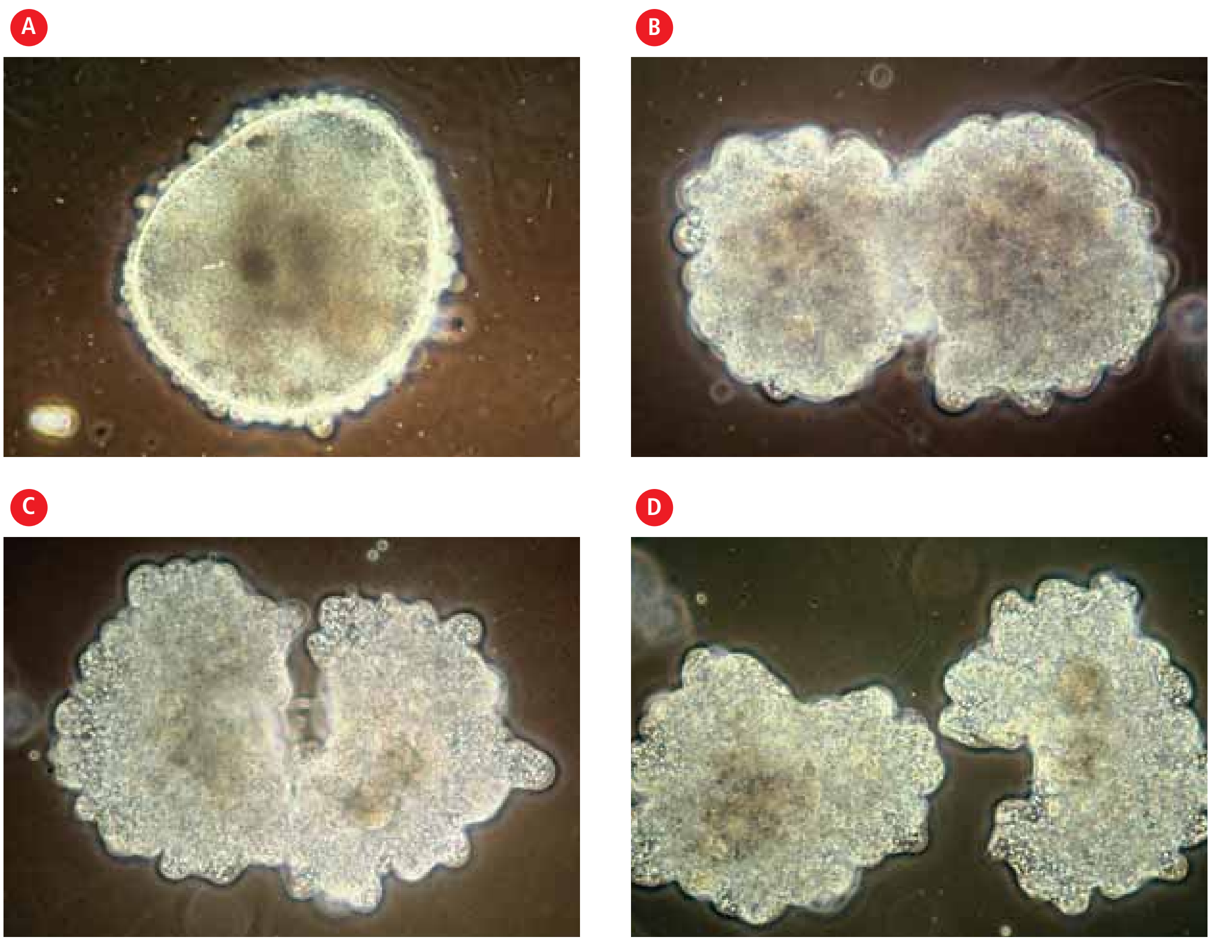


Figure 5.18 Binary fission in an amoeba

Binary fission is the only method of reproduction for some types of bacteria. Since bacteria do not have a nucleus, they do not undergo mitosis. However, the one ring of DNA does replicate (Figure 5.19). If the environmental conditions are favourable, a bacterium can reproduce every 20 minutes by this method. You may have had an experience where you became ill very quickly. Within two days of *Streptococcus* bacteria entering your body, you may get a very sore throat and fever because the bacteria multiply into millions very quickly.

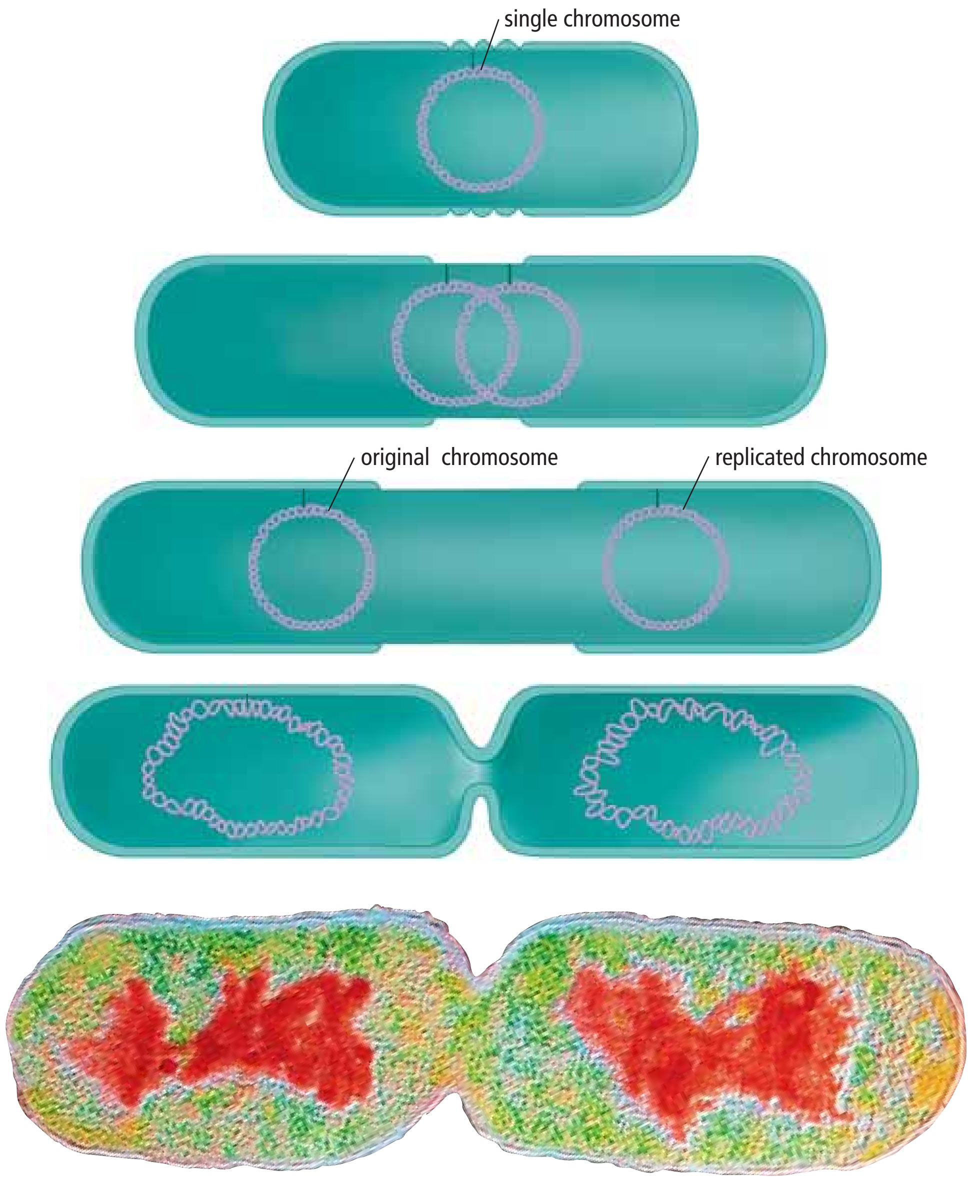


Figure 5.19 Binary fission in a bacterium

Word Connect

The term "binary fission" comes from the Latin words *binarius*, meaning two together, and *fissio*, meaning to split.

Figure 5.20 These marine algae can cause red tide.

The dinoflagellate *Alexandrium acatenella*, which is one species of marine algae that causes paralytic shellfish poisoning, also reproduces by binary fission (Figure 5.20).

Mutation can happen during binary fission when errors occur during DNA replication or when chromosomes fail to move into the two new cells. The DNA in bacteria, for example, can mutate rapidly, which can make bacteria very resistant to antibiotics.

Budding

Since some multicellular organisms, such as hydras and sponges, have only a few different cell types, they are also able to reproduce asexually. Areas of an individual may undergo repeated mitosis and cell division and can develop into an identical organism in a method called **budding**. The hydra and the sponge develop an outgrowth or bud, as shown in Figure 5.21A and Figure 5.21B. The bud may detach from the parent and become a new individual or remain attached. Unicellular yeast cells also reproduce by budding, as shown in Figure 5.21C.

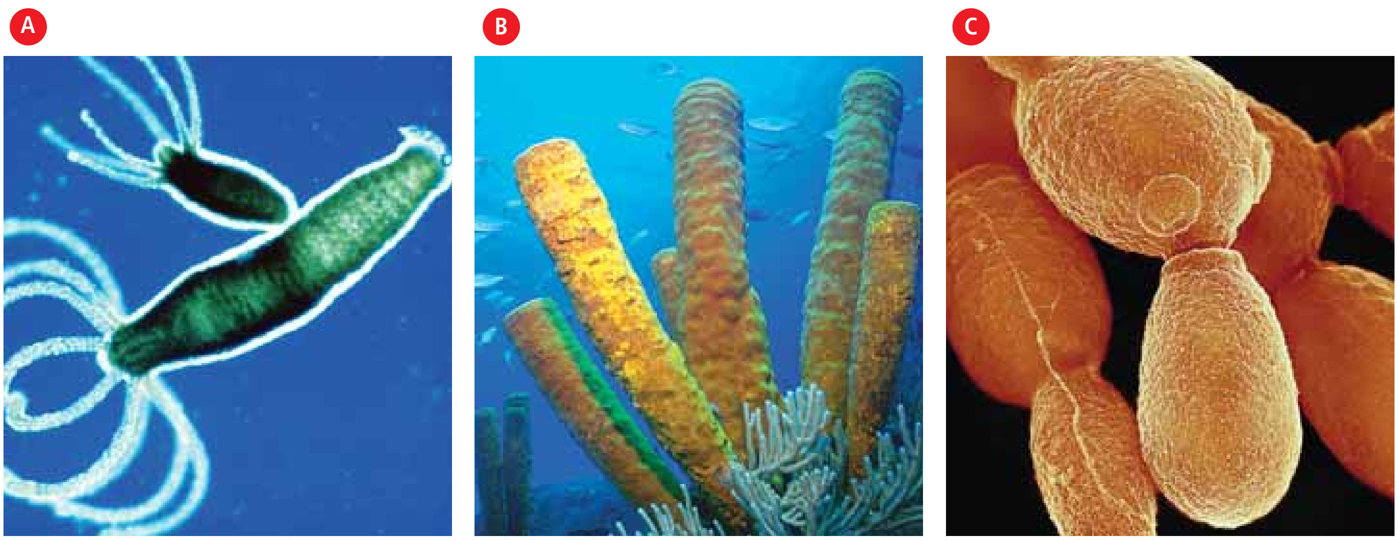


Figure 5.21 Budding can occur in some multicellular organisms such as the hydra (A) and the sponge (B) and in some unicellular organisms such as yeast (C).

Budding is advantageous for animals such as sponges, which attach to rock and move very little. Colonies can be maintained in the same place, or new colonies can be established when buds break away from their parents and are carried to new locations.

Fragmentation

Some animals and many plants can reproduce by a method called **fragmentation**. If an organism breaks apart as a result of injury, each fragment then develops into a clone of its parent.

Some animals, such as certain species of sea star, can reproduce asexually from fragments (Figure 5.22). In these species, if one of the arms detaches from the parent's body, it can develop into another sea star if it contains enough of the parent sea star's genetic information. The success of sea stars has had an impact on the shellfish industry. Most sea stars are carnivorous (meat eaters) and feed on oysters and clams, but they will also eat any type of animal tissue.

Figure 5.22 If the otter drops a fragment of this meal into the water, the fragment may develop into a completely new sea star.

Plants can also reproduce by fragmentation provided that their environment does not change and there are enough nutrients available. Eurasian milfoil is an example of such a plant. Eurasian milfoil is an aquatic weed that is not native to North America. It was accidentally introduced into Okanagan Lake about 40 years ago. Boat propellers are largely responsible for the spread of Eurasian milfoil into many lakes across British Columbia. The propellers chop up the plant, and plant fragments are transferred on boat motors from lake to lake. Since Eurasian milfoil reproduces quickly by fragmentation, it can cause great harm to the lake ecosystems into which it is introduced (Figure 5.23).

Figure 5.23 The ability of Eurasian milfoil to reproduce by fragmentation means it can take over a water body very quickly and rob other aquatic plants and organisms of nutrients.

Vegetative reproduction

Many plants can also reproduce by **vegetative reproduction**. Vegetative reproduction occurs when special cells, usually in plant stems and plant roots, divide repeatedly to form structures that will eventually develop into a plant identical to the parent. Tulip, daffodil, and hyacinth bulbs, strawberry stem runners, and potato sprouts or "eyes" produce new plants by this natural method of asexual reproduction (Figure 5.24).

The main disadvantage of vegetative reproduction is that the new plants will all grow very close to each other and to the parent. This can lead to a competition for soil, nutrients, and light and can cause the plants to be less healthy.

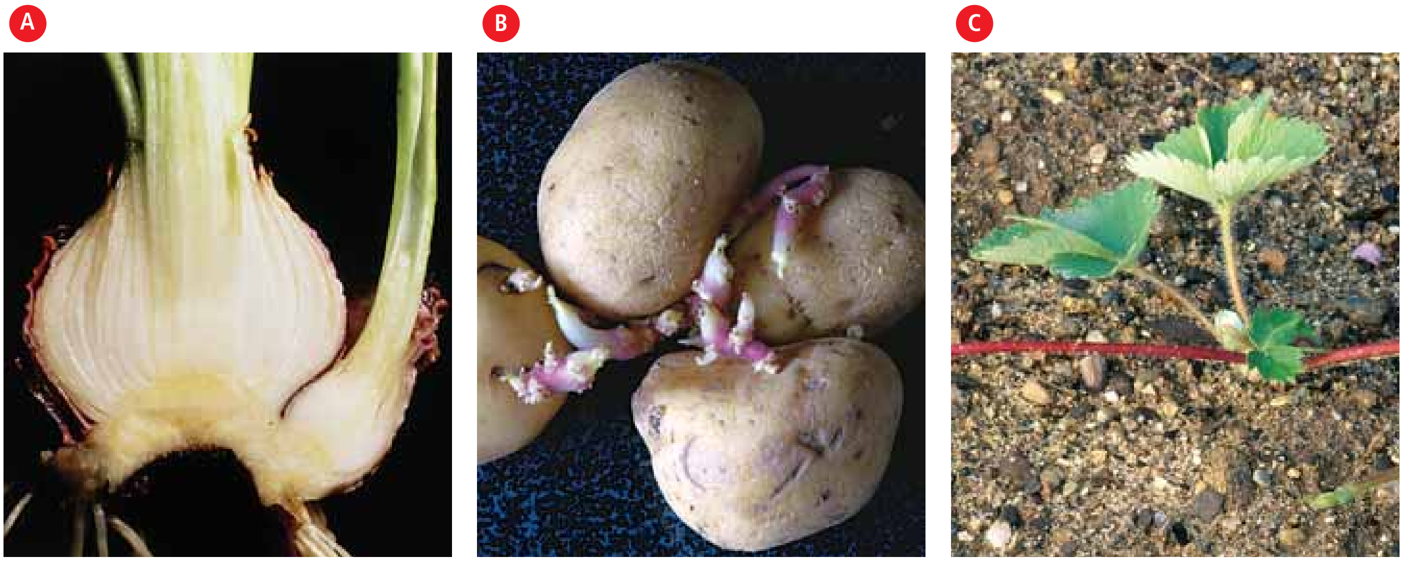


Figure 5.24 A new plant is forming from the bulb of this hyacinth (A). The sprouts or "eyes" growing from these potatoes can develop into separate plants (B). New strawberry plants form where strawberry runners develop roots (C).

Benefits to humans of vegetative reproduction

Asexual reproduction of plants has benefited humans for centuries. Potatoes, for example, are the number one tuber crop in the world. Originating in South America, potatoes were taken to Europe by explorers around the beginning of the 1500s. Since then, potatoes have become an important crop in many parts of the world.

The common camas is another plant that can reproduce asexually (Figure 5.25 on the next page). The bulb provided a staple, starchy food for First Nations, especially the Coast Salish ancestors of the Songhees First Nation. The city of Victoria was once known as Camosack, because the area around Beacon Hill provided one of the best growing areas for camas on Vancouver Island. People of the Songhees First Nation maintained the grasslands in which camas grew and harvested the bulbs for their own food. They also traded the bulbs with the Nuu-chah-nulth people of the west coast.

Figure 5.25 The habitat of the common camas is increasingly threatened by urban development.

Did You Know?

The aspen, which can reproduce through vegetative reproduction, is dying in western North America from mysterious causes. The closeness of the trees and their genetic similarity may be factors in their decline.

Throughout history, humans have assisted nature in helping plants reproduce. Human-assisted methods of vegetative reproduction include methods such as cuttings and grafts. In the cutting method, a plant grower removes a section of stem (or leaf or root) and plants the cutting in a special growing medium. With increased technology, researchers have determined the correct amounts of nutrients necessary to help cuttings grow roots. More than 45 different kinds of house plants, such as the African violet, can reproduce by this method. Plant hormones, which are chemical messengers, are often applied to the cut stem (Figure 5.26). The hormones signal the nuclei in the cells of the cutting to stimulate cell division and growth, which causes some cells to develop into root tissue (Figure 5.27).

Figure 5.26 Cuttings are often dipped into rooting powder containing plant hormones.

Figure 5.27 Root tissue has developed from the stem cutting of an African violet.

For plants that cannot grow roots from cuttings, growers use a method called grafting to produce new plants. In grafting, stems called scions are attached to the rooted stock (or "rootstock") of a similar plant species (Figure 5.28A). This technique is often used to reproduce apple trees and rose plants. Grafting has several advantages. It can help the scion benefit from a more vigorous root system. Grafted trees produce fruit within two to three years because of the developed root system onto which they are attached. (Trees grown from seeds can take 5 to 10 years to produce apples.) Grafting can also control the eventual size of the plant. For example, apple scions are often grafted onto dwarfing rootstock so that they will develop into smaller trees. Another form of grafting is called budding, which is also used to grow apple trees (Figure 5.28B).

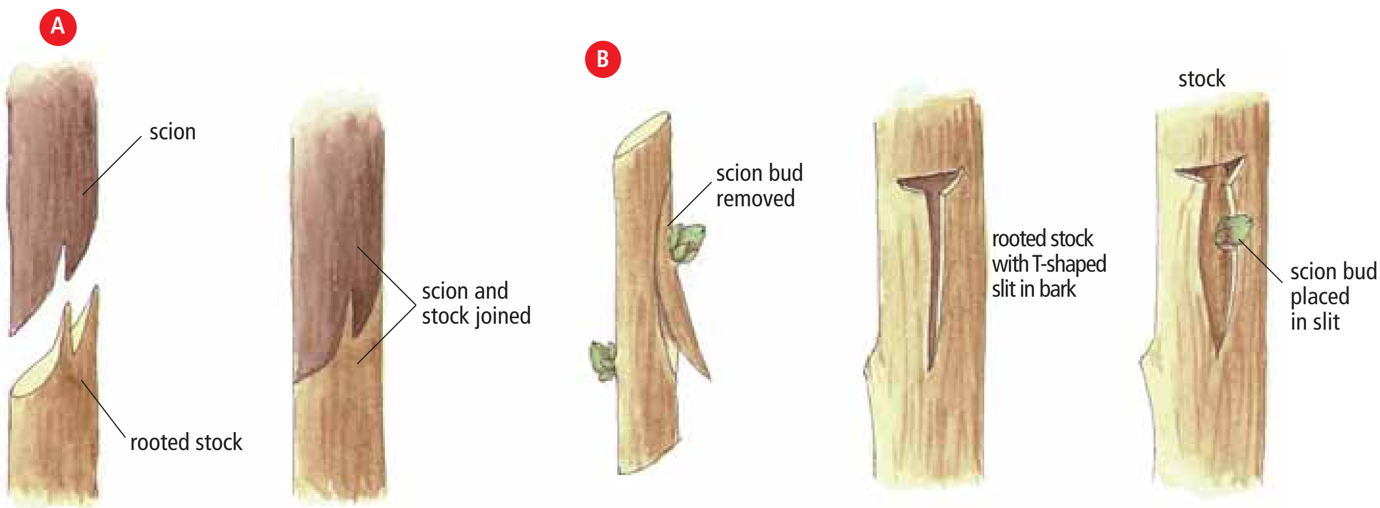


Figure 5.28 In grafting, parts of a desirable plant are removed and attached to the rooted stock of another plant. In Figure A, a stem called a scion is attached to the rooted stock of a plant. In Figure B, a plant bud is removed from the desired plant and attached to the rooted stock.

Spore formation

Some bacteria, micro-organisms, and fungi such as bread mould (Figure 5.29 on the next page) and puffballs (Figure 5.30 on the next page) can reproduce asexually by forming single-celled **spores**. A spore is a reproductive cell that grows into a new individual by mitosis. Some plants such as mosses and ferns can also form spores to reproduce. Spores are very light in weight, and spore producers rely on water or wind to carry the spores away from the parent. If conditions are suitable—there is enough moisture, the temperature is right, and there is a source of food—a new individual will begin to grow wherever it lands. Many spore types have a tough outer coating that allows them to survive in harsh conditions such as drought or extreme temperatures until conditions become favourable.

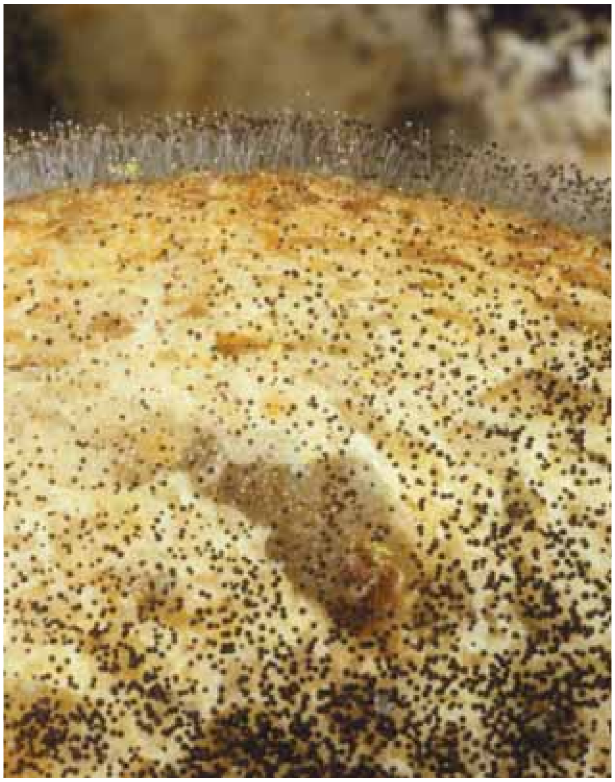


Figure 5.29 Each black dot on this bread mould is a spore. Millions of spores can be found on one piece of mouldy bread.

Figure 5.30 The cloud of spores rising up into the air will be carried away from the parent fungus by wind.

In this section, you have read about a variety of organisms that reproduce asexually. You have also learned that asexual reproduction has both advantages and disadvantages for the survival of these species. Table 5.1 presents a short summary of the advantages and disadvantages of asexual reproduction.

Table 5.1 Advantages and Disadvantages of Asexual Reproduction

Advantages	Disadvantages
• Large numbers of offspring are reproduced very quickly from only one parent when conditions are favourable.	• Offspring are genetic clones. A negative mutation can make asexually produced organisms susceptible to disease and can destroy large numbers of offspring.
• Large colonies can form that can out-compete other organisms for nutrients and water.	• Some methods of asexual reproduction produce offspring that are close together and compete for food and space.
• Large numbers of organisms mean that species may survive when conditions or the number of predators change.	• Unfavourable conditions such as extreme temperatures can wipe out entire colonies.
• Energy is not required to find a mate.	

Human-assisted Cloning

You have learned that a number of asexual cloning methods occur in nature: binary fission, budding, fragmentation, vegetative reproduction, and spore production. In plants that reproduce asexually, each cell has the potential to grow into an identical plant. Because of this ability, researchers can clone plants from cuttings, as discussed earlier in this section. Less complex animals such as sponges, hydras, and worms can clone themselves by asexual methods. Unlike less complex animals and plants, more complex, multicellular animals lose this cloning ability as their cells become specialized. In order for cloning to take place, human assistance is required.

Human-assisted plant and animal cloning can be used to save the genetic information from endangered animal species or to mass-produce an organism with a desired trait. For instance, in British Columbia, researchers are working to clone pine trees that are naturally resistant to the mountain pine beetle (Figure 5.31).

Explore More

Cloning can also be used to produce pigs whose organs are used for human transplants. Find out more about different types of cloning. Begin your research at **www.bcscience9.ca.**

Figure 5.31 Many forests of lodgepole pines have been killed by mountain pine beetles. Some trees have been able to produce enough sticky resin to keep the pest from boring deep inside the tree. Planting clones of these particular trees might stop the destruction of pine forests.

Reproductive cloning

Reproductive cloning is also called adult DNA cloning. The purpose of this type of cloning is to produce a genetic duplicate of an existing or previously existing organism with desirable qualities. For example, if you have a cow that produces a lot of milk, you might want to clone this particular animal. Since all the cow's cells have become specialized, you cannot turn just any body cell—say, a skin cell—into another individual. However, you could take the nucleus from the skin cell and put it into an egg cell that has had the nucleus removed.

The method used to clone Dolly, the world's most famous cloned sheep, transferred the nucleus from a mammary gland cell into an egg cell without a nucleus (Figure 5.32). The fused cell was then transplanted into a surrogate (substitute) mother, and Dolly was eventually born. A problem with this process is that only 10 percent of clones usually survive. Also, the surviving clones can be abnormally large and have higher rates of infection and cancer. Dolly lived for only six years, dying of a lung disease common in sheep. Before her death, she appeared to be aging faster than sheep usually do.

internet connect

Try simulating the cloning process yourself by going to **www.bcscience9.ca**.

Therapeutic cloning

Therapeutic cloning is used to correct health problems. ("Therapeutic" means to have healing ability.) Both human embryonic stem cells and adult stem cells can be used for this purpose. **Stem cells** are cells that have the potential to become many different types of cells. **Embryonic stem cells** are more desirable for therapeutic cloning because they can become any one of our 200 types of body cells.

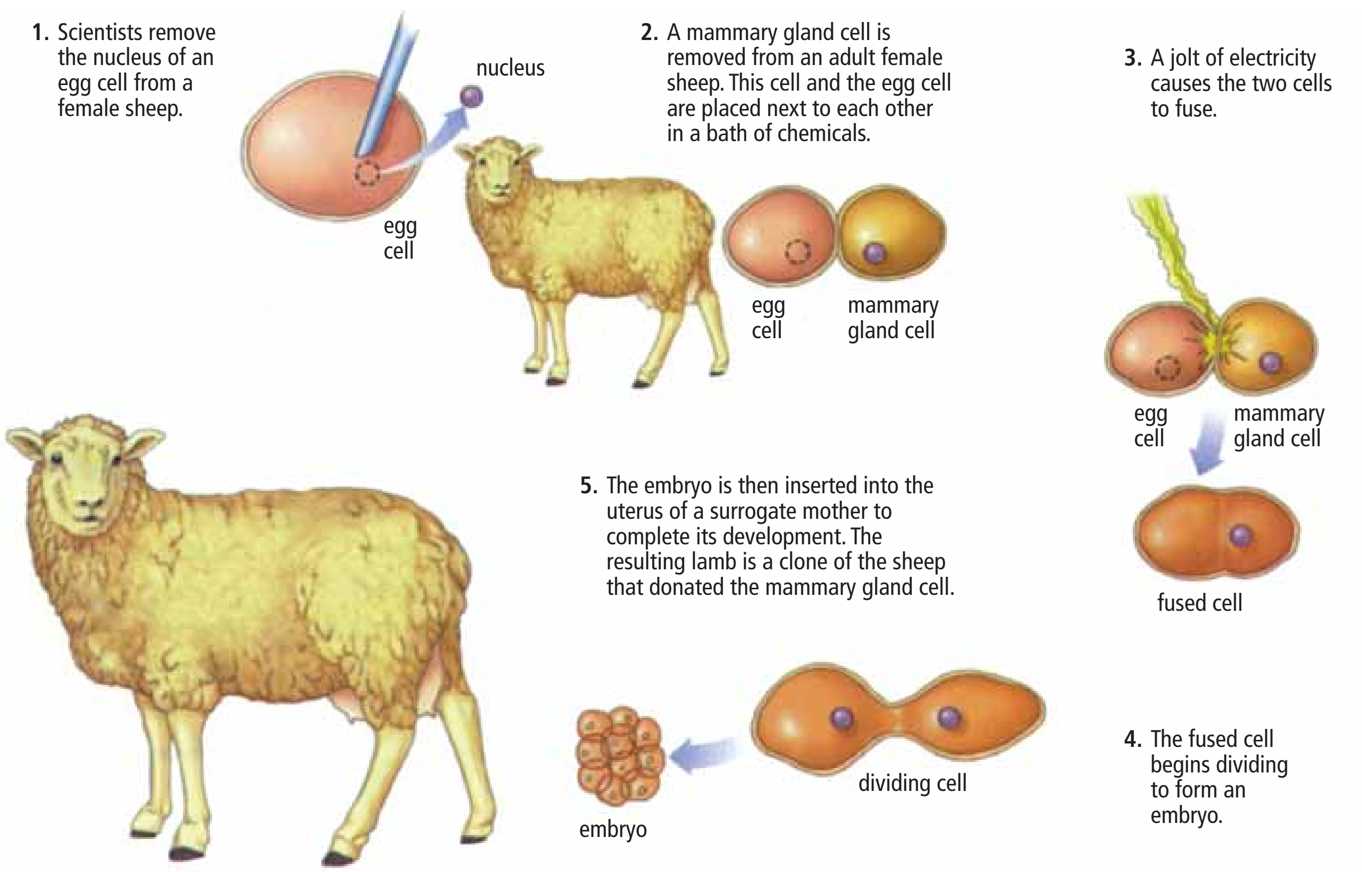


Figure 5.32 The reproductive cloning process

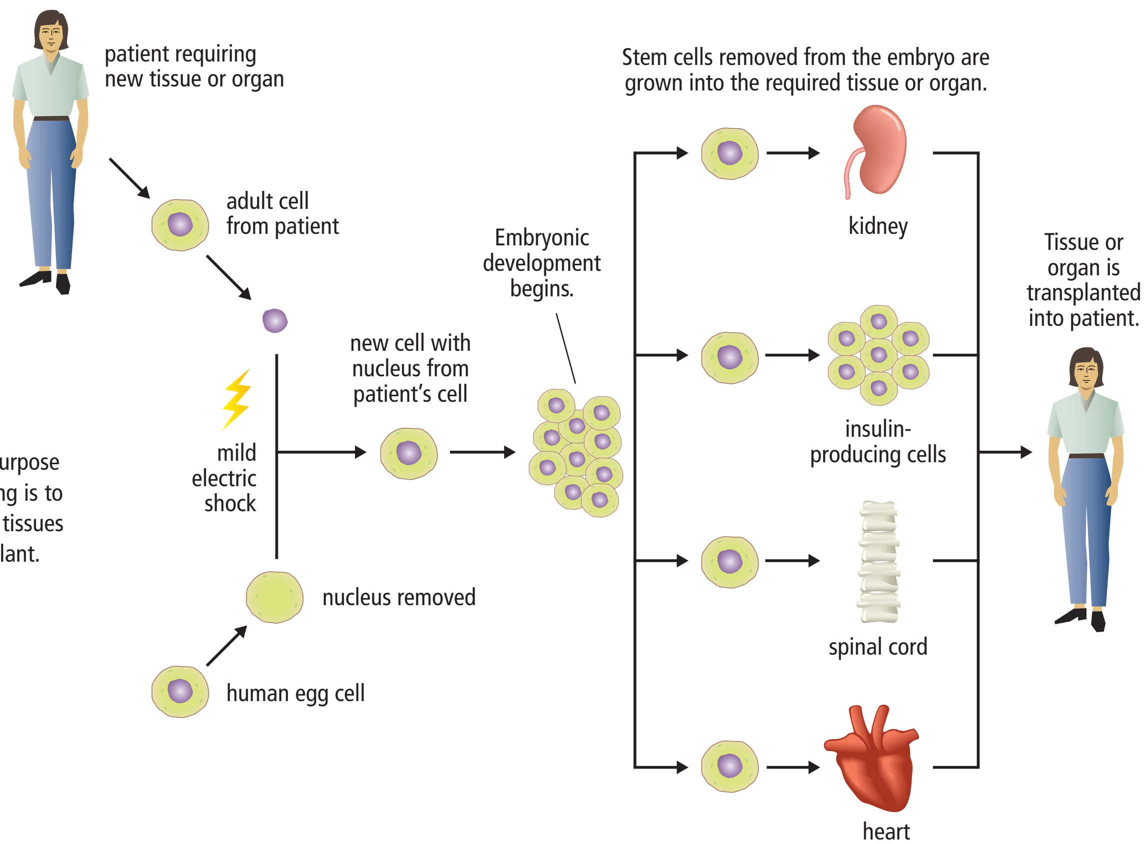


Figure 5.33 The purpose of therapeutic cloning is to produce specialized tissues or organs for transplant.

Did You Know?

Canadian biophysicist James Till and hematologist Ernest McCulloch were the first scientists to identify stem cells. Their research in the 1960s at the University of Toronto explained the underlying principles of bone marrow transplantation, which is now widely used to prolong the lives of patients with leukemia and other blood cancers. By identifying stem cells and investigating their properties, Drs. Till and McCulloch laid the foundation for all current work with both embryonic and adult stem cells.

Stem cells can be used to replace damaged cells in patients with diabetes, spinal injuries, or Parkinson's disease. Since adult stem cells are not as adaptable, embryonic stem cells are often used in therapeutic cloning (Figure 5.33). However, adult stem cells from bone marrow have been used in transplants for 30 years, and recently other kinds of adult stem cells have been used to regenerate nerves and heart tissue and to treat diabetes.

Researchers now believe that adult stem cells may become the basis for many more therapies. Being able to use adult stem cells would eliminate concerns about the use of embryonic stem cells. Some people feel that it is wrong to destroy cells that are able to develop into an individual. As a teenager you do have a very small number of stem cells, but these cells can only become a few different cell types, unlike embryonic stem cells that can become any type of cell.

Reading Check

1. How does binary fission in bacteria differ from binary fission in eukaryotic cells?
2. How does budding in yeast differ from binary fission in amoebas?
3. What is fragmentation?
4. What is plant grafting?
5. What is therapeutic cloning?

5-2B Determining the Best Conditions for Yeast Reproduction

Conduct an INVESTIGATION

Inquiry Focus

SkillCheck

- Observing
- Measuring
- Controlling variables
- Working co-operatively

Safety

- Be careful when handling acids (vinegar) and bases (ammonia).
- Wash your hands thoroughly after doing this investigation.

Materials

Part 1

- petri dish
- 0.5 g yeast
- 1 g sucrose (table sugar)
- 5 mL warm tap water (24–27°C)
- thermometer
- medicine dropper or toothpick
- microscope slide
- cover slip
- microscope

Science Skills

Go to Science Skill 9 for information about how to use your microscope.

Yeast are small single-celled fungi. They obtain energy from sucrose in a process called fermentation. During this process, carbon dioxide and alcohol are produced. Yeast are used to make bread, beer, wine, and cheese. In this investigation, you will first observe yeast budding under the microscope, and then you will conduct two experiments to determine what the optimum conditions are for yeast reproduction. You will consider the effect of nutrients and pH level (acidity and alkalinity) on yeast reproduction. As more yeast are produced, more fermentation will occur. The amount of fermentation that occurs can be compared by collecting the carbon dioxide gas produced. You may conduct all three parts of this investigation, or your teacher may ask you to conduct only one part and report your findings to the rest of the class.

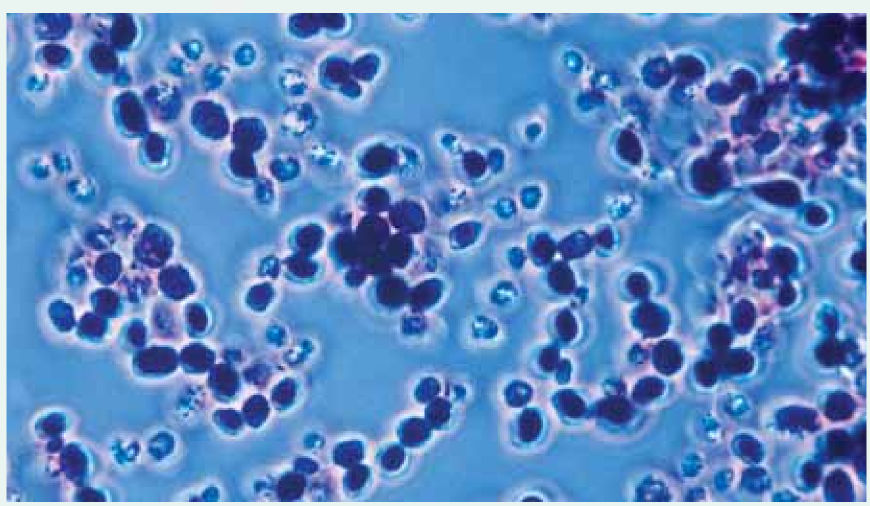
Question

What are the optimum conditions for yeast reproduction?

Procedure

Part 1 Observing Budding in Yeast

1. Place 0.5 g of yeast and 1 g of sugar in a petri dish.
2. Confirm that the water temperature is correct using the thermometer, then add 5 mL warm water and let the dish sit covered on your lab bench for 10 min.
3. Smear a yeast sample on a slide with a toothpick or place a small drop on the slide using a medicine dropper. Cover with the cover slip.
4. Observe the yeast under the microscope using high power. You may need to reduce the light using the diaphragm below the stage.
5. You should see circle-shaped yeast cells. Look for cells that appear to have a little bump on them. Record your observation in a drawing.
6. Clean up and put away the equipment you have used.



Reproducing yeast cells

Part 2

- 4 Erlenmeyer flasks or small glass soft-drink bottles
- wax pencil or marker
- 320 mL hot tap water (40ºC)
- thermometer
- 85 g sucrose (table sugar)
- stirring rods
- 16 g yeast
- four 7.8 cm balloons
- masking tape
- string or thread

Part 3

- 4 Erlenmeyer flasks or small glass soft-drink bottles
- wax pencil or marker
- 320 mL hot tap water (40ºC)
- thermometer
- 20 g sucrose (table sugar)
- stirring rods
- medicine dropper
- 10 mL vinegar
- 10 mL ammonia
- pH paper
- 16 g yeast
- four 7.8 cm balloons
- masking tape
- thread or string

Part 2 Observing the Effect of Nutrients

7. Label the flasks A through D with the wax pencil.
8. Confirm that the water temperature is correct using the thermometer, then add 80 mL of hot water to each flask.
9. Dissolve the following amounts of sucrose in each flask:

   Flask A: 0 g

   Flask B: 5 g

   Flask C: 30 g

   Flask D: 50 g
10. Add 4 g of yeast to each solution and stir.
11. Place a balloon on each flask, and seal it tightly with masking tape.
12. Every 2 min, stir the contents of each flask by swirling it slowly.
13. After 15 min, record your observations in a table (like the one below), and make additional observations every 10 min until no further changes occur. During your observations, describe the fermentation activity in each flask and measure the circumference of each balloon using the string or thread.

Flask	Conditions	Fermentation Observed	Carbon Dioxide Produced*
A	0 g sucrose		
B	5 g sucrose		
C	30 g sucrose		
D	50 g sucrose		

*Measured by the balloon circumference in cm

14. Remove the balloons very carefully as the foam may rise and spill all over you and the lab bench.
15. Clean up and put away the equipment you have used.

Part 3 Observing the Effect of pH

16. Label the flasks E through H with the wax pencil.
17. Confirm that the water temperature is correct using the thermometer, then add 80 mL of hot water to each flask.
18. Dissolve 5 g of sucrose in each flask.
19. Use pH paper to verify the level on the 14-point pH scale as you use the medicine dropper to add drops of vinegar or ammonia as follows:

   Flask E: add enough vinegar to adjust the pH to 3.

   Flask F: add enough vinegar to adjust the pH to 5.

   Flask G: add enough vinegar or ammonia to adjust the pH to 7.

   Flask H: add enough ammonia to adjust the pH to 10.

20. Add 4 g of yeast to each solution and stir.
21. Place a balloon on each flask, and seal it tightly with masking tape.
22. Every 2 min, stir the contents of each flask by swirling it slowly.
23. After 15 min, record your observations in a table (like the one below), and make additional observations every 10 min until no further changes occur. During your observations, describe the fermentation activity in each flask and measure the circumference of each balloon using the string or thread.

Flask	Conditions	Fermentation Observed	Carbon Dioxide Produced*
E	40°C + pH 3		
F	40°C + pH 5		
G	40°C + pH 7		
H	40°C + pH 10		

*Measured by the balloon circumference in cm

24. Remove the balloons very carefully as the foam may rise and spill all over you and the lab bench.
25. Clean up as instructed by the teacher, and put away the equipment you have used.

Analyze

1. Describe what you saw that indicated yeast reproduction.
2. Which flasks showed the greatest rate of yeast reproduction?
3. Compare the contents of the flasks at the beginning of Part 2 and at the end of Part 2. Were they the same? Explain.
4. Compare the contents of the flasks at the beginning of Part 3 and at the end of Part 3. Were they the same? Explain.
5. What conditions were the least favourable for reproduction?
6. Describe the controls that were used in this investigation.

Conclude and Apply

1. Design an experiment to test the effect of temperature on yeast. Write out a list of materials and a procedure. If time permits, the teacher may allow you to carry out your experiment.
2. Draw bar graphs to compare the balloon circumference with changing nutrient concentration. On the same graph, using different colours, draw bar graphs comparing the balloon circumference with changes in pH.
3. If a baker wanted to maximize the rising of a batch of bread, what suggestions would you give the baker?

Science Watch

Living Glue

Scientists at the University of British Columbia are working to create a living glue. In the future, surgeons will use this glue to cushion and attach artificial joints and bones damaged by age or sport injuries.

People receiving hip replacements will benefit most from this new biotechnology. Hip replacements often fail over time because the acrylic glue used to attach the prosthetic joint breaks down the tissue around the joint. Such tissue damage causes inflammation and pain. To repair a failed hip replacement, a second surgery is required. This second surgery packs the area around the joint with bone chips taken from cadavers (dead bodies). Bone chips are in limited supply and can cause infection.

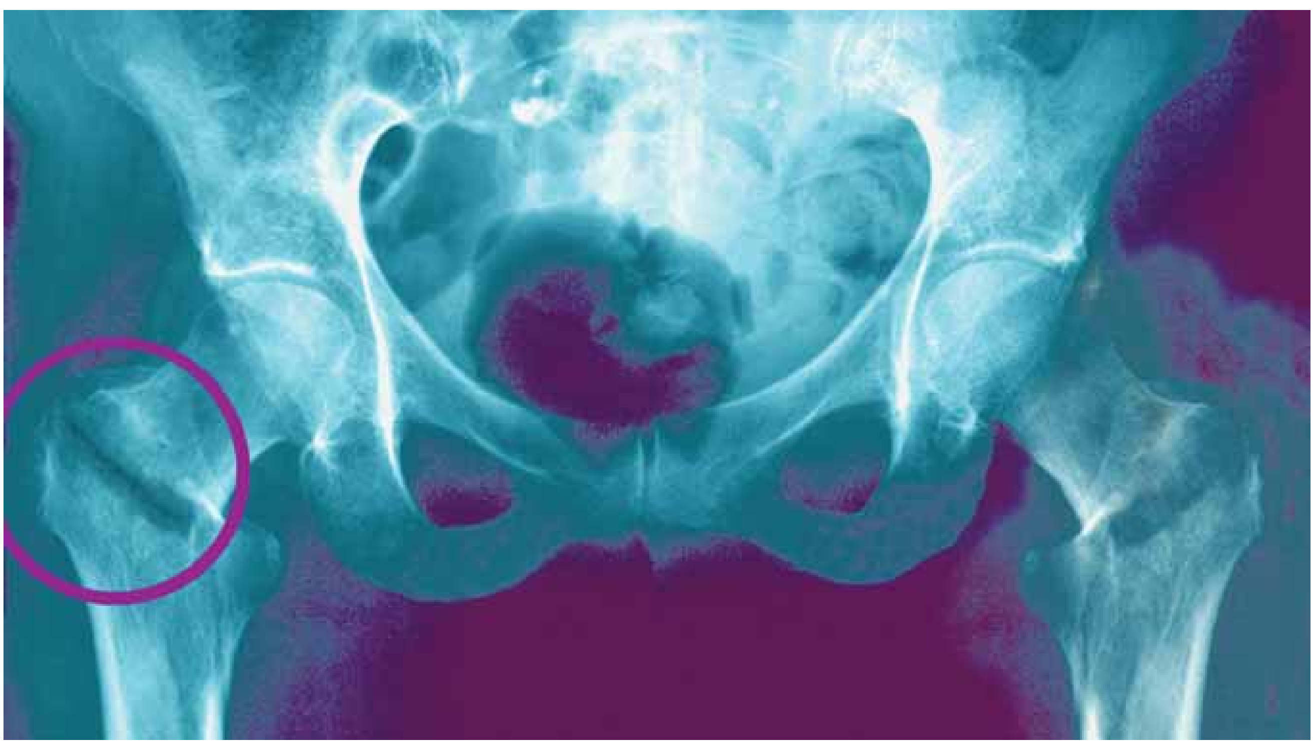
Researchers are developing tiny sponges made of biodegradable material that will act as scaffolds, or frames, for stem cell growth. Stem cells can be obtained from the patient's own bone marrow. They are then mixed with minerals and other materials that will encourage cell growth and tissue attachment to the prosthetic joint or bone.

For this technology to be successful, sponges that form the frame must contain holes. These holes provide room for bone marrow stem cells to grow and divide. The chemicals used in the frame must not kill the cells. The frame itself must be able to bear the weight of the artificial hip joint implants. Once the bone marrow stem cells have grown and become attached to the prosthetic joint, the frame must disintegrate because it is no longer needed.

About 20 000 hip replacement surgeries are performed annually in Canada with a failure rate of 10 percent. Researchers at the University of British Columbia hope that human clinical trials can begin using their living glue in the near future.

Questions

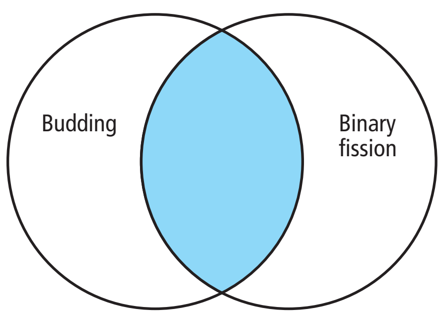
1. Why do hip replacements fail?
2. Why do you think it is important to obtain stem cells from the patient and not someone else?
3. What concerns must be addressed if the sponge frame is to be successful?



Check Your Understanding

Checking Concepts

1. Match the following types of asexual reproduction with the examples in parts (a) to (e).
   A. binary fission
   B. budding
   C. fragmentation
   D. vegetative reproduction
   E. spore formation
   (a) reproduction that begins as an outgrowth of the parent, then separates to become an independent organism
   (b) bacteria
   (c) hydra
   (d) an animal that grows from a piece that has separated from the parent
   (e) a reproductive cell that may be able to survive extreme conditions
2. Draw a Venn diagram like the one below to compare and contrast budding and binary fission.



3. List two multicellular organisms that reproduce by budding.
4. List three ways plants can reproduce asexually.
5. Explain why organisms that reproduce asexually often produce large numbers of offspring.
6. How do some spores survive unfavourable conditions?

Understanding Key Ideas

7. There is a bacterium on the laboratory bench beside you. What do you think limits the number of times the bacterium will divide?
8. Why are most multicellular organisms unable to reproduce by budding?
9. Explain why bacteria do not undergo mitosis.
10. How are embryonic human stem cells like plant cells?
11. Sea stars are able to attach to oysters, pry open their shells, and eat the insides. Oyster farmers once tried to destroy sea stars by cutting them into pieces and throwing them back into the ocean. Predict what happened.
12. Why do you think boaters are asked to clean weeds off their motors before entering and after exiting a water body?
13. What are the advantages and disadvantages of asexual reproduction?
14. Draw a Venn diagram to compare and contrast reproductive and therapeutic cloning.

Pause and Reflect

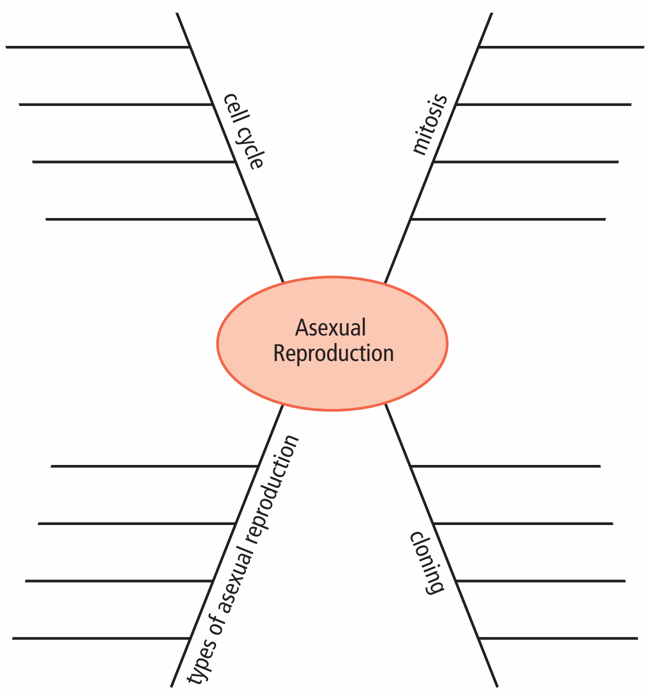
Imagine that you had a clone of yourself. Do you think that the clone would think and behave identically to you? Give reasons for your answer.

Chapter 5

Chapter Review

Prepare Your Own Summary

In this chapter, you investigated the cell cycle, mitosis, and how cells and organisms reproduce asexually. Create your own summary of the key ideas in this chapter by making a spider map. Copy the following spider map into your notebook. Beside each idea, fill in as many words as you can related to that idea. When you have completed the map, go back through the chapter and look for other words you could include. Add these words to the map using a different colour of pen.



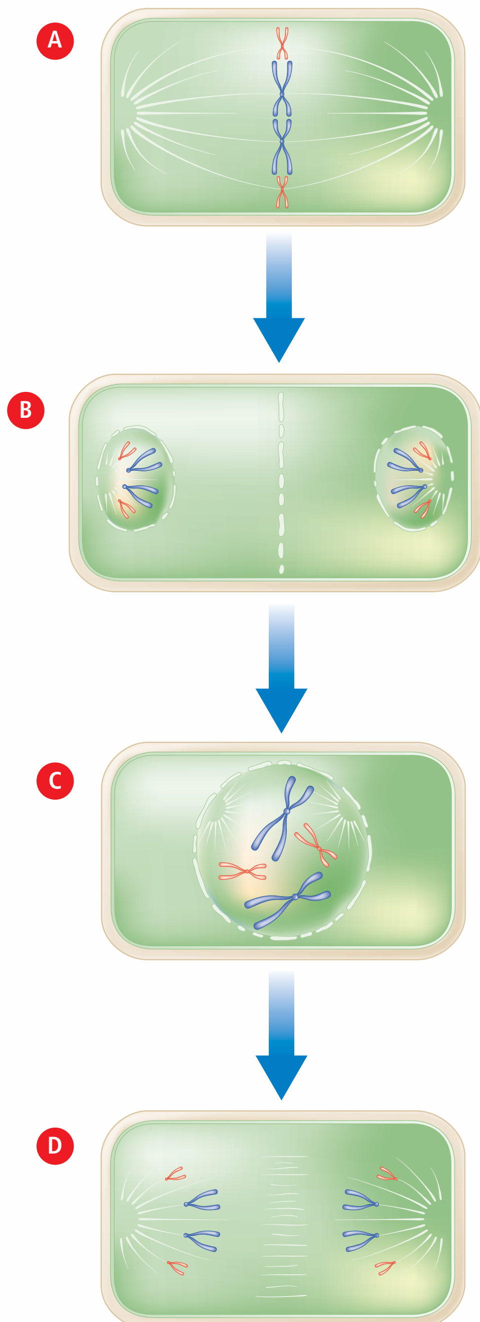
Checking Concepts

1. Why is cell division necessary in unicellular organisms?
2. Why is cell division necessary in multicellular organisms?
3. What are the three stages of the cell cycle?
4. Cells spend much of their time in interphase. What is occurring during this stage?
5. There are checkpoints in the cell cycle. What events must occur in the cell to prevent each checkpoint protein from sending a message to the nucleus to destroy the cell?
6. What would happen if a cell was unable to make protein to form spindle fibres?
7. What can occur if there is a mutation in a checkpoint protein?
8. How does binary fission result in bacteria becoming resistant to antibiotics?
9. Design a chart listing the stages of the cell cycle. For each stage, describe one important event.
10. Design a chart listing the phases of mitosis. For each phase, describe one important event.
11. Make a sketch to illustrate how mitosis in plant cells differs from mitosis in animal cells.
12. What is the major disadvantage of asexual reproduction?
13. Give three reasons for human-assisted cloning.
14. What is reproductive cloning?
15. What are stem cells?

Understanding Key Ideas

16. What are two characteristics of asexual reproduction?
17. Why must the nuclear membrane disintegrate during prophase?

18. Look at the following cells.
    (a) What type of cells are they?
    (b) Explain how you know.
    (c) Write down the correct sequence of letters to show the phases of mitosis.
    (d) Write down the name and a brief description of each phase.



19. Explain what might happen if the chromosomes did not separate correctly during anaphase.
20. How do cancer cells spread to a new location?
21. How do blood vessels help cancer cells to multiply?
22. A laboratory technician is observing some cells under a microscope. What might she look for to determine if any of the cells are cancer cells?
23. Only less complex forms of animal life can reproduce by asexual reproduction. Why?
24. Why are there concerns about stem cell research?
25. How might a scientist determine the best conditions for reproduction for an amoeba?
26. How might therapeutic cloning be used in the future?

Pause and Reflect

As we learn more about cell reproduction, technologies such as human-assisted plant and animal cloning will become much more widely available. Who should control access to these technologies: government, business, or only people who can afford them?