6.2 Sexual Reproduction

In sexual reproduction, a male gamete (sperm cell) must fertilize a female gamete (egg cell). As a result of meiosis and the union of sperm and egg cells, no two individuals will have the same DNA, except identical twins. Many aquatic animals reproduce through external fertilization. Most land animals reproduce through internal fertilization. Following fertilization, the zygote and embryo start to divide by mitosis, and cells will differentiate.

Words to Know

differentiation
embryonic development
external fertilization
internal fertilization
mating

Figure 6.14 The purple sea urchin has been used extensively in scientific research.

Purple sea urchins are familiar sights along the coast of British Columbia (Figure 6.14) and are one of the most useful models for scientific research. In fact, the sexual reproductive process of the sea urchin has been studied for decades, enabling scientists to gain a greater understanding of how animal sperm cells and animal egg cells meet and result in fertilization.

In Chapter 5, you learned that asexual reproduction requires only one parent and can occur wherever that parent is located if conditions are favourable. Sexual reproduction requires two parents who must bring two gametes together for fertilization to occur. To survive, sexually reproducing species must mate with members of their own species. For years, scientists wondered how different types of sea urchins living close together were able to accomplish sexual reproduction within their own species, since sea urchins bring gametes together by releasing great clouds of sperm and egg cells into the water.

Scientists wondered just how the sperm cells of the purple sea urchin were able to fertilize the egg cells of other purple sea urchins and not the egg cells of the green sea urchin, which reproduces in the same ocean waters. Researchers found that the sperm and egg cells of all species of sea urchins have unique proteins on their surfaces. Researchers also found that the surfaces of sea urchin eggs have unique sugars. In order for fertilization to occur, sugar-protein recognition must occur. In other words, fertilization in a particular species of sea urchin will occur only if the right sugar meets the right protein of that species.

Because sea urchin eggs are transparent, scientists can observe the changes that occur within the egg after fertilization to study how the fertilized egg begins to develop (Figure 6.15). Scientists can use these observations to gain a better understanding of fertilization among other animals.

Did You Know?

Molecular biologists at Simon Fraser University and the Michael Smith Genome Sciences Centre in Vancouver participated in an international study to map the genome of the purple sea urchin. They discovered that the sea urchin has many of the same genes as humans, including those linked to diseases such as hardening of the arteries, muscular dystrophy, and several brain disorders.

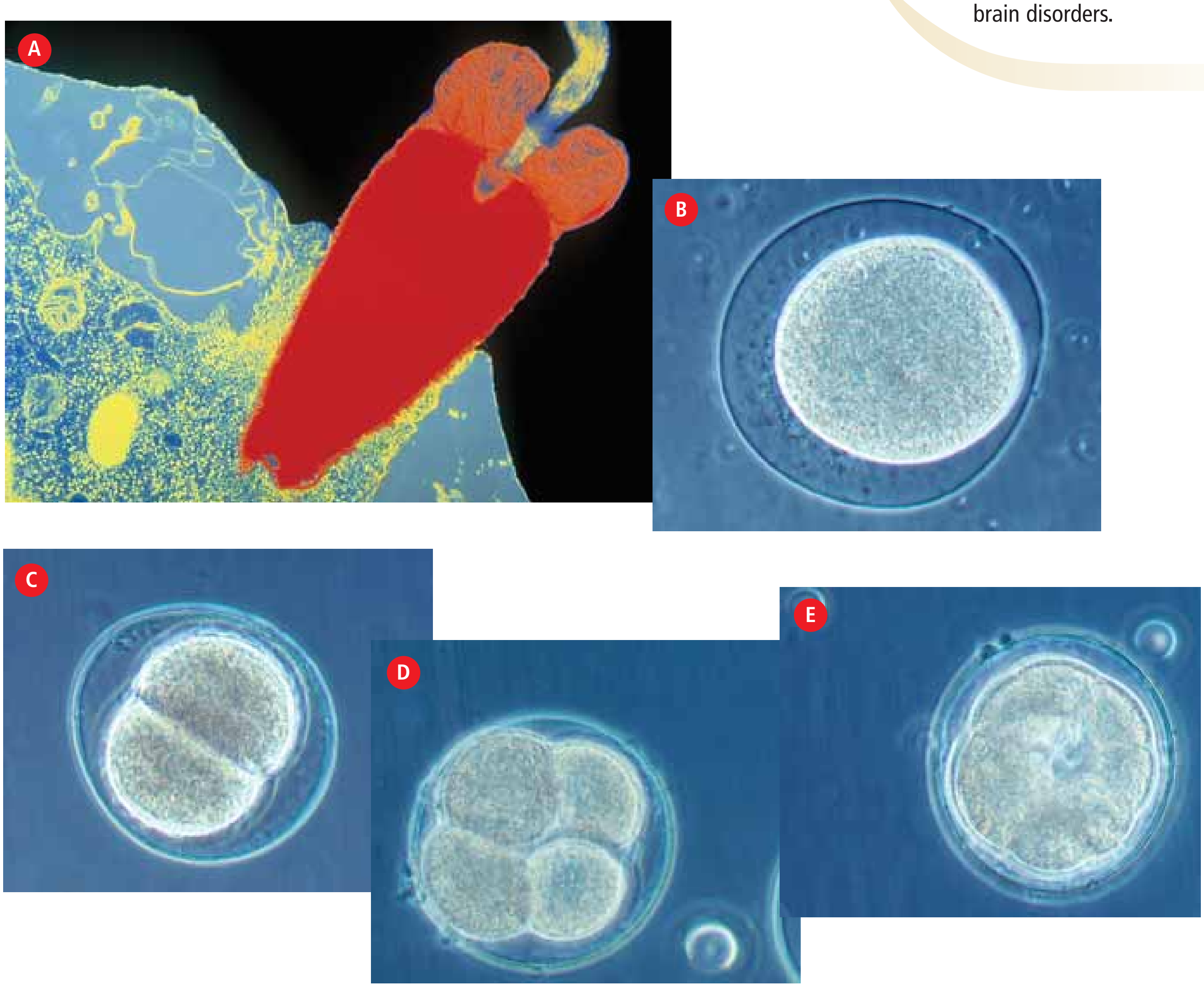

Figure 6.15 This series of photographs shows the process of fertilization and early development in the sea urchin (A to E). Sea urchin egg cells are the same size as human egg cells. Their size and transparency make them a model organism for the study of reproduction in humans and other animals.

Sexual Reproduction

In section 6.1, you learned how male and female gametes are formed and how meiosis produces gametes that are not genetically identical. Sexual reproduction is the process that brings these non-identical gametes together to form a new organism. Sexual reproduction has three stages: mating, fertilization, and development.

Mating

Mating is the process by which gametes arrive in the same place at the same time. Many animals have mating seasons that take place at certain times of the year to ensure that environmental conditions will be favourable for the development of their offspring. For example, sheep, goats, and deer mate in the fall and winter so that their offspring will be born in the spring when conditions are less harsh. Horses mate in the summer, but because the time between fertilization and birth is longer in horses, their offspring are also born in the spring.

Mammals mate on land or in water, depending on the species. Land-dwelling mammals such as mountain goats mate in mountainous areas. Their offspring are often born on very narrow ledges or steep slopes, which provide protection from predators (Figure 6.16).

Figure 6.16 Young mountain goats are born with the ability to run easily over steep and rocky ground to keep up with their mothers.

Water-dwelling mammals such as orcas mate in the ocean and usually produce one offspring about every five years (Figure 6.17 on the next page). New research by the Vancouver Aquarium Marine Science Centre indicates that resident orcas (whales that always visit the same locations) usually mate with partners that have different vocal calls from those of their birth group. Choosing a partner with a different vocal call increases the likelihood that the partner has different genes. Therefore, this mating pattern may result in genetic variation among resident orca groups.

Figure 6.17 Young orcas swim very close to their mothers for protection.

Methods of Fertilization

For sexually reproducing animals and plants, there are two ways for the union of sperm and egg cells to occur—through either external fertilization or internal fertilization.

Once the egg is fertilized, cell division will occur only if certain conditions are met.

- There must be enough nutrients for the rapidly dividing embryo.
- The temperature must be warm enough so that proteins and enzymes will function properly during chemical reactions in the developing embryo.
- There must be sufficient moisture so that the embryo does not dry out.
- The embryo must be protected from predators and from other environmental factors such as ultraviolet radiation. (You will learn more about human embryonic development on page 216.)

External fertilization

In **external fertilization**, a sperm cell and an egg cell unite outside the bodies of the parents. If a sperm cell comes in contact with an egg cell of the same species, fertilization may occur. External fertilization is common in animals that live in the water. Both sea urchins and fish such as salmon use this method. The males and females of both species release their gametes into the water in a process called spawning. Figure 6.18 shows a short-spined sea urchin spawning.

The female sea urchin produces several million eggs per year, and the reproductive organs of a sea urchin can be up to 80 percent of a sea urchin's mass during mating season.

Figure 6.18 A short-spined sea urchin releases a cloud of eggs.

Because sea urchin eggs are fertilized outside the body of the female, not all of the eggs will be fertilized. Often, egg cells do not survive ocean storms that disturb the tide pools and coral reefs in which sea urchins live. The sea urchin also has many predators, so even if the eggs are fertilized the developing embryos or developing young are frequently eaten. Figure 6.19 shows the life cycle of a sea urchin, which begins with external fertilization.

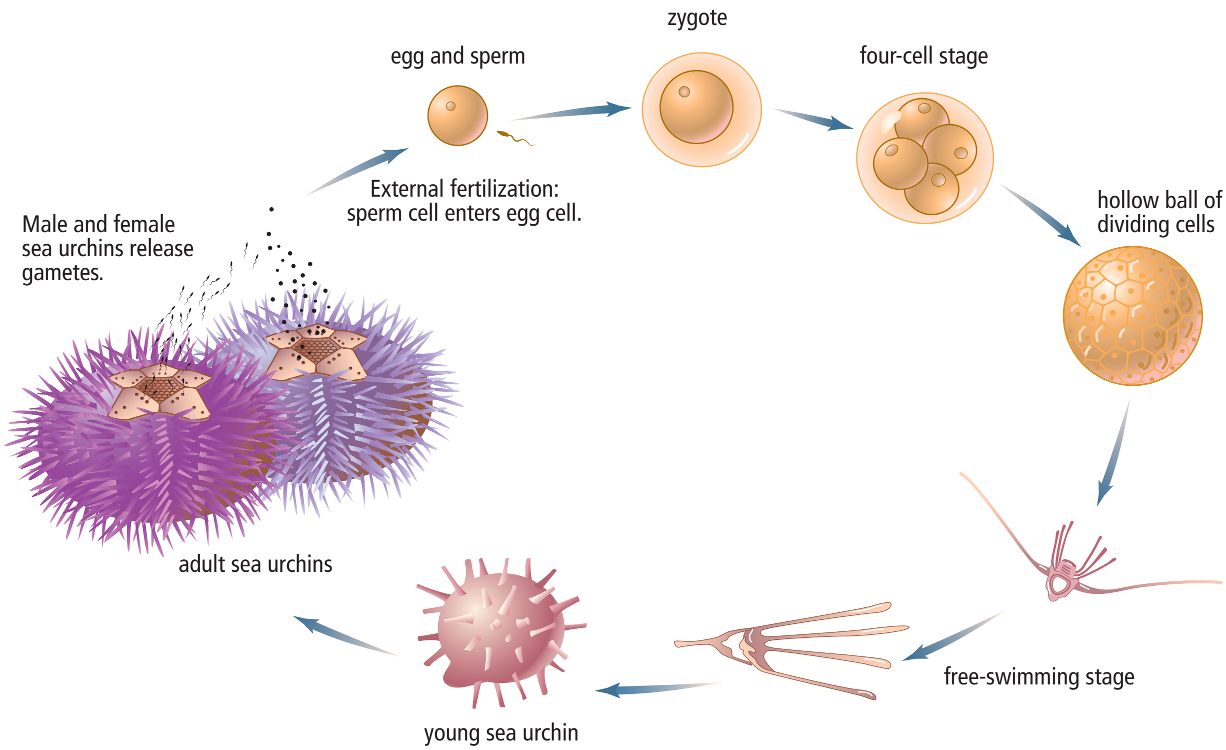

Figure 6.19 The life cycle of the sea urchin. Many water-dwelling animals that rely on external fertilization have a similar life cycle.

External fertilization for salmon takes place in the gravel beds of rivers and streams (Figure 6.20A on the next page). With sweeping movements of her tail, the female salmon digs out a gravel nest. The male swims by and releases his sperm as the female deposits her eggs. Both the male and female salmon die after spawning (Figure 6.20B on the next page).

Figure 6.20A Spawning sockeye salmon

Figure 6.20B Eggs are deposited during spawning, and the adults die soon afterward.

External fertilization can also occur in plants such as mosses and ferns (Figure 6.21). Since many of these plants live in moist environments, water transports their gametes, enabling sperm cells and egg cells to meet.

Figure 6.21 Mosses live in moist environments.

External fertilization provides an advantage because very little energy is required to find a mate, and large numbers of offspring are produced at one time. The ability to produce many offspring at once means that some individuals of a population may survive to reproduce in the event of an environmental disaster such as an oil spill that kills off most of the population. Since offspring are usually widely spread out, they do not compete with their parents for food. In addition, there is little chance that the egg from an offspring will be fertilized by the sperm of a parent, so genetic variation will be maintained.

There are, however, some disadvantages to external reproduction. Although millions of gametes are released, many will not survive outside the parents' bodies or meet to result in fertilization. Since zygotes and embryos form outside of the parents' bodies, they are unprotected and often preyed upon. In addition, since parents do not care for their offspring, few survive to adulthood.

Internal fertilization

Water-dwelling orcas and most land-dwelling animals, such as mountain goats and humans, reproduce by **internal fertilization**. In internal fertilization, sperm cells are deposited inside the female's body where they meet an egg cell. In humans, more than 100 million sperm cells are deposited at one time, but only about 100 sperm cells will meet a single human egg (Figure 6.22). Once a single sperm has penetrated an egg cell, the egg cell membrane changes its electrical charge, which produces chemical reactions that prevent any more sperm from entering the egg. A similar process occurs in all sexually reproducing animals, and all animals have a similar life cycle (Figure 6.23). As in external fertilization, preventing the entrance of more than one sperm ensures that only one set of male chromosomes can unite with chromosomes in the nucleus of the egg cell.

Figure 6.22 In internal fertilization, gametes meet inside the female's body. Only one sperm cell will fertilize the egg cell.

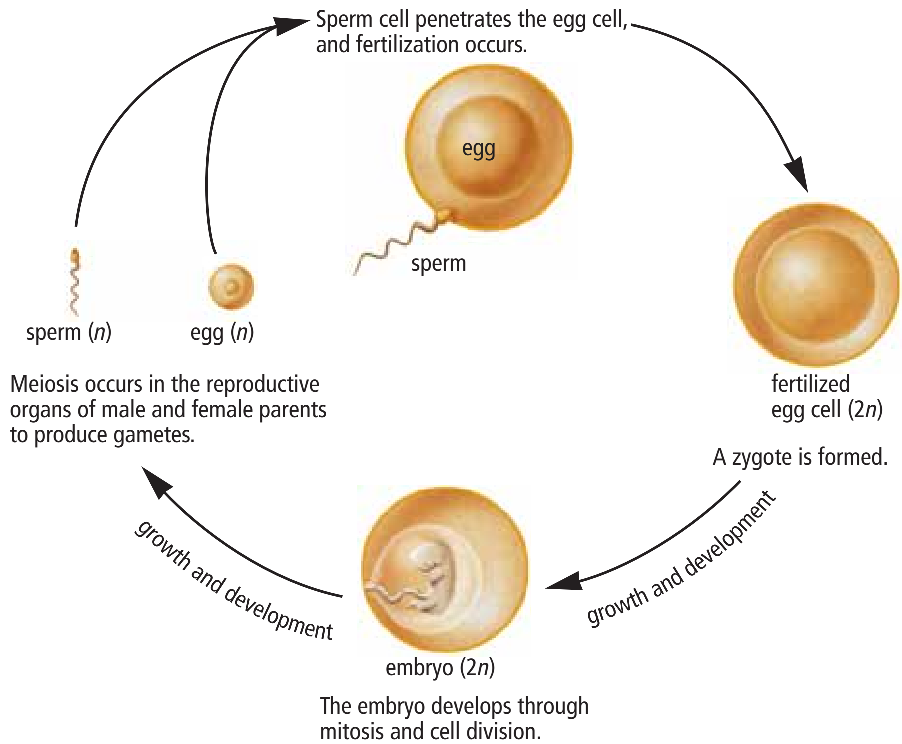

Figure 6.23 The life cycle of animals

In internal fertilization, the embryo develops and is nourished inside the mother's body for a period of time. This stage of internal development also means that the embryo is protected from predators.

After the offspring are born, most mammals continue to protect their young for months or years (Figure 6.24 on the next page). In animals that lay eggs, such as the mallard duck and the grass snake (Figure 6.25 on the next page), eggs are protected by the mother as they develop outside the mother's body.

Figure 6.24 Mountain lion cubs learn from their mothers how to survive in the wild. Generally, cubs stay with their mothers for about two years.

Figure 6.25 A grass snake guards her eggs.

Figure 6.26 Male sage grouses puff themselves and put on a lively dance performance to attract females. Such mating behaviour uses a great deal of energy.

Internal fertilization provides an advantage because more offspring survive as a result of embryo protection and parental care. However, internal fertilization requires more energy to find a mate. Some animals, such as the blue grouse (found in British Columbia) and the sage grouse (found on the Prairies), have complex mating behaviours that require large amounts of energy (Figure 6.26). Internal fertilization also results in the production of fewer zygotes compared with external fertilization.

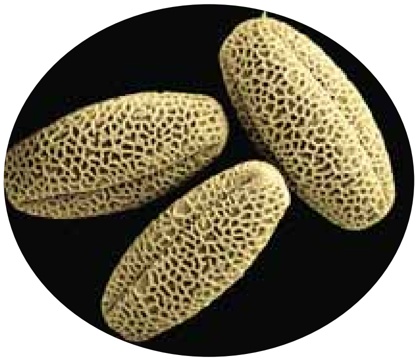

Figure 6.27 Pollen grains enlarged approximately 1900×

Pollination

In most plants, internal fertilization is achieved through a process called pollination. **Pollination** is the transfer of male gametes in structures called **pollen** (Figure 6.27) from the male reproductive part of a plant to the female reproductive part of a plant. Pollen grains carry the sperm cells in a protective case to the **ovules**, which are the female plant structures that contain the egg cells. Figure 6.28 shows the main reproductive structures of a flowering plant. The reproductive organ of the male is the stamen. The reproductive organ of the female is the pistil.

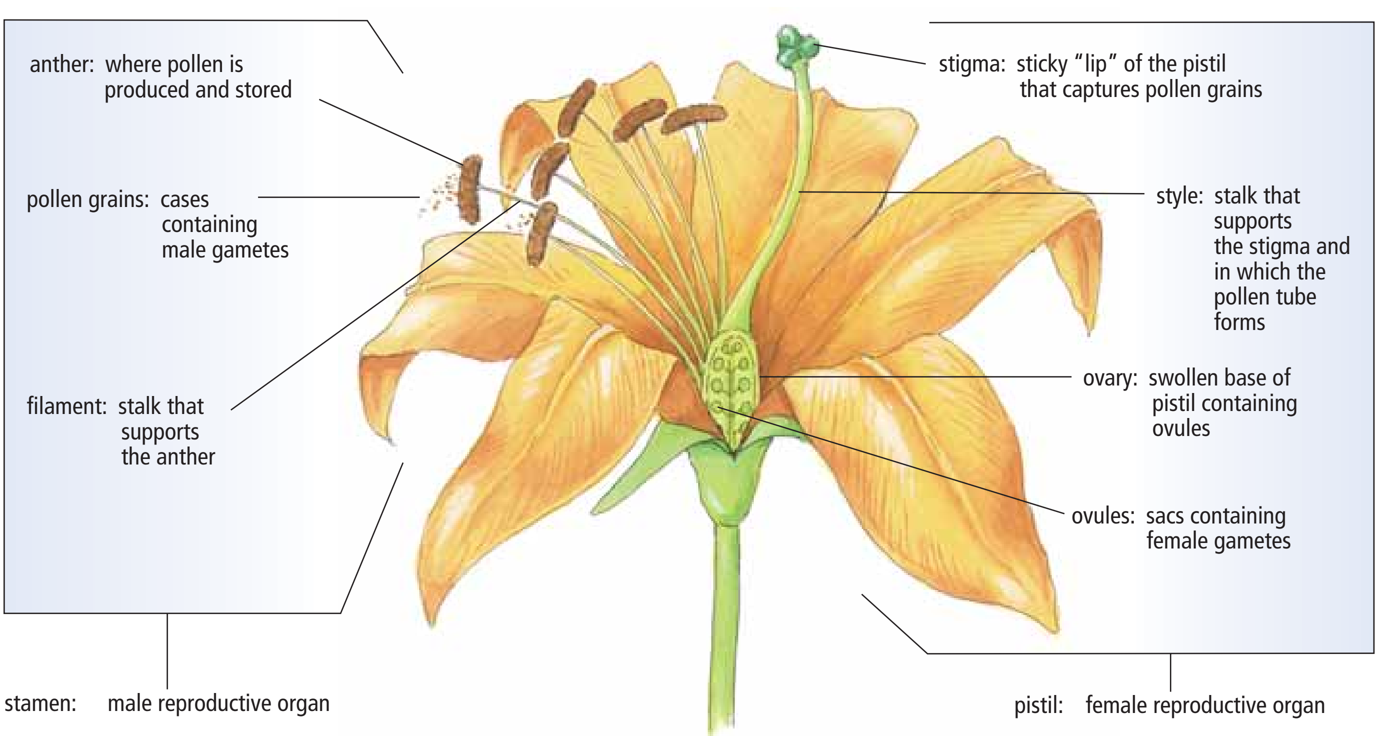

Figure 6.28 The reproductive structures of a flowering plant

After the pollen lands on the female part of the plant, a **pollen tube** forms, which is a structure that delivers the sperm cells to the egg cells (Figure 6.29 on the next page). Following fertilization, a zygote grows into an embryo and is nourished by food stored within the seed in which the embryo grows. The seed's tough outer coating protects the developing embryo.

Figure 6.29 The pollen tube of a winter jasmine flower

Colourful flowers can attract bees and other insects that feed on plant sugars (nectar) and pollen. Bees collect pollen and nectar to feed themselves and their young. Special hairs on their hind legs and abdomen allow them to collect large amounts of pollen in pollen baskets. Since bees visit many flowers before returning to their hives or nests, they often transfer pollen between flowers of the same species (Figure 6.30). This is why bees are called pollinators. Other animals, such as fruit bats, can also pollinate flowers when they drink the nectar and eat the pollen of particular flowers.

Bats are less attracted by the colour of the flowers, since they visit plants at night. Some researchers think that certain flowers visited by nectar-sipping bats may offer extra calcium, which would be helpful to female bats who are still feeding their young.

Figure 6.30 A honeybee gathers pollen from a blanket flower.

internet connect

Bees are attracted to flowers not only for their pollen and nectar. Bees can increase their body temperature by seeking out certain flowers that generate heat energy. To find out more about this relationship, go to **www.bcscience9.ca.**

Pollen transport

Some flowering plants such as willow, hazelnut, and aspens have flowers that do not have petals. Plants like these release their pollen into the air so that the wind can carry the pollen to the female reproductive parts of other flowers (Figure 6.31).

Genetic variation in flowering plants is maintained because seeds are often enclosed in a fruit that can be transported away from the parent plant by animals who eat the fruit. Since many seeds have a tough outer coat, they are often not digested by animals. As a result, the embryo may survive, grow, and reproduce away from the parent.

Figure 6.31 A willow tree releases pollen into the air.

Figure 6.32 The female cones of a Douglas fir tree. Pollen is released from the male cones.

Plants such as Douglas fir trees do not have flowers. Instead, sperm and egg cells are produced in male and female cones (Figure 6.32). Such cone-bearing plants are called conifers. Pollen is released from the male cones and is carried by the wind to the female cones. The embryo is protected within seeds in the female cone and completes its development there. The winged seeds that are eventually released are often transported by birds and small animals to new locations.

Since genes are reshuffled in meiosis during the production of egg and sperm cells, new Douglas fir trees may be resistant to disease or insect infestation. As a result, trees that survive with these favourable characteristics can pass them on to their offspring.

Reading Check

1. Egg and sperm cells have substances on their surfaces that aid in species identification. What are these substances?
2. What is the method of fertilization for land-dwelling animals?
3. What is the method of fertilization for water-dwelling animals?
4. What is pollination?
5. What can be found inside a seed?

6-2A Predict a Pollinator

Find Out ACTIVITY

Flowering plants require pollination for sexual reproduction to occur. Since flowers differ in size, colour, and shape depending on the species, they must be able to attract different types of pollinators. In this activity, you will predict what type of pollinator is needed for each flower shown in the photographs below.

What to Do

1. Look at each of the photographs below and read the captions. Use this information to predict what type of pollinator is needed for each flower.
2. Record your predictions and explain why the predicted pollinator is suited to each flower.
3. Compare your predictions with those of another classmate.

What Did You Find Out?

1. What are some ways in which flowering plants attract pollinators?
2. Draw a flower that would be attractive to a specific pollinator. Use a different example from the examples given here.

Orchids offer a landing pad for their pollinators.

These white flowers are pollinated at night.

The flowers of these plants are not brightly coloured and do not have a strong odour.

Embryonic Development

The early development of an organism is called **embryonic development**. In humans, embryonic development takes place in the first two months after fertilization. Scientists investigate developing embryos for a number of reasons. Some investigate the process in organisms such as the sea urchin to better understand embryonic development in other organisms. Others study the developing embryo to help them design new technologies to assist in animal reproduction or to cure genetic diseases. Embryologists are specialists in the study of embryos and are experts on the stages of development that follow the fertilization of an egg. The following paragraphs outline the information embryologists must know.

After fertilization, the fertilized egg, or zygote, begins the process of mitosis and undergoes a series of rapid cell divisions. By the end of the first week, the zygote divides many times to form a ball of cells. At this stage, the ball of cells is about 0.2 mm in diameter and is called a **morula**. The next stage of development occurs at the end of the second week when a hollow ball of cells forms, which is called a **blastula**. The blastula is about 1.5 mm in diameter. Figure 6.33 shows the first stages of human embryonic development, which are similar to the early stages of sea urchin development that you saw in Figure 6.15 on page 205.

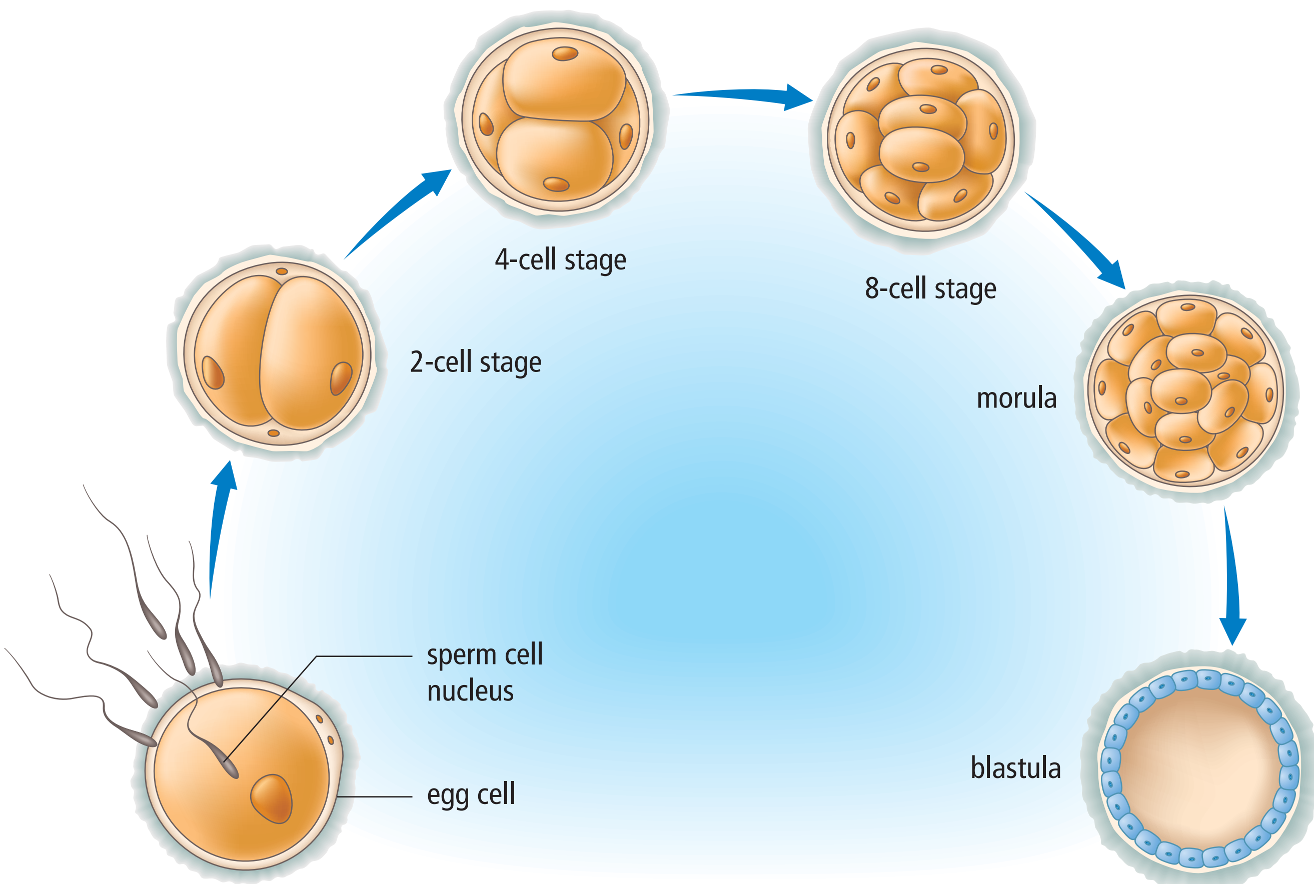

Figure 6.33 Mitosis and cell division are the basis of embryonic development.

At this point in embryonic development, the cells are also known as embryonic stem cells. As you learned in Chapter 5, embryonic stem cells, under the right conditions, can grow into any other type of cell. Scientists have spent decades investigating this ability and have started to develop ways to control which cells embryonic stem cells can produce. For example, scientists recently added a series of chemicals to embryonic stem cells to produce cells that make insulin. For a person with diabetes, this is an exciting discovery. There is now a possibility that the damaged insulin-producing cells could be replaced by healthy insulin-producing cells grown from embryonic stem cells.

In the next stage of development, the cells of the blastula organize themselves into three layers. At this stage, the developing embryo is called the **gastrula** (Figure 6.34). The outside layer of the gastrula is called the **ectoderm**. Cells in this layer will eventually form skin and the nervous system. The middle layer is called the **mesoderm** and will form the kidneys, muscles, blood vessels, reproductive organs, and bones. The inner layer is called the **endoderm** and will form the lungs, liver, and the lining of the digestive system.

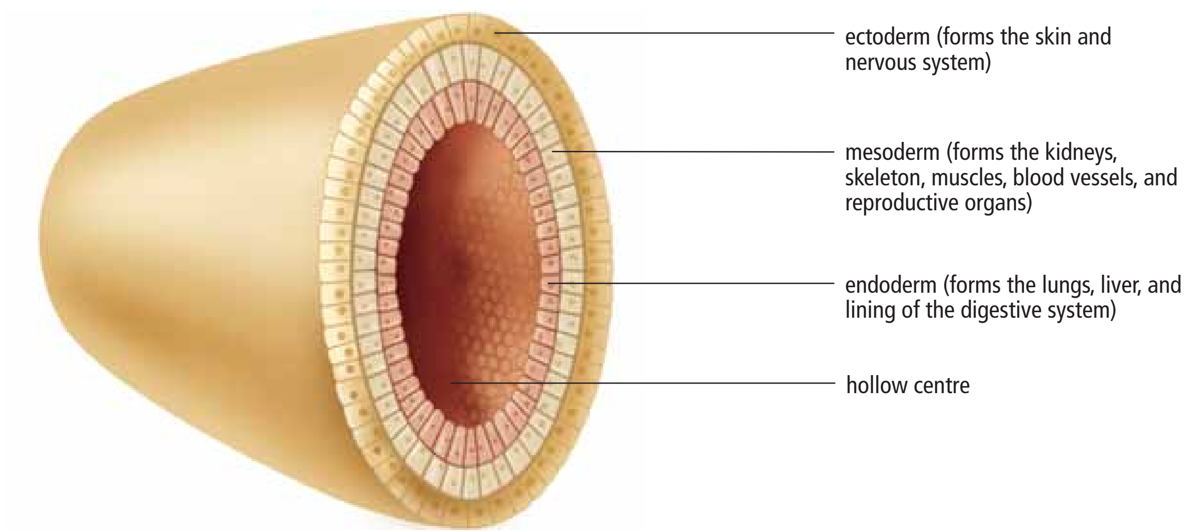

Figure 6.34 In the gastrula, cells are organized in three layers. Cells in these layers will eventually form organs.

Word Connect

The words "ectoderm," "mesoderm," and "endoderm" come from the Greek words meaning outer skin, middle skin, and inner skin.

Explore More

Scientists have been able to extract stem cells from the fluid that surrounds a developing embryo. Find out how this important discovery may help in the repair of tissues and the reproduction of organs for transplant. Begin your research at **www.bcscience9.ca**.

Fetal Development

In Figure 6.34 on the previous page, you saw that in the gastrula stage cells became organized into the ectoderm, mesoderm, and endoderm. In humans, these cell layers will eventually form the organs and tissues of a human baby. This process is called **differentiation**, which continues for a period of 38 weeks. Differentiation is often divided into three periods of time called trimesters. Each trimester is approximately three months long, and major developmental changes occur in each trimester.

First trimester: developing organ systems

During the first trimester, all the organ systems begin to develop and form. At four weeks, the brain and spinal cord are developing (Figure 6.35A). By eight weeks, bone cells are forming (Figure 6.35B), and the embryo is called a **fetus**. By 12 weeks in fetal development, the organ systems have formed (Figure 6.35C). On average, at the end of the first trimester, the fetus is about 28 g in mass and about 9 cm long.

Figure 6.35A The embryo at 4 weeks

Figure 6.35B The fetus at 8 weeks

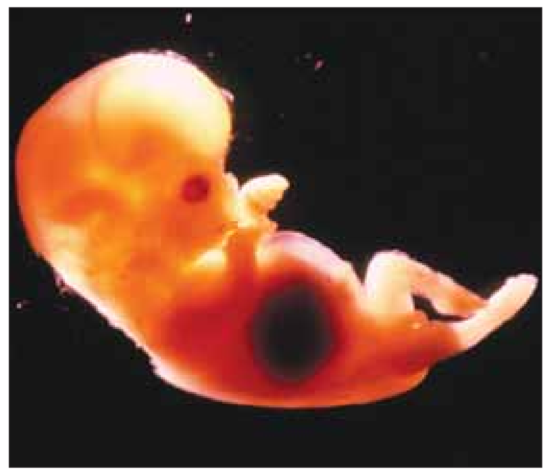

Figure 6.35C The fetus at 12 weeks

Second trimester: growth

The fetus grows rapidly from 12 weeks to 16 weeks (Figure 6.36 on the next page). Then growth slows between 20 weeks and 24 weeks. By 20 weeks, the mother can feel the fetus moving. By the end of the second trimester, the fetus weighs about 650 g and is 35 cm long.

Figure 6.36 The fetus at 16 weeks

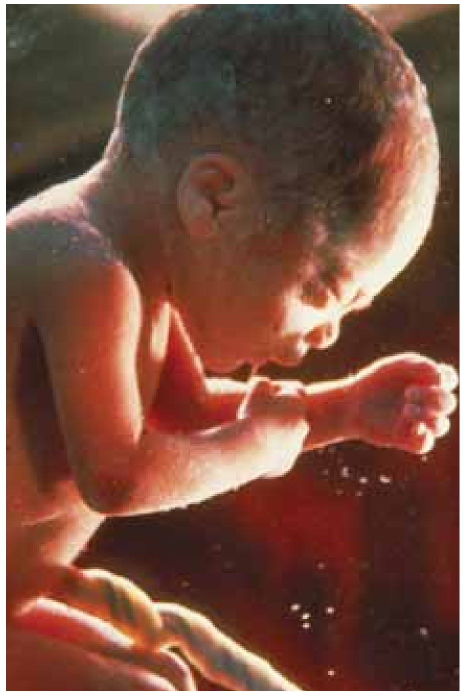

Figure 6.37 The fetus at eight to nine months

Third trimester: continued growth

In the third trimester, the fetus continues to grow in preparation for birth. This includes significant growth of the brain. By 32 weeks, or the eighth month, fat is deposited under the skin to help insulate and keep the baby warm after birth (Figure 6.37). At the end of the third trimester, the fetus weighs approximately 3300 g and is 40 to 50 cm long.

Table 6.1 summarizes some of the major events in fetal development.

Table 6.1 Main Events in Fetal Development

Trimester	Stage	Time from Fertilization	Length of Embryo/Fetus
First	• Brain and spinal cord are forming.	4 weeks	4 mm
	• Digits have appeared. Ears, kidneys, lungs, liver, and muscles are developing.	8 weeks	4 cm
	• Sexual differentiation almost complete.	12 weeks	9 cm
Second	• Fetal movements are felt.	16–18 weeks	20 cm
	• Eyelids open. Fetus can survive outside of the mother with specialized care.	24 weeks	35 cm
Third	• Rapid weight gain occurs due to the growth and accumulation of fat.	26–38 weeks	40–50 cm

internet connect

To follow the week-by-week development of an embryo and a fetus until birth, go to **www.bcscience9.ca.**

Advantages and Disadvantages of Sexual Reproduction

In this section, you have read about how a variety of organisms reproduce sexually. Table 6.2 shows that sexual reproduction has both advantages and disadvantages for their survival.

Table 6.2 Advantages and Disadvantages of Sexual Reproduction

Advantages	Disadvantages
• Very little energy required to find a mate (external fertilization).	• More energy generally required to find a mate (internal fertilization).
• Greater numbers of offspring can repopulate an area after a disaster (external fertilization).	• Fewer offspring produced, so if the number of predators increases a population will decline (internal fertilization).
• More protection is given to the embryo and more parental care is given to offspring (internal fertilization).	• Gametes, embryos, and offspring are unprotected and are often preyed upon (external fertilization).
• Offspring are genetically different from their parents, so they may survive new diseases or other threats that appear in a population.	

6-2B Comparing Sexual and Asexual Reproduction

Think About It

You have been studying asexual and sexual reproduction in various organisms. Now it is time to compare the advantages and disadvantages of these two types of reproduction.

What to Do

1. Working with a partner, locate and review the information in Table 5.1 on page 175 and in Table 6.2 on this page. You may also want to read the text in each section that appears before the tables.
2. Summarize each advantage and disadvantage in a few words and record each summary on a small piece of paper.
3. On top of your desk, organize all your summaries in a way that you believe best demonstrates your understanding of the advantages and disadvantages of asexual and sexual reproduction.
4. Working on your own, transfer your summaries into a graphic organizer of your choice. You may want to add pictures and additional information as needed. (For more ideas on graphic organizers, go to Science Skill 12.)
5. When you are finished, review a classmate's graphic organizer.
6. Add one more idea that you learned from your classmate's work to your own graphic organizer.

What Did You Find Out?

1. Imagine you had to list the advantages of asexual and sexual reproduction in order of importance. What do you think is the most important advantage for each type of reproduction?

6-2C

Comparing Differentiation in Embryos

Find Out ACTIVITY

Some animals have similar patterns of differentiation and development. In this activity, you will compare embryonic development in six embryos.

What to Do

1. Study the diagram below. The embryos are shown at three stages of embryonic development. Predict which series of embryos shows the development of a chicken, fish, human, rabbit, salamander, and tortoise.
2. List and describe three similarities and three differences in development among the embryos shown below.
3. Compare your findings with those of another group.

What Did You Find Out?

1. Were you able to predict which types of embryos are shown in the first stage of development? Explain.
2. At what stage of embryonic development does differentiation become most apparent?
3. Using the information you have learned in this chapter, explain why the organisms shown below appear to be similar in stage 1, but not in later stages of development.

I

II

III

Career Connect

Biologist

Dr. Louise R. Page

How do snails eat? How do they catch their prey? Do young snails feed the same as adult snails? These are questions that intrigue Dr. Louise R. Page, an associate professor of biology at the University of Victoria. Dr. Page teaches university classes and conducts research on slugs and snails to shed light on the evolution of species.

Q. How did you get interested in working with animals?

A. When I was a child, my father sparked my interest in biology. He had little education but was fascinated with animals and how they work. His enthusiasm was contagious.

Q. What are you researching at the moment?

A. My latest research is on the feeding structures of marine snails. I am researching how changes in their development have produced the great variety of forms we see today. Some snails have a simple rasp inside the mouth used for scraping algae off rocks while others have a long proboscis that shoots out quickly to stun prey. How did this complex feeding apparatus evolve from the simple scraping feeding apparatus? More intriguing still is that most of these snails have a larval stage that feeds very differently from the adult stage.

Q. Why do you need to know about cell division in your research?

A. Every multicellular animal begins its life as a single cell: the fertilized egg cell. That egg cell divides to produce the many cells that will then undergo specialization to produce a mouse, or a human, or a larval snail. Except in a few cases, cell division continues throughout life to replace worn-out or damaged parts or simply to enlarge the organism. Large size can lead to a competitive advantage by making an organism too big for some predators to tackle.

Q. What type of equipment do you use?

A. Much of my time is spent culturing larval marine snails, which does not require a lot of sophisticated equipment. To study the developing cells and tissues of these larvae, I use a variety of different types of microscopes, such as a standard bright field microscope with digital and video camera attachments and scanning and transmission electron microscopes. I also use the confocal laser scanning microscope, which allows me to visualize components of tissues that have been labelled with fluorescent probes that glow brightly when viewed with this microscope.

Q. What do you hope your research will accomplish?

A. I hope that my research will lead to a better understanding of the incredibly diverse ways in which developmental processes have changed during evolution.

Q. What would you like people to know about biology?

A. Biological research often involves long hours of data collection, but when a new discovery is made the thrill is worth it. Regardless of whether a student pursues a career in biology, it is important that all of us appreciate the importance of biodiversity and a healthy ecosystem. Even pests and disease are important to understand. The varieties of organisms we share the planet with make it a beautiful and fascinating place.

Questions

1. What are four different microscopes that Dr. Page uses?
2. What does she hope her research will do?
3. What organisms does Dr. Page use in her work?

Check Your Understanding

Checking Concepts

1. What are two conditions that must be met for sexual reproduction to occur?
2. Name and briefly describe the three stages of sexual reproduction.
3. Mammals can mate on land or water depending on the species. Describe an example of a mammal that mates in water.
4. What is internal fertilization?
5. What is external fertilization?
6. Why is it important that only one sperm fertilizes an egg?
7. Why is water or water-containing fluid necessary for animals that reproduce sexually?
8. What is the function of the pollen tube?
9. Describe one difference in how flowering plants and cone-bearing plants sexually reproduce.
10. List the following stages of human development in order.
    (a) blastula
    (b) zygote
    (c) fetus
    (d) gastrula
    (e) morula
11. Draw a sketch of a morula, a blastula, and a gastrula.
12. Match the tissue types or organs (on the right) to the embryonic layer from which they develop (on the left).

Embryonic Layer	Tissue Type/Organ
(a) ectoderm	(i) skin
(b) endoderm	(ii) nervous system
(c) mesoderm	(iii) skeletal system
	(iv) kidneys
	(v) digestive system
	(vi) lungs

13. What is the name of the female plant structure that stores egg cells?

Understanding Key Ideas

14. Using a graphic organizer of your choice, compare the advantages and disadvantages of internal and external fertilization.
15. How do animals that reproduce using external fertilization increase the chances of an egg cell and a sperm cell meeting?
16. A salamander lays eggs in the water and a lizard lays eggs on land. Predict which animal would lay more eggs at a time, and explain why.
17. How do both a bee and the plant it visits benefit from pollination?
18. Why would a plant pollinated by a bat not require colourful flowers?
19. How do animals transport seeds to different locations?
20. Copy and complete the following chart on fetal development.

Trimester	Major Developmental Events
First	
Second	
Third	

Pause and Reflect

Why does sexual reproduction provide more of an opportunity for genetic diversity in a species compared to asexual reproduction?