Grade 9 Science May 13-19, 2020

Below you will find this week's science nine assignments. This week's assignment has only one student worksheet on chemistry review and sexual reproduction and meiosis, please read instructions carefully and finish the required worksheet. The 'extending your learning' is offered for those who want to go beyond the minimal requirements.

If you need or want assistance on the assignment provided below, we are offering 'office hours' using the platform 'Zoom' twice per week with one of the four science teachers: Mr. Kyle Conne, Ms. Alanna Skene, Mr. Aren Goodman and Mr. James Cutt. Please see the end of this document for this week's office hours. However, if you wish to speak directly with your science nine teacher, please do not hesitate to email them or ask a question on your classes Office 365 Team page at any time and they will respond in a timely manner. Submitting completed work: Please submit your completed work by May 19, 2020 via **your Office 365 Class Teams account, ideally by clicking the "Turned In" button or through email. Assignments and any relevant resources will be posted in your class' Teams Account.**

Learning Intentions:

1. Core Competencies of Communication, Thinking and Personal and Social Awareness and Curricular Competencies relating to making observations aimed at identifying students' own questions, including increasingly complex ones, about the world around them.
2. Big idea: Cells are derived from cells
    - How do cells multiply and function
    - Asexual reproduction: mitosis as a process in which pre-existing cells make 2 identical copies of themselves and the different forms of asexual reproduction (cloning, grafting, budding, fission and spores)
    - Sexual Reproduction: meiosis as the process of producing sex cells (egg/ovum and sperm cells) and sexual reproduction resulting in genetically different, yet similar, offspring to the parents

Assignment Instructions:

Outline: Please access your Office.com Science Class Teams account and ensure that you can access the instructions, online videos and student worksheets. Please complete the student worksheets and turn them into your teacher.

Required materials:

- Science 9 May 13-19, 2020 Assignment # 6 Instructions
- BC Science nine textbook of chapter 5.2 (See Assignment #5), 6.1 and 6.2 and Chemistry Databook (see Assignment #3)

- Article titled: “Wizard of odds: wizard or muggle--could the chances of becoming one lie in a person's genes?”
- Biology-Sexual Reproduction and Meiosis Student Worksheet

Criteria / Rubric:

Assessment is based on a 4-point proficiency scale:

emerging	developing	proficient	extending
The student demonstrates an initial understanding of the concepts and competencies relevant to the expected learning.	The student demonstrates a partial understanding of the concepts and competencies relevant to the expected learning.	The student demonstrates a solid understanding of the concepts and competencies relevant to the expected learning.	The student demonstrates a sophisticated understanding of the concepts and competencies relevant to the expected learning.

Assignment:

Please complete the “Biology-Sexual Reproduction and Meiosis Student Worksheet”. This worksheet has review material from last week’s assignment on asexual reproduction and leads students through how all cells are derived from other cells in a process called sexual reproduction. Please follow the instructions on worksheet for each section. You will need to watch the video linked in the instructions of this assignment. You will probably wish to open the video in a new “tab” or “screen” so that you are able to pause and re-watch them and to also ensure that you are able to fill in the information in your student worksheet as you view the videos. Once you have completed the worksheet, please “Turn-In” the worksheet in your Teams class account.

Extending Your Learning (Optional):

Please read the worksheet titled “Science 9 Enrichment Activity May 13-262, 2020”. Student will need to read the article and watch the videos posted in the worksheet, complete the worksheet and submit it to their teacher by turning it in to their Teams class account

Office Hours: May 13 - 19 (via ZOOM: https://zoom.us/join):

Time - 1:00pm to 2:00pm

Thursday, May 14: Mr. James Cutt, Mrs. Alanna Skene and Mr. Aren Goodman
- Meeting ID: 916 773 99798
- Password: science

Monday, May 18: Mrs. Alanna Skene, Mr. James Cutt, and Mr. Aren Goodman
- Meeting ID: 990 8478 0100
- Password: science

Biology – Sexual Reproduction and Meiosis Student Worksheet

Welcome to week six where we continue our exploration of reproduction, with a focus now on sexual reproduction.

Part A: Review (Chemistry)

Please write the formula or name corresponding to the given name or formula for the following ionic compounds. You can use the "subscript" button in the "Home" bar to make small numbers.

Hints:

1. *For every question ask yourself, "Is this covalent or ionic?".*
2. *If the question is covalent, use prefixes and DO NOT BALANCE charges. If you need help, use the flow chart for covalent compounds found on the back of the chemistry reference package.*
3. *If the question is ionic, you need to draw a t-chart to balance the charges. DO NOT use prefixes. If you need help, use the flow chart for ionic compounds found on the back of the chemistry reference package.*
4. *If an element ends in something other than 'ide' it might be polyatomic. Treat these as ionic compounds. We have created these in* ***bold*** *below.*

Carbon trisulphide	Cs_2SO_4
Chromium (III) bromide	Mn_3P_4

Part B: Review (Asexual Reproduction and Mitosis)

Before we start, using p.175, section 5.2 of the textbook, complete the following chart reviewing the advantages and disadvantages of asexual reproduction.

Advantages and Disadvantages of **Asexual** Reproduction

Advantages	Disadvantages
•	•
•	•
•	•
•	•

Review questions:

1. Why are most multicellular organisms unable to reproduce by budding?

2. To eat, sea stars attach their legs 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.

3. If you drive to Shawnigan Lake, you will see a large sign asking all boaters to clean weeds off their motors and hulls before entering and after exiting the lake. Explain why this is asked of boaters (hint: it has to do with asexual reproduction).

4. Mitosis can be remembered through the acronym PMAT. The letters stand for prophase, metaphase, anaphase, and telophase. How did the 'Amobea Sisters' explain a way of remembering what each term means?
   P –
   M –
   A –
   T –

5. Name four different cells in our body that reproduce through asexual reproduction?

6. What are the only two cells in our body that do not reproduce through asexual reproduction?

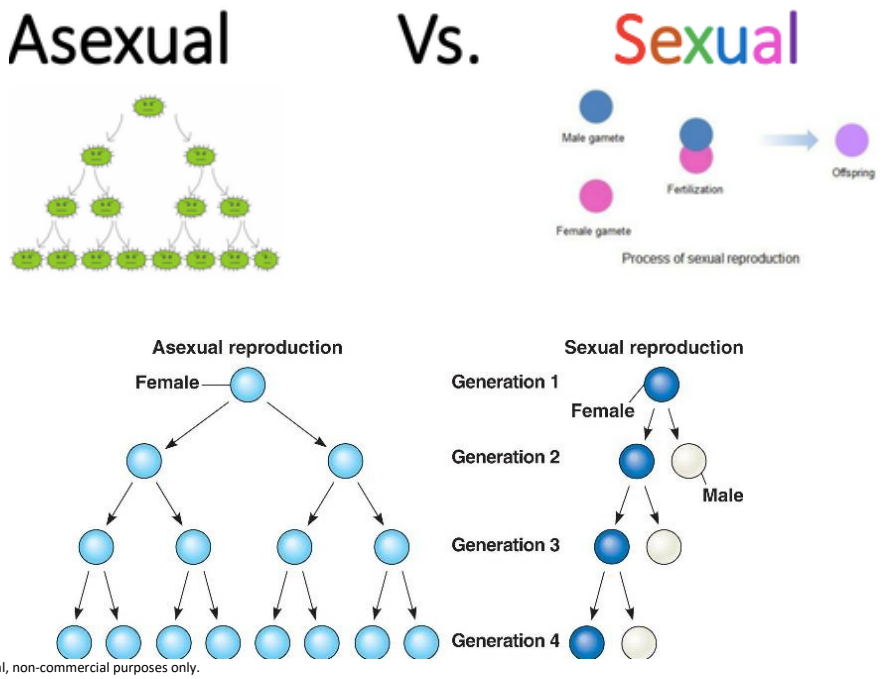
Part C: Sexual Reproduction

Look at the people around you in your family. How are they similar? How are they different? Each one of them has some differences in genetic information even though you are in the same family. This genetic information determines why members of your family share some similar characteristics but also have slightly different characteristics. This, of course, is the same for all living things that reproduce sexually, including plants and animals. In this assignment, you will explore the method of reproduction by which an organism receives genetic information from both its parents.

To begin, read pages 188 – 194 (Section 6.1 in your textbook) and answer the following questions:

1. What does the term **genetic diversity** mean?

2. Using the following diagrams of the outcomes of asexual and sexual reproduction, describe What is the function of **meiosis** is?



Because organisms that reproduce asexually do not have to search for a mate, asexual reproduction is very rapid and produces a large number of offspring. Sexual reproduction, though more time consuming, is far more common as it creates genetically different offspring and allows for a population to survive in a constantly changing environment.

3. A) What is the haploid number of chromosomes in humans?_____
   B) What is the diploid number of chromosomes in humans?_____

4. Male sex cells are called _____ or _____.
5. Female sex cells are called _____ or _____.

6. What is another name for a fertilized egg?

Part D: Internal and External Fertilization

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.

1. You are about to watch a video titled, "Learn Biology: How to draw a Punnett Square." Before watching the movie, take a guess as to what this will be about and write this guess below. ("IDK or I don't know" is **NOT** an answer).

2. Watch the following video by selecting the link below:
   https://www.youtube.com/watch?v=prkHKjfUmMs

3. Fill in the following Punnett square and answer the following questions:
   (B = dominant allele; b = recessive allele)

	B	b
b		
b		

   If B = brown eyes and b = blue eyes, and using the above Punnett square, what are the probabilities for the following:
   a. Probability of brown eyes = _____ % or Fraction /4
   b. Probability of blue eyes = _____ % or Fraction /4

4. Complete another Punnett square for runner beans with the following probabilities (presuming G = yellow colour allele; g = green coloured allele) You will need to add the parent alleles so they work out to the following probabilities.
   a. 50 % yellow beans
   b. 50% green beans

5. Read the article titled: "Wizard of odds: wizard or muggle--could the chances of becoming one lie in a person's genes?" from the "Reference Materials".

   After reading the article, complete the following questions by selecting the correct multiple choice answer and writing its letter on the line provided or completing the question asked:

   a. Genes are segments of (A) RNA. (B) DNA. (C) NBA. _____

   b. Different versions of a gene are called (A) pedigrees. (B) alleles. (C) carriers._____

   c. The characteristics people inherit from their parents are called (A) genes. (B) traits. (C) ancestral lines. _____

   d. Cystic fibrosis develops when a child inherits A) two recessive alleles. B) one dominant allele and one recessive allele. C) two dominant alleles._____ _____

   e. About how many genes does a human have A) 2500, B)25000, C) 250000_____ _____

   f. Complete the Punnett square below with the following information and answer the question: If one human parent is a wizard (ww) and one is a muggle (MM), what are the odds their kids will be a wizard?

6. Using p.220, section 6.2 of the textbook, complete the following chart reviewing the advantages and disadvantages of sexual reproduction.

Advantages and Disadvantages of **Sexual** Reproduction

Advantages	Disadvantages
•	•
•	•
•	•
•	•

Part E: Asexual and Sexual Research Project

Now that you know about asexual and sexual reproduction, complete the following project.

Create a portfolio demonstrating evidence of living things around your home and neighbourhood that reproduce sexually and asexually.

Criteria:

1. Must include four examples of living things from your home or neighbourhood that reproduce **asexually**.

2. Must include four examples of living things your home or neighbourhood that reproduce **sexually** (only **one mammal** may be included)

3. Write the name of the two sources you used to confirm the reproductive method of each of your organisms. Use the following citation helper to help you properly credit the information you use: http://www.citationmachine.net (APA format)

4. Presentation of evidence: photos (are easy to insert into the area provided) or drawings (take a picture of your drawing and upload it to your "My Work" section of the Teams Assignment).

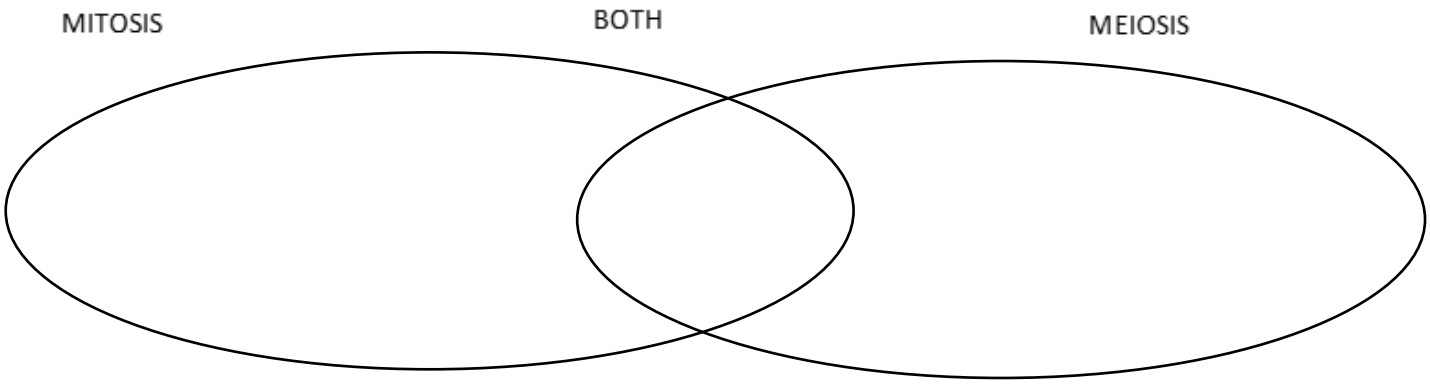
5. Each living thing must include its name.

6. At the end of the assignment, include the differences and similarities between **mitosis** and **meiosis**.

Sexual and Asexual Reproduction Assignment

ASEXUAL REPRODUCTION			
	Name of organism:		Name of organism:
	Name of organism:		Name of organism:

SEXUAL REPRODUCTION			
	Name of organism:		Name of organism:
	Name of organism:		Name of organism:


MITOSIS
BOTH
MEIOSIS

Wizard of odds: wizard or muggle--could the chances of becoming one lie in a person's genes?

Author: Chris Jozefowicz
Date: Mar. 17, 2006
From: Current Science, a Weekly Reader publication(Vol. 91, Issue 13)
Publisher: Scholastic, Inc.

HARRY POTTER'S WORLD

In Harry Potter's world, wizards are born, not made. Just look at Harry. He was raised from infancy by two muggles (normal, magic-less people), Uncle Vernon and Aunt Petunia Dursley. They couldn't pull a rabbit from a hat, let alone use a Cheering Charm to bring some happiness into their mean little lives.

If Harry didn't pick up his magic skills from the adults who raised him, where did his powers come from? From his parents, of course, the witch Lily Evans and the wizard James Potter. In the same way that tall children tend to have tall parents, the wizard children in J. K. Rowling's fiction seem to have magic parents.

That's not the case for Hermione Granger, however. Both of her parents are muggles, yet she is one of the best students at the Hogwarts School of Witchcraft and Wizardry. If children derive their magic powers from their parents, where did Hermione's magic come from? Is there any logic in the world of wizards?

Yes, say genetics researchers in Australia. Last summer, they published a letter in the science journal Nature contending that wizarding could have a genetic basis. Their theory is as fanciful as a flying broomstick, but Harry's world can still teach us something about how people inherit different characteristics, says Jeff Craig, a geneticist at the Royal Children's Hospital in Melbourne, Australia.

GENETIC BULLIES

Geneticists call the characteristics that we inherit from our parents traits. Traits, such as eye color and hair color, are determined by long stretches of DNA called genes. Every person has two versions of each gene, one inherited from Dad, and one from Morn. Sometimes the two versions are identical. Sometimes they are different and are termed alleles. Two brothers can have different eye colors because each brother inherited a different set of alleles from their parents.

What's more, some alleles, called dominant alleles, have a stronger effect on traits than other, weaker alleles, which are called recessive alleles. Craig

likens the situation to a schoolyard. "The dominant allele is a bully," he says, "and if there is a bully around, the recessives are put in their place. But when there is no one to pick on them, when there is no bully around, the recessives can express themselves."

HARRY, HERMIONE, HEREDITY

Craig, together with education researchers Renee Dow and MaryAnne Aitken, suggests that wizardry arises from a recessive allele (w) that gives people magic powers. The muggle version (M) of the same gene is a dominant allele. Only a child who inherits one wizard allele from each parent (ww) can become a wizard. If child inherits two muggle alleles (MM), he or she won't have magic powers.

Because both of Harry's parents had magical powers, each one must have had two recessive alleles (ww). They could have passed on only recessive genes to Harry, destining him to become a wizard.

Hermione's inheritance is more complex, because both her parents are muggles. Craig says Hermione's parents must both be carriers of the wizard allele. A carrier has a recessive allele and a dominant allele--in this case, a w and an M. Each of Hermione's parents would still be a muggle because muggleness is dominant and overpowers wizarding. But the Grangers could make a magic child by passing on two recessive alleles to their child. (See "Muggles in the Mix.")

In real life, certain diseases, such as cystic fibrosis, are inherited in a similar manner. Cystic fibrosis is a disease that causes a buildup of thick mucus in the lungs that leads to breathing problems. It arises when a child inherits two recessive alleles, one from each parent.

HOGWARTS OR HOGWASH?

One month after Craig's letter appeared, Nature published a response from a trio of researchers in plant genetics at the University of Cambridge in England. They disagree with the Australian team's notion. "We believe the assumption that wizarding has a genetic basis to be deterministic and unsupported by available evidence," they wrote.

The Cambridge group complains that if wizarding is determined by recessive alleles, it should have turned up more often in the Granger family pedigree--the family's ancestral line. "As Rowling fans could point out," the Cambridge researchers wrote, "Hermione's parents were muggle dentists who lack any family history of wizarding."

But Craig says researchers don't always find a family history of disease in real-life medical conditions that arise from two recessive alleles. "In many of

the pedigrees, the ancestors don't show a single case," he says. "Two different recessive alleles just happen to come together in a particular generation." The alleles are not only recessive but also rare.

The Cambridge researchers also have a more general complaint. They think Craig's idea is deterministic--that it takes a complex trait like wizarding and assumes without evidence that it must have a simple genetic explanation. Perhaps wizarding arises from the interaction of many genes and various environmental influences.

"I think that's a valid point," Craig concedes. "We have to beware of the attitude of determinism. But I think it depends on how serious you want to take it. We think they were being a bit too serious there."

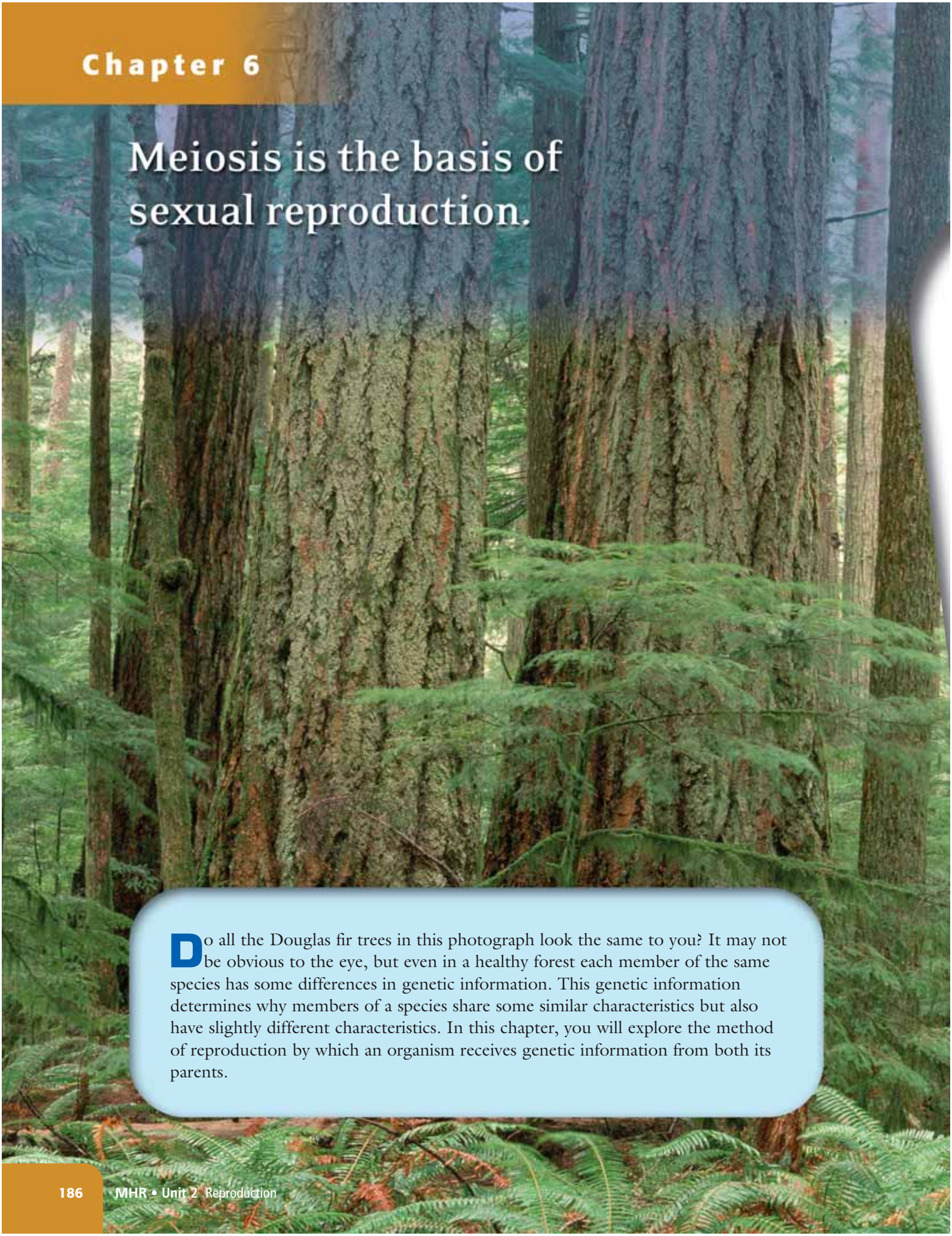
MUGGLES IN THE MIX

Punnet squares are used to chart possible inheritance patterns. The alleles of each parent are displayed at the top and the side of the square. Each box represents a possible pairing of alleles in a child. For Hermione Granger to become a wizard, her parents had to have this square:

Every child from two Mw parents has an equal chance of getting a muggle or a wizard allele from each parent. But because the muggle allele is dominant, there are three chances of producing a muggle and only one chance of producing a wizard. Therefore, on average, only one of four children (or 25 percent) would be a wizard.

Chapter 6

Meiosis is the basis of sexual reproduction.



Do all the Douglas fir trees in this photograph look the same to you? It may not be obvious to the eye, but even in a healthy forest each member of the same species has some differences in genetic information. This genetic information determines why members of a species share some similar characteristics but also have slightly different characteristics. In this chapter, you will explore the method of reproduction by which an organism receives genetic information from both its parents.

What You Will Learn

In this chapter, you will

- **explain** how organisms maintain genetic diversity
- **describe** how a zygote forms and develops
- **distinguish** the process of mitosis from meiosis
- **explain** the role of stem cells in embryonic development

Why It Is Important

Understanding meiosis and sexual reproduction is important for understanding how many species in our world maintain genetic diversity and how genetic disorders are inherited.

Skills You Will Use

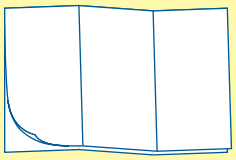
In this chapter, you will

- **predict** how genetic variation can affect the ability of organisms to survive
- **communicate** your understanding of how mitosis differs from meiosis
- **model** how genes are reshuffled in meiosis
- **compare** the advantages and disadvantages of sexual and asexual reproduction

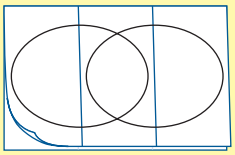
FOLDABLES™
Reading & Study Skills

Make the following Foldable and use it to take notes on what you learn in Chapter 6.

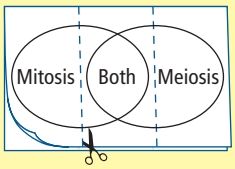
STEP 1 **Fold** a sheet of paper in half top to bottom and then fold it into thirds.



STEP 2 **Open** the Foldable, and **draw** a giant Venn diagram on one side.



STEP 3 **Label** as shown, then **cut** along the fold lines on the Venn diagram side to form three tabs.



Finding Common Traits As you read this chapter, use the Venn diagram Foldable to compare mitosis and meiosis and to determine what they have in common.

6.1 Meiosis

The process of meiosis results in the production of special cells called gametes. Gametes have half the number of chromosomes as body cells. Cell division occurs twice in meiosis: once at the end of meiosis I and again at the end of meiosis II. In meiosis I, matching pairs of chromosomes called homologous chromosomes separate. In meiosis II, sister chromatids separate. The process of meiosis shuffles genetic information and results in variation in the gametes.

Words to Know

diploid number
embryo
fertilization
gametes
genetic diversity
haploid number
homologous chromosomes
sexual reproduction
zygote

When you look around your classroom, you will see students of differing heights, facial features, and hair colour. When you look at the photographs in Figure 6.1, you will see some organisms from the same species that look quite different from one another and some that look the same. What do all of these organisms have in common? They have all been produced by a process called **sexual reproduction**. Unlike asexual reproduction, which requires only one parent and produces identical offspring, sexual reproduction requires two parents. Sexual reproduction produces offspring that are genetically different from each other, from either parent, and from any other member of their species. Sometimes these genetic differences are visible, such as the coat colour of the llamas in Figure 6.1A. Sometimes, genetic differences are not visible, such as in the owls in Figure 6.1B.

Figure 6.1A Offspring that result from sexual reproduction are genetically different.

Figure 6.1B Genetic differences may or may not be visible.

Variation, or inherited genetic differences in a species, is called **genetic diversity**. Genetic diversity is the result of sexual reproduction, which randomly sorts, or shuffles, DNA. Because of the combination of genes received from its parents, an organism may be better equipped to cope with changes in its environment. Therefore, one organism of a species may gain an advantage over another organism of the same species.

6-1A Eating Like a Bird

Find Out ACTIVITY

The genetic variation that results from sexual reproduction can give an organism a survival advantage. An organism may be stronger, better at escaping predators, or more skilled at obtaining food. In certain species of birds, for example, variation in beak size and shape can help a species survive in an environment with a specific food source. In this activity, you will determine which type of beak provides a survival advantage for a bird given a particular food source.

Safety

- Never eat anything in the science room.

Materials

- spoon
- chopsticks (one set)
- forceps or tweezers (one pair)
- marbles
- toothpicks
- cereal
- pennies
- timer

What to Do

1. Work in a group of four. Predict which "beak" (spoon, chopsticks, or forceps) will pick up each of the "foods" (marbles, toothpicks, cereal, pennies) the best. Record your predictions.
2. Design a chart to record data on how much food is collected with each type of beak.
3. Put the food in a pile in the middle of a table top. Three members of your group will each use one of the beaks to pick up food from the pile. The fourth person will time the group members for 1 min as they race to pick up as much food as possible. The fourth person will then record the data.
4. Decide on the best type of graph to illustrate your group's data. Construct a graph to display the data.
5. Clean up and put away the equipment you have used.

Science Skills

Go to Science Skill 5 for information about how to organize your data into a graph.

What Did You Find Out?

1. Did your group's predictions match your results? Explain.
2. Compare your group's results with those of two other groups.
   (a) How are the results the same?
   (b) How are the results different?
3. Which beak would provide a survival advantage in an environment where marbles are the only food source? Explain.
4. Which beak would provide a survival advantage in an environment where toothpicks are the only food source? Explain.

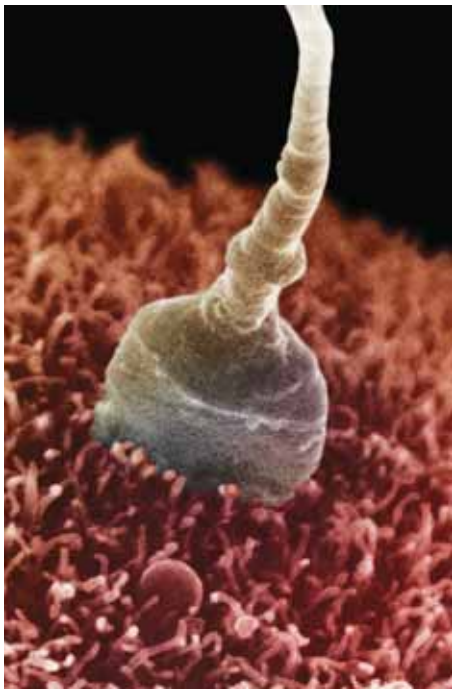


Figure 6.2 A human sperm enters a human egg cell, resulting in fertilization.

The Role of Gametes

Genetic information is passed along in the chromosomes an offspring inherits from its parents. In section 4.1, you learned that all organisms have a specific number of chromosomes in their body cells. In eukaryotic organisms, this chromosome number is referred to as the **diploid number** ($2n$). Diploid means that a body cell has two sets of chromosomes. The diploid number for humans is 46, or 2×23 chromosomes. Mitosis ensures that the diploid number always stays the same and that the genetic information contained within your body cells also remains the same, unless a mutation occurs.

So what makes humans genetically different from each other? Humans inherit one set of 23 chromosomes from their female parent and one set of 23 chromosomes from their male parent. Each set of these inherited chromosomes is referred to as the **haploid number** (n). Haploid chromosomes are carried in **gametes**, which are specialized cells necessary for reproduction. In animals, male gametes are called sperm cells and female gametes are called egg cells.

During a process called **fertilization**, an egg cell is penetrated by a sperm cell (Figure 6.2), and the haploid genetic information of both male and female gametes combines. The result of this process is a diploid cell called a **zygote**. A zygote receives half its chromosomes from its female parent and half from its male parent. The zygote then undergoes mitosis and cell division and develops into an **embryo**.

Figure 6.3 shows how a zygote inherits its diploid number and develops into an organism.

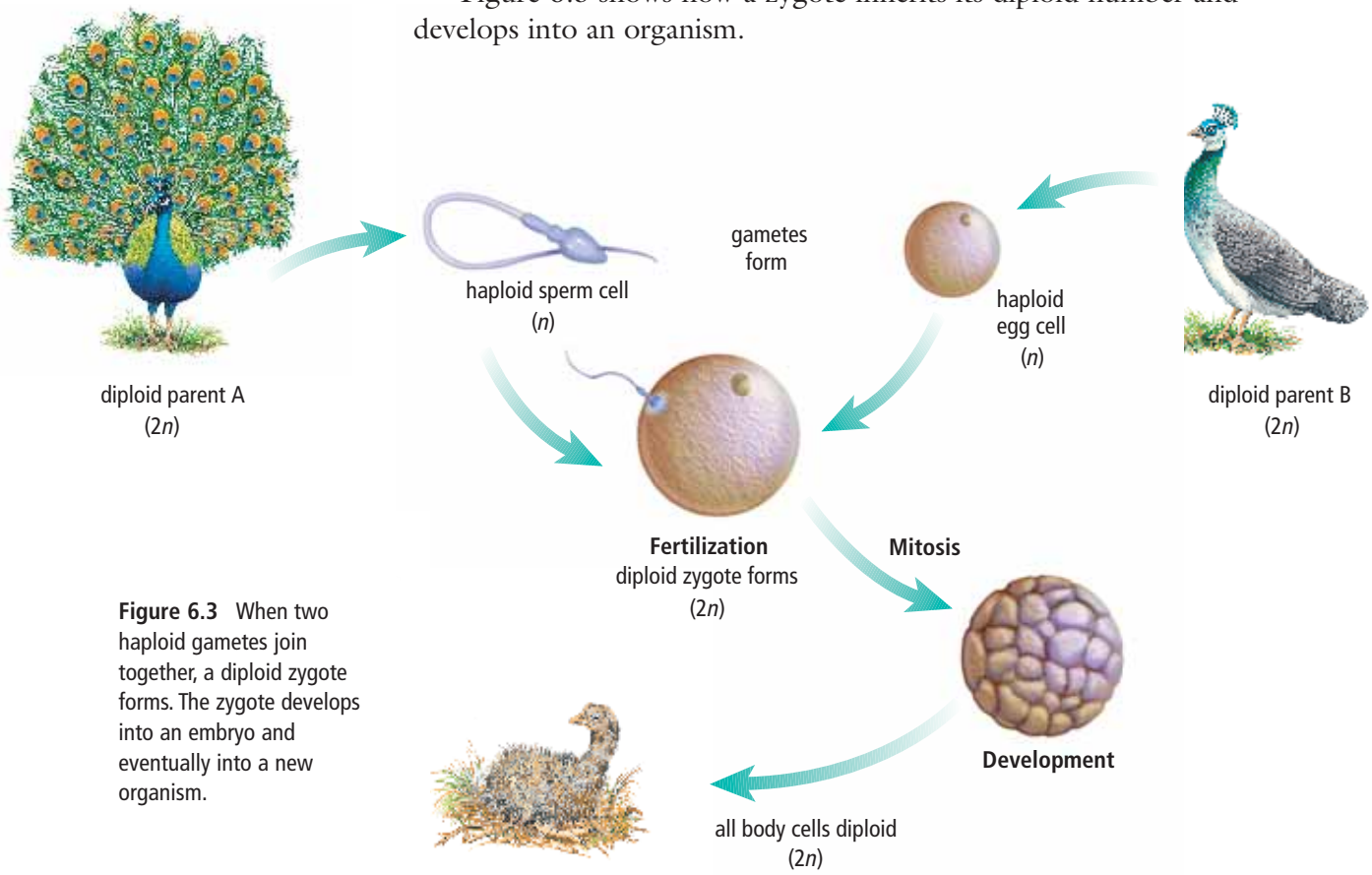


Figure 6.3 When two haploid gametes join together, a diploid zygote forms. The zygote develops into an embryo and eventually into a new organism.

Meiosis: Reducing Chromosome Number

The process that produces gametes with half the number of chromosomes as body cells is called **meiosis**. Without meiosis, the joining of a sperm cell and an egg cell during fertilization would produce an offspring with two times the original number of chromosomes as its parents. Figure 6.4 shows how meiosis produces gametes with half the number of chromosomes of the parent cells. As you look at the figure, notice that DNA replicates only once in the process, even though two cell divisions occur.

Word Connect

"Meiosis" is derived from the Greek word *meion*, which means to reduce.

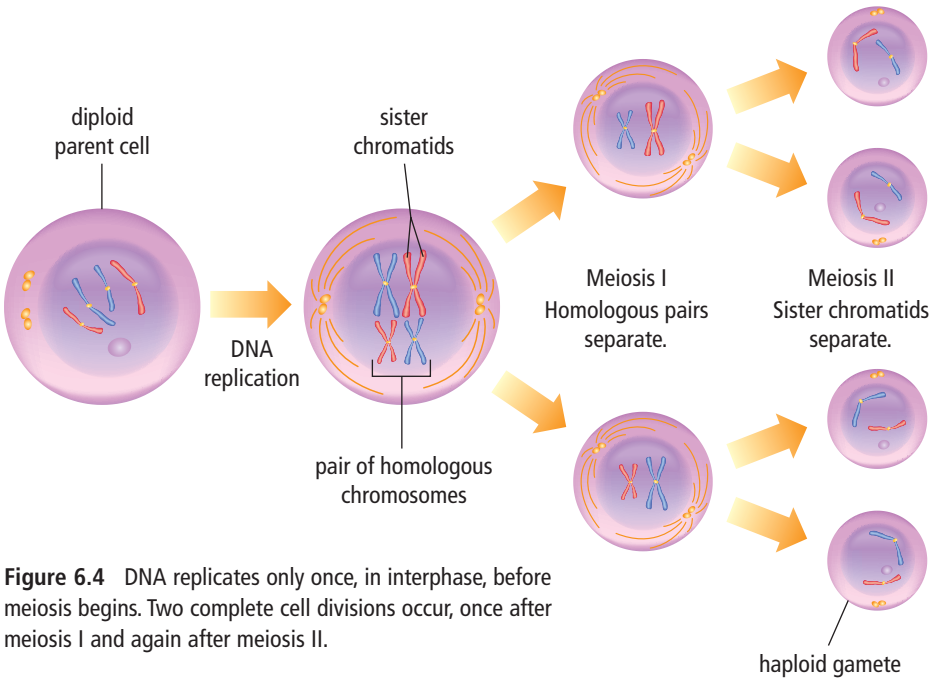


Figure 6.4 DNA replicates only once, in interphase, before meiosis begins. Two complete cell divisions occur, once after meiosis I and again after meiosis II.

Meiosis I

In Chapter 5, you saw that in mitosis each of the 46 chromosomes lines up along the equator of the cell during metaphase. The sister chromatids then move to opposite poles of the cell. Meiosis I differs from mitosis because in meiosis I a pair of matching chromosomes, one chromosome from each parent, lines up at the equator. Scientists refer to this pair of matching chromosomes as a pair of **homologous chromosomes** (Figure 6.5). In meiosis I, the homologous chromosome pair separates and moves to opposite poles of the cell. Two daughter cells result from meiosis I.

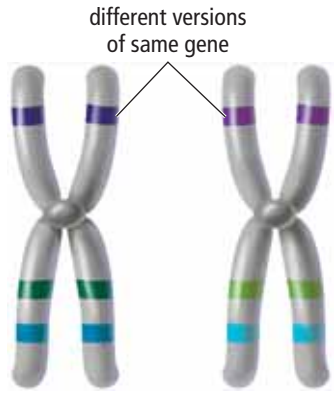


Figure 6.5 Homologous pairs are the same size and shape and have genes in the same location, as shown by the coloured bands in this illustration. Each chromosome may have different versions of those genes, as shown by the different shades of each colour.

Meiosis II

DNA is not replicated again before meiosis II begins. Chemical messages trigger the cells to begin the cell division process. Meiosis II is like mitosis because in both processes the chromatids of each chromosome are pulled to opposite poles. Each daughter cell inherits one chromatid from each chromosome. The result is four haploid cells, each with half the number of chromosomes.

Events in Meiosis that Produce Variation

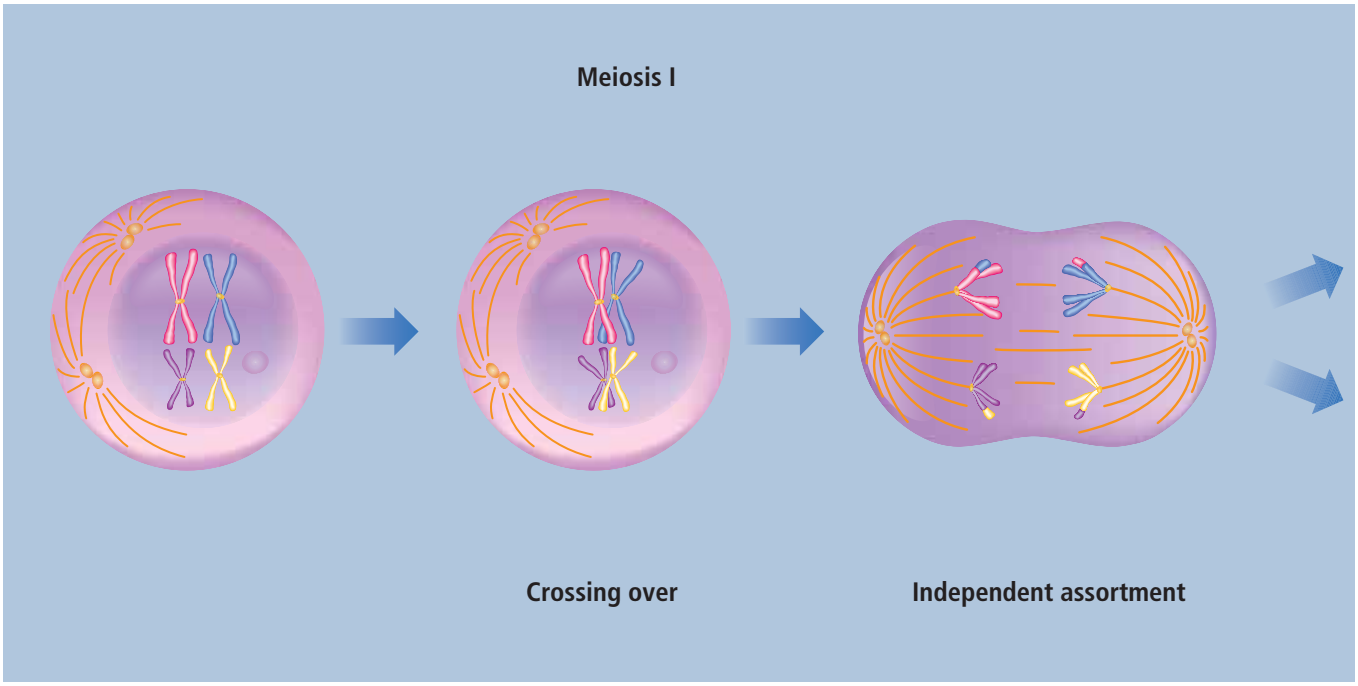


Figure 6.6A In crossing over, non-sister chromatids exchange DNA. In independent assortment, homologous chromosomes separate. Both events result in variation in gametes.

Crossing over

Crossing over is an important event that occurs between each chromosome pair in meiosis I. In crossing over, parts of non-sister chromatids "cross over" each other and exchange segments of DNA (Figure 6.6A). As a result of this exchange, each chromosome picks up new genetic information from the other. Multiple crossovers can occur between two chromosomes. Therefore, crossing over creates an infinite number of genetic possibilities for just one gamete and results in variation.

Independent assortment

Another important event occurs in meiosis I and produces variation. It is called **independent assortment**. During this event, homologous pairs of chromosomes separate at the equator and move toward opposite poles of the cell (Figure 6.6A). For each of the 23 pairs of human chromosomes, there are two possibilities for how a chromosome will eventually sort itself into the daughter cells (Figure 6.6B on the next page). There are more than 8 million combinations possible for these 23 pairs in any egg or sperm cell. When fertilization occurs, 70 trillion different zygotes are possible from the combination of one sperm cell and one egg cell! This explains why people look different from each other and why even brothers and sisters do not look the same.

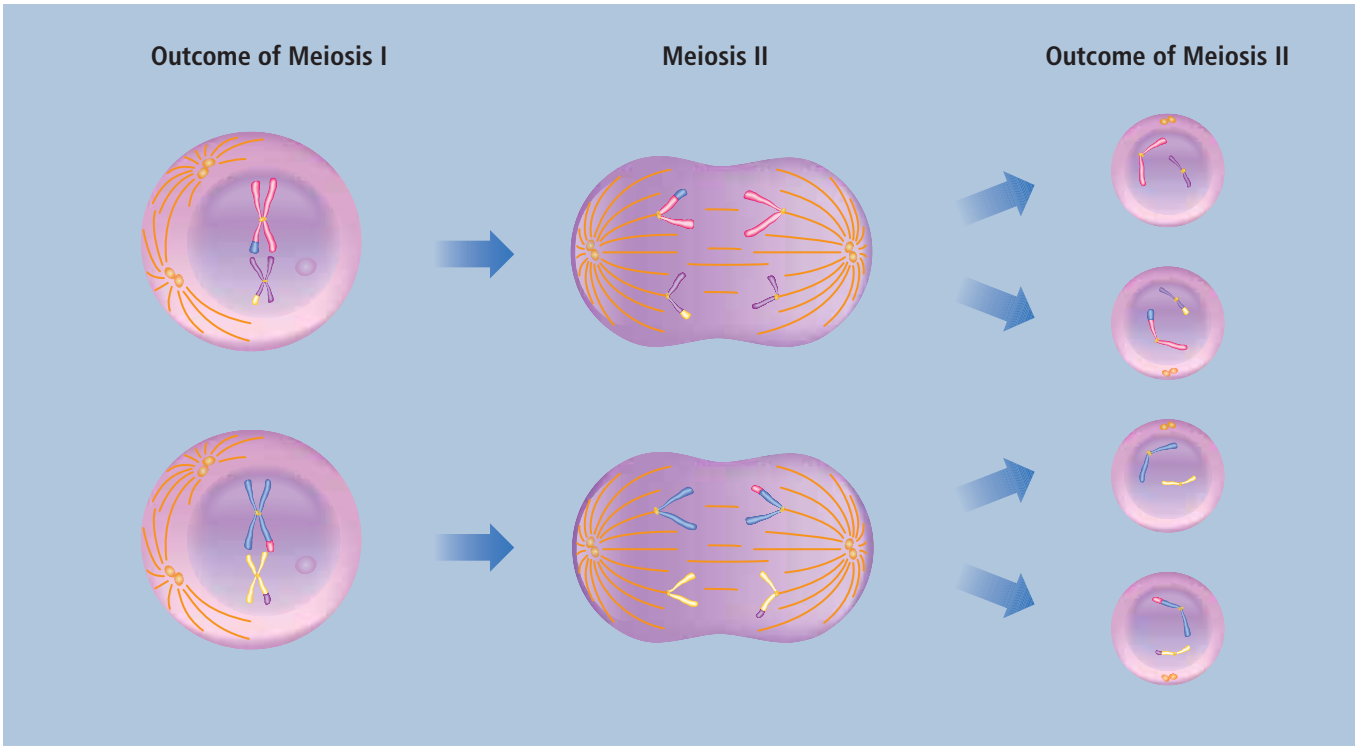


Figure 6.6B After meiosis, chromosomes separate and sort themselves into daughter cells.

Gamete formation

Although the process of meiosis is the same for males and females, gamete formation is different (Figure 6.7). In males, meiosis I occurs and produces two cells. It is immediately followed by meiosis II if there are enough nutrients for cell division. The result is four cells with the cytoplasm and organelles equally divided among them. All four cells may develop into mature sperm.

In females, meiosis I occurs and produces two egg cells, but there is an unequal division of the cytoplasm and organelles. Following meiosis II, three of the cells will disintegrate. The remaining one large egg cell retains most of the cytoplasm and is available for fertilization.

Suggested Activities

Conduct an Investigation 6-1C on page 198
Conduct an Investigation 6-1D on page 200

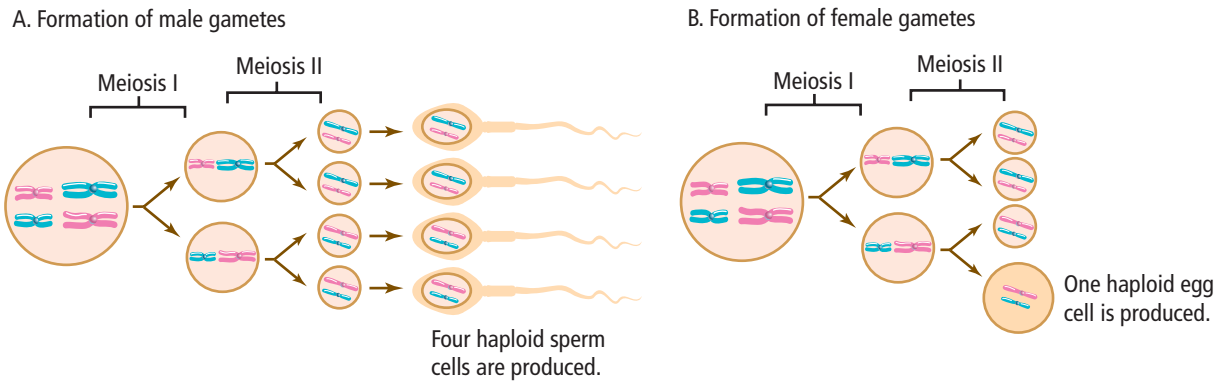


Figure 6.7 Meiosis occurs continuously in the testes of human males from puberty. In females, meiosis begins in the ovaries before birth, then stops until puberty and the onset of the menstrual cycle.

Reading Check

1. What does the term genetic diversity mean?
2. What is the function of meiosis?
3. (a) What is the haploid number of chromosomes in humans?
   (b) What is the diploid number of chromosomes in humans?
4. What is another name for a fertilized egg?
5. What are homologous chromosomes?

Chromosome Mutations in Meiosis

In Chapter 4, you learned that small mutations in genes may have no effect on an organism or may cause disease. Big changes in the organization of DNA and genes happen when pieces of chromosomes are lost, duplicated, or moved within a chromosome or moved to another chromosome. These changes often occur during meiosis. They affect many genes in the chromosome and change the proteins made by those genes (Figure 6.8).

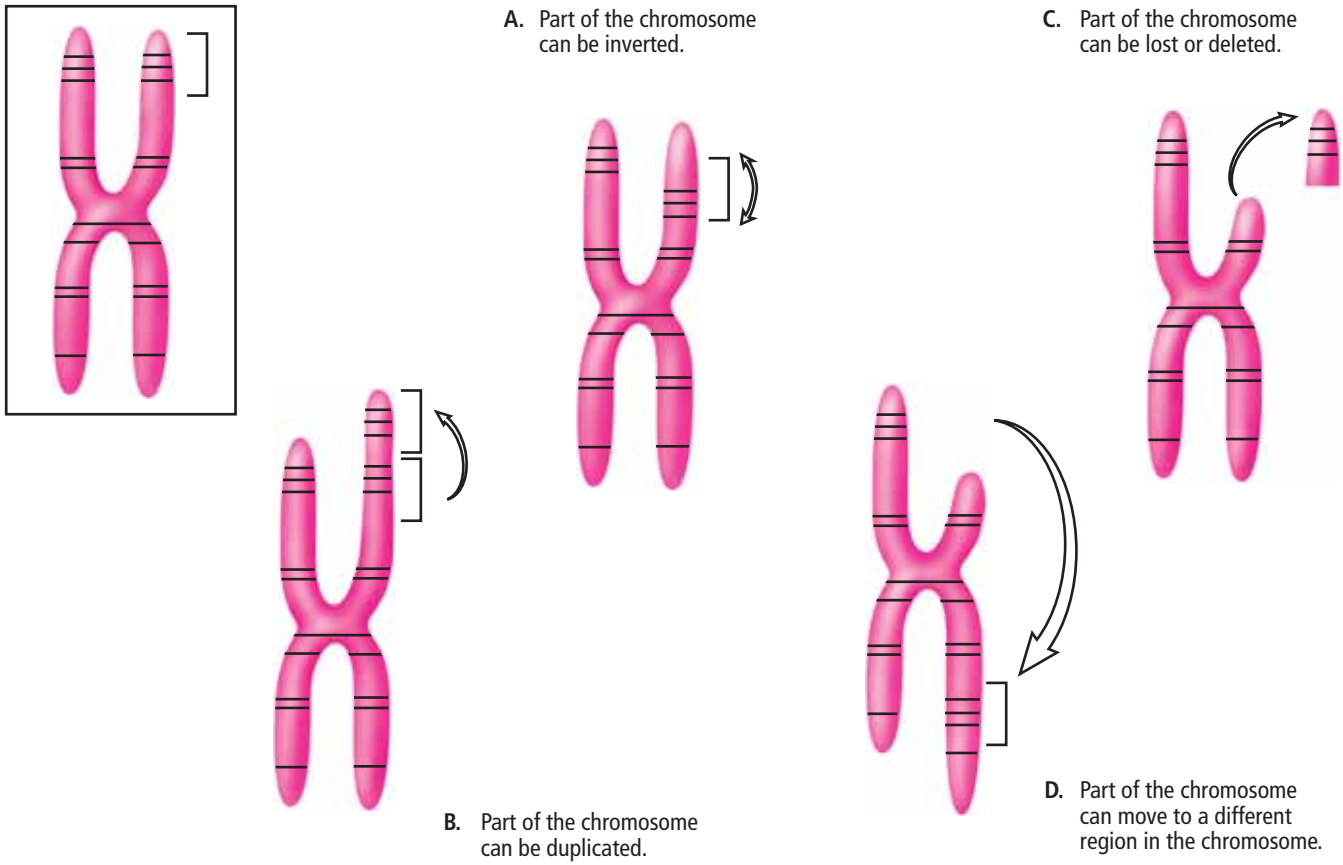


Figure 6.8 Several types of chromosome mutations

Chromosome mutations also occur when cells are exposed to mutagens such as radiation or chemicals. The effect of chromosome mutation can be seen in fruit flies exposed to mutagens. Some mutant fruit flies have legs growing where antennae should be (Figure 6.9). Others, called shar-pei mutants, have wrinkled heads that look like the wrinkled heads of a type of dog known as a shar-pei. Chromosome mutations are frequently seen in the eye colour of fruit flies. Normal fruit flies have brick red eyes. Mutant fruit flies have pink, purple, maroon, or green eyes. Some mutant fruit flies have perfectly functional eyes growing out of their wings.

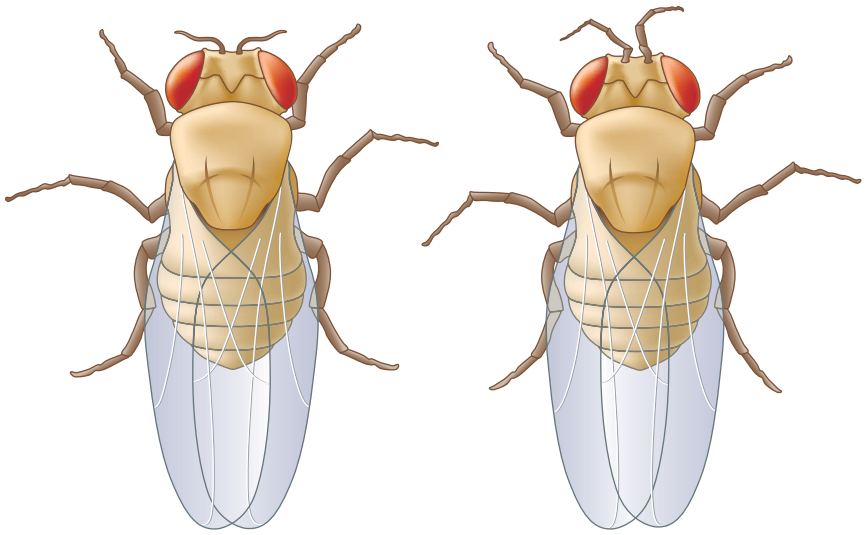


Figure 6.9 An example of chromosome mutation in fruit flies. The fruit fly on the right has legs growing where antennae should be.

Whole chromosome mutations can occur in meiosis I (when homologous chromosomes fail to separate) or in meiosis II (when sister chromatids fail to separate). The result is that one gamete will have two copies of one chromosome and the other will have no copy of that chromosome. Many chromosome mutations are not passed from one generation to the next. For example, large chromosome errors are prevented from being passed along because the offspring either fails to develop or does not live to reach reproductive age and adulthood.

internet connect

Drosophilists are scientists who study fruit flies to understand how mutation occurs. Scientists can produce mutations in fruit flies to learn what happens when a gene stops functioning and no longer produces a specific protein. To learn more about fruit fly genetics, go to **www.bcscience9.ca.**

Figure 6.10 Males and females have specific karyotypes.

Diagnosing Genetic Disorders

Figure 6.10 shows a picture of two teenagers. A geneticist can prepare a different type of picture of these individuals, one that shows all of their chromosomes arranged in a particular order. This picture is called a **karyotype** and is shown in Figure 6.11. Karyotypes are prepared by cutting and pasting chromosomes taken from body cells during mitosis. The homologous chromosomes are identified and paired by size, centromere location, and banding patterns.

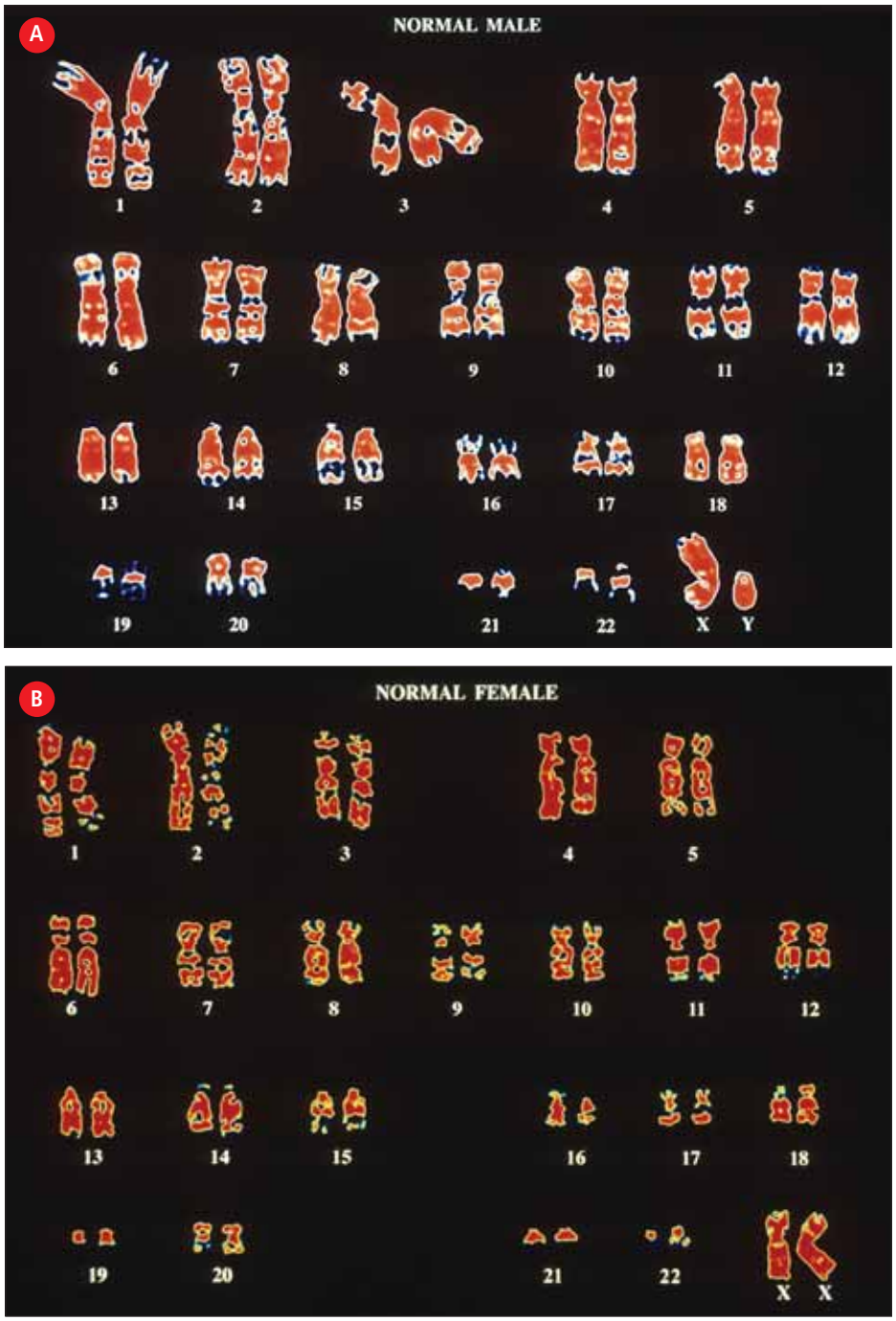


Figure 6.11 Karyotype of a normal male (A) and a normal female (B)

By analyzing karyotypes, geneticists can determine when a whole chromosome mutation has occurred. Understanding which chromosomes have been affected helps physicians diagnose and treat patients with genetic disorders or **syndromes**. A syndrome is a particular disease or disorder with a specific group of symptoms that occur together. One example is Down syndrome, which is one of the most frequently occurring types of chromosome mutations. Individuals with Down syndrome (Figure 6.12) have characteristic facial features and shorter stature and may be prone to developing heart defects and diseases such as Alzheimer's and leukemia. Ninety-five percent of the cases of Down syndrome are caused by an extra 21st chromosome (Figure 6.13).

Figure 6.12 People with Down syndrome are active participants in their communities.

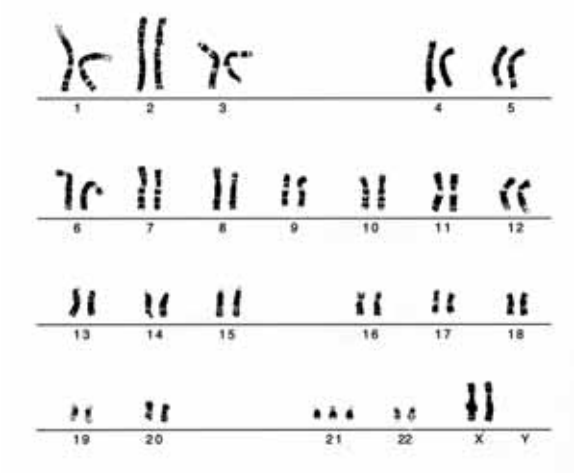


Figure 6.13 The karyotype of a person with Down syndrome

6-1B Analyzing a Karyotype

Find Out ACTIVITY

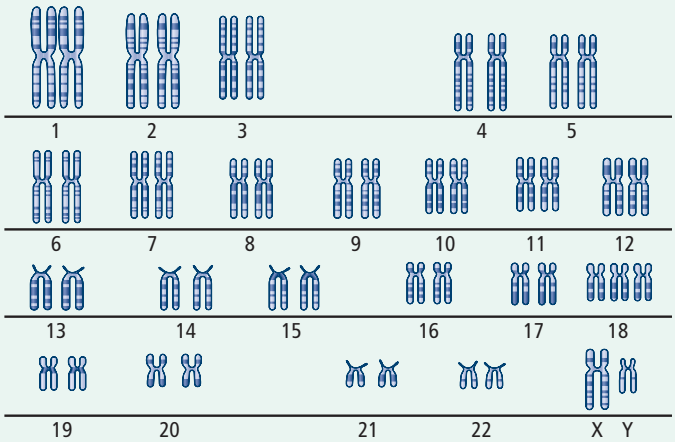
Geneticists study karyotypes to determine if any chromosome mutations have occurred. In this activity, you will analyze a karyotype of Edwards syndrome.

What to Do

1. Examine the karyotype of Edwards syndrome (right).
2. Count and record the total number of chromosomes and chromosome pairs.
3. Determine whether the individual is male or female.

What Did You Find Out?

1. What chromosome error did you identify?
2. (a) Would karyotyping identify a gene mutation?
   (b) Why or why not?



6-1C Comparing Mitosis and Meiosis

SkillCheck

- Classifying
- Communicating
- Evaluating information
- Working co-operatively

Materials

- *BC Science 9* textbook

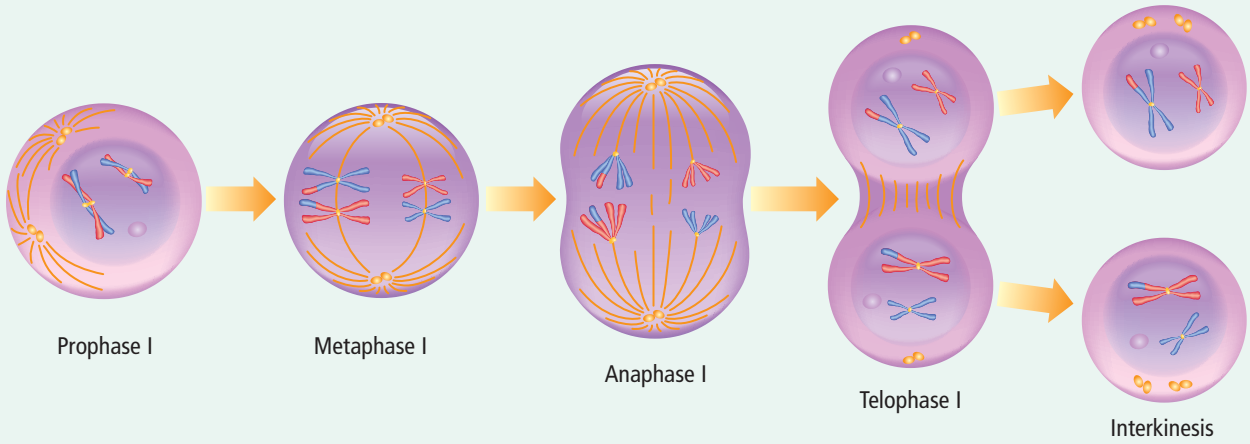
Mitosis and meiosis are two methods of cell reproduction. These two cell division methods have different purposes. Body cells divide by mitosis so that each of the two daughter cells receives a full set of chromosomes. Sex cells divide by meiosis with the result that each of the four cells produced receives half the number of chromosomes. In this activity, you will use your knowledge of mitosis to help further your understanding about the events in meiosis.

Question

How are the processes of mitosis and meiosis similar and how are they different?

Procedure

1. Work with a partner. Study the diagram shown here, which shows the events of meiosis. Carefully compare this diagram to Figure 5.8 of mitosis and the description of cytokinesis on pages 156 to 158. Compare the activities of the chromosomes, nucleus, and cell membrane at each stage.



Meiosis I

Prophase I

Homologous chromosomes pair up, and non-sister chromatids exchange genetic material. This process is called crossing over.

Metaphase I

Homologous chromosomes pair up at the equator.

Anaphase I

Homologous chromosomes separate and are pulled to opposite poles by the spindle fibres.

Telophase I

One chromosome from each homologous pair is at each pole of the cell.

Interkinesis

Interkinesis is the stage between cell divisions. During this time, the cell will grow and make proteins as in interphase of mitosis. Unlike interphase in mitosis, there is no replication of DNA during this stage.

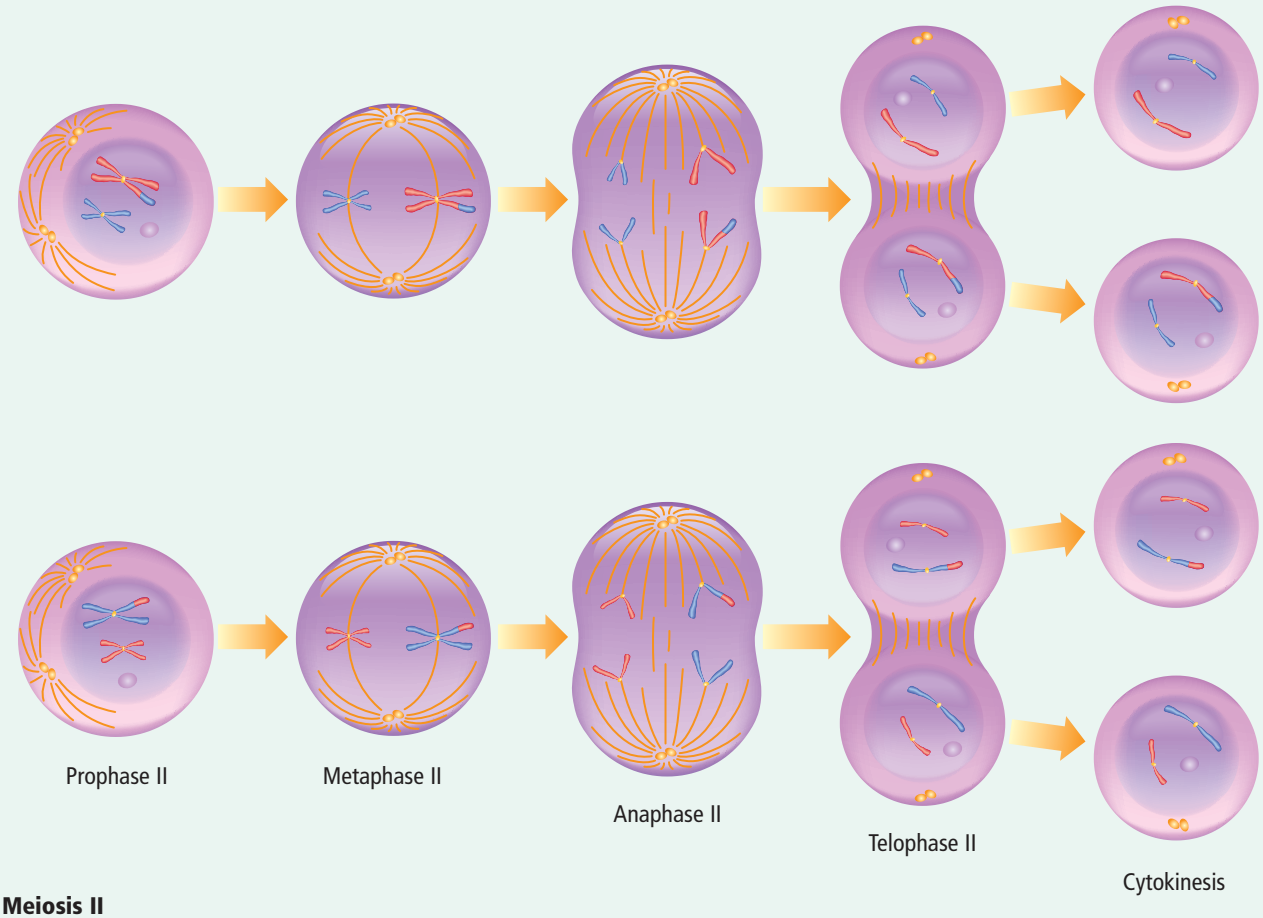
2. Your teacher will give you a chart in which you can compare meiosis I with mitosis. Write a brief description for each phase of meiosis I and mitosis in the chart.
3. Your teacher will give you a chart in which you can compare meiosis II with mitosis. Write a brief description for each phase of meiosis II and mitosis.
4. Compare your completed charts with another group's charts. Add any additional information to your charts.

Analyze

1. Is meiosis I or meiosis II more similar to mitosis? Explain.
2. List three similarities between mitosis and meiosis.
3. List three differences between mitosis and meiosis.

Conclude and Apply

1. (a) In a paragraph, explain the differences between mitosis and meiosis.
   (b) Explain which method contributes to genetic variation and why.



Meiosis II

Prophase II
There is one chromosome of the homologous pair in each cell.

Metaphase II
The X-shaped chromosomes form a single line across the middle of the cell.

Anaphase II
Sister chromatids move to opposite poles of the cell. Once they separate, each sister chromatid is considered to be a chromosome.

Telophase II
Spindle fibres begin to disappear, and a nuclear membrane forms around each set of chromosomes.

Cytokinesis
In cytokinesis, the two daughter cells are separated.

6-1D Modelling How Variation Occurs in Meiosis

SkillCheck

- Predicting
- Communicating
- Modelling
- Working co-operatively

Safety

- Be careful. The pipe cleaner ends are sharp.
- Do not put the pipe cleaners near anyone's eyes.

Materials

- 2 pink pipe cleaners
- 2 blue pipe cleaners
- scissors
- 4 beads, which 2 pipe cleaners can fit through
- red or pink pencil crayon
- blue pencil crayon
- blank paper

Genetic diversity is necessary for survival of a species. The process of mitosis in asexual reproduction does not produce variation, but the process of meiosis in sexual reproduction does produce variation. Two important events that occur in meiosis are crossing over and independent assortment. In this activity, you will model both of these events.

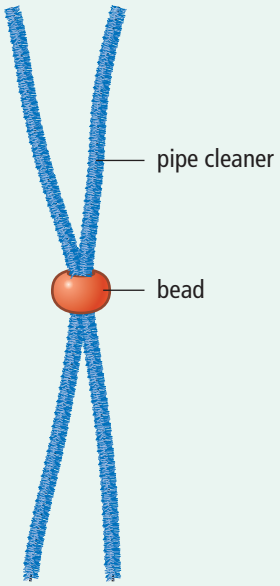
Question

How many different combinations can result from a single crossover in one pair of chromosomes?

Procedure

Part 1 Modelling Crossing Over

1. Cut a pink pipe cleaner $\frac{2}{3}$ of the way along its length.
2. Repeat this procedure for the other pink pipe cleaner and the two blue pipe cleaners.
3. Using two pipe cleaners the same length and colour, join the pipe cleaners in the middle by threading them through a bead (see the illustration below). The bead represents the centromere, and the two pipe cleaners represent the two chromatids of the chromosome. The pink chromosomes represent chromosomes that were inherited from the female parent. The blue chromosomes represent chromosomes inherited from the male parent.



Use a bead to join two pipe cleaners together.

4. Repeat step 3 for the remaining pipe cleaner pieces.
5. Pair up the pipe cleaners by length. The longer pink and blue pair represents one homologous pair of chromosomes, the shorter pair another homologous pair.
6. You will now model crossing over. The scissors represent an enzyme that cuts the chromosome. Use the scissors to cut one of the longer pink chromosomes 3 cm from its end. Cut a blue chromosome 3 cm from its end.
7. Attach the pink piece of chromosome to the shortened blue chromosome by twisting the wires together. Attach the blue piece of chromosome to the shortened pink chromosome by twisting the wires together. This models the action of enzymes reconnecting the pieces.
8. Copy the chart below in your notebook. Using your pink and blue pencil crayons, draw the chromosomes before and after crossing over occurs.

Appearance of Chromatids Before Crossing Over	Appearance of Chromatids After Crossing Over

Part 2 Modelling Independent Assortment

9. Draw a large circle on a blank piece of paper. Draw a dotted line across the diameter to represent the equator. Place the two pairs of homologous chromosomes from Part 1 at the equator as in metaphase I.
10. Model anaphase I by moving the homologous pairs apart toward opposite poles. On another sheet of paper, draw the two daughter cells that result, using pink and blue pencil crayons. Make sure you include the correct colours of the recombined chromosomes that resulted from crossing over.
11. Predict how many other different daughter cells are possible. Record your prediction.
12. Continue to model and draw all possible daughter cells that could result from the independent assortment of these two chromosome pairs.
13. Draw the possible gametes that could result following metaphase II.
14. Clean up and put away the equipment you have used.

Analyze

1. How many possible gametes could result from crossing over and the independent assortment of the two chromosome pairs?

Conclude and Apply

1. (a) Would crossing over between sister chromatids increase variation?
   (b) Explain why or why not.
2. How many possible gametes could result from crossing over and the independent assortment of the two chromosome pairs if crossing over had occurred in both chromosome pairs?

NATIONAL GEOGRAPHIC

VISUALIZING POLYPLOIDY IN PLANTS

You received a haploid (*n*) set of chromosomes from each of your parents, making you a diploid (2*n*) organism. In nature, however, many plants are polyploid—they have three (3*n*), four (4*n*), or more sets of chromosomes. We depend on some of these plants for food.

▲ **TRIPLOID** Bright yellow bananas typically come from triploid (3*n*) banana plants. Plants with an odd number of chromosome sets usually cannot reproduce sexually and have very small seeds or none at all.

▲ **TETRAPLOID** Polyploidy occurs naturally in many plants—including peanuts and daylilies—due to mistakes in mitosis or meiosis.

▼ **HEXAPLOID** Modern cultivated strains of oats have six sets of chromosomes, making them hexaploid (6*n*) plants.

▲ **OCTOPLOID** Polyploid plants often are bigger than nonpolyploid plants and may have especially large leaves, flowers, or fruits. Strawberries are an example of octoploid (8*n*) plants.

Check Your Understanding

Checking Concepts

1. Compare the number of chromosomes in a human skin cell to the number of chromosomes in a human egg cell.
2. What characteristics could you use to identify a pair of homologous chromosomes?
3. What are the benefits of genetic diversity?
4. How does a zygote become an embryo?
5. Identify whether each of the following is an event in meiosis I or meiosis II.
   (a) Individual chromosomes move to the equator.
   (b) Homologous pairs of chromosomes move together to the equator.
   (c) Crossing over occurs.
   (d) Homologous chromosomes move to opposite poles.
   (e) Centromeres divide.
6. Copy the following table in your notebook. Complete the table comparing mitosis and meiosis.

Question	Mitosis	Meiosis
Where does it take place?		
How many cells are produced?		
What happens to the number of chromosomes?		
How do parent and daughter cells differ genetically?		
How do daughter cells compare to each other genetically?		

7. What is the difference between chromosomes in meiosis I and mitosis?
8. How does the number of chromosomes in metaphase of mitosis compare to the number of duplicated chromosomes in metaphase II of meiosis?
9. Explain how crossing over can result in variation.
10. Explain how independent assortment can result in variation.
11. Give an example of a chromosome mutation.
12. Give an example of a genetic disorder.

Understanding Key Ideas

13. Whole chromosomes can be lost or added during meiosis. Explain how this can occur.
14. Explain why meiosis is important for the survival of organisms.
15. Explain how you can tell whether a sperm cell is in meiosis I or meiosis II.
16. Draw a pair of homologous chromosomes before and after crossing over.
17. A dog has 76 chromosomes.
    (a) How many pairs of homologous chromosomes does it have?
    (b) How many chromosomes would be in each sperm cell of a dog?
18. What stage of the cell cycle would be best to use for karyotyping? Explain.

Pause and Reflect

Two types of twins can result from fertilization: identical twins and fraternal, non-identical twins. Identical twins result when one embryo splits in two. Such twins are genetically identical and look the same. However, their fingerprints will differ because fingerprints are caused by the movement of the fluid that surrounds the fetus as it grows inside the mother. As identical twins age, they will look less alike. What types of changes may occur that will make the twins less alike?

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.

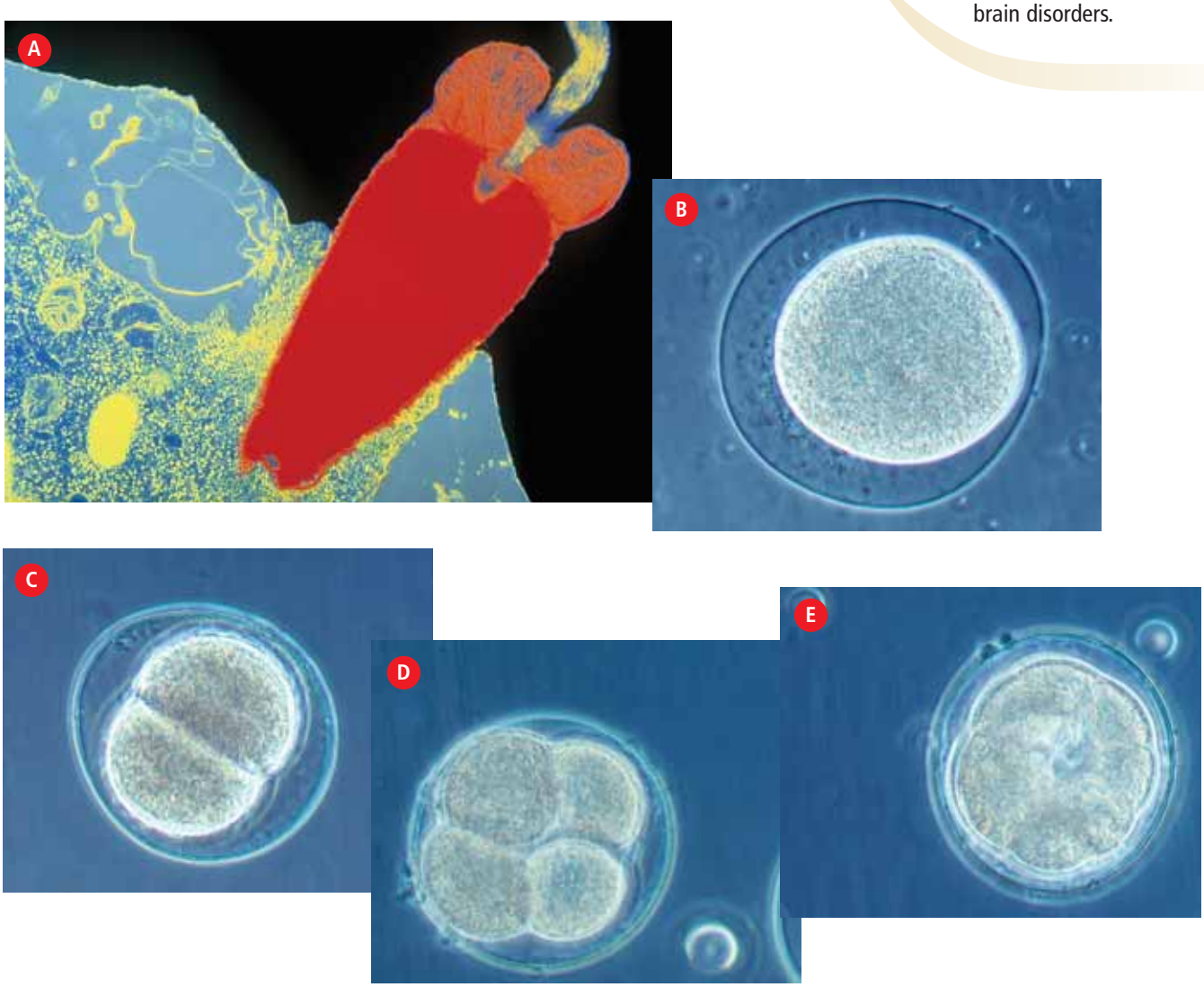


Figure 6.15 This series of photographs shows the process of fertilization and early development in the sea urchin (A to E). Sea urchin egg cells are the same size as human egg cells. Their size and transparency make them a model organism for the study of reproduction in humans and other animals.

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.

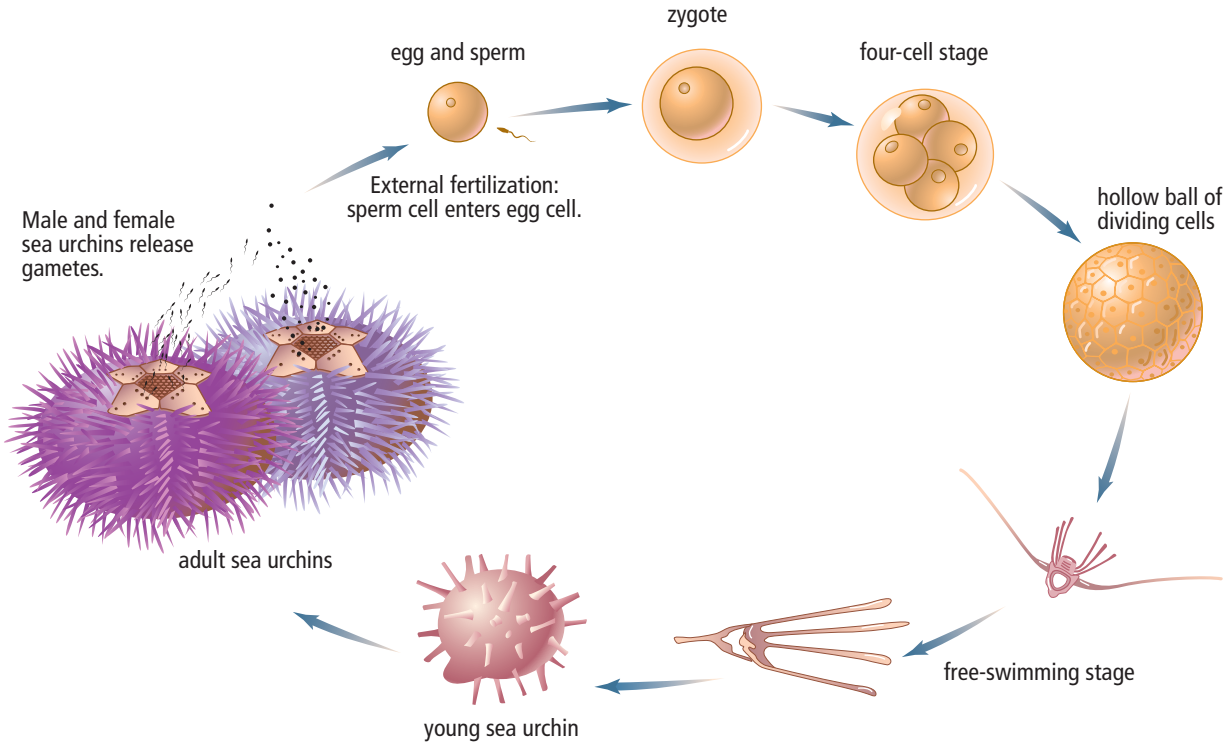


Figure 6.19 The life cycle of the sea urchin. Many water-dwelling animals that rely on external fertilization have a similar life cycle.

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.

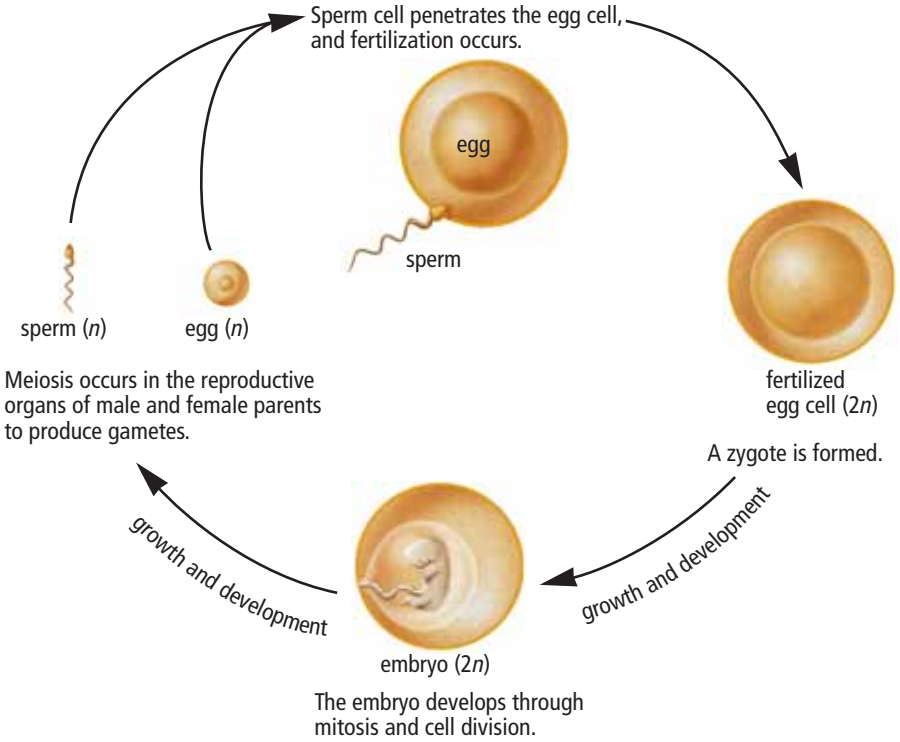


Figure 6.23 The life cycle of animals

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.

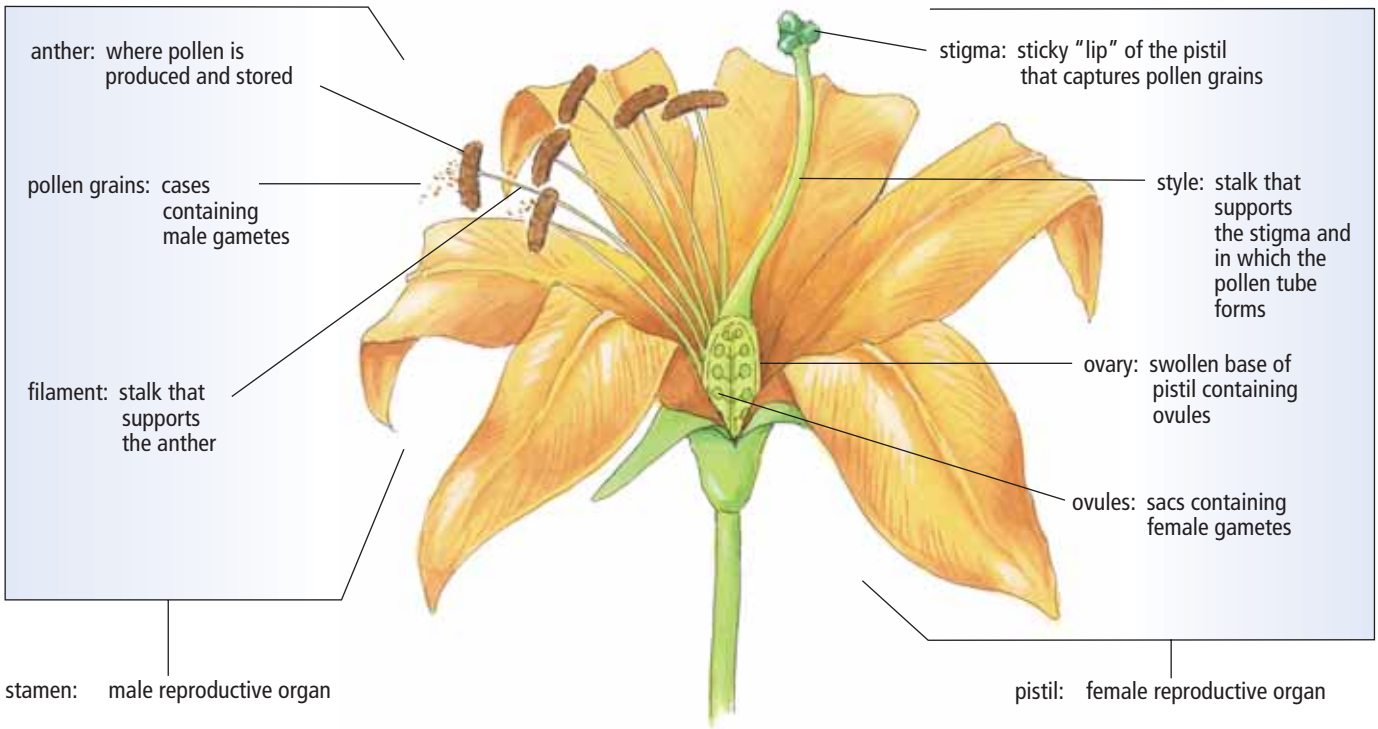


Figure 6.28 The reproductive structures of a flowering plant

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.

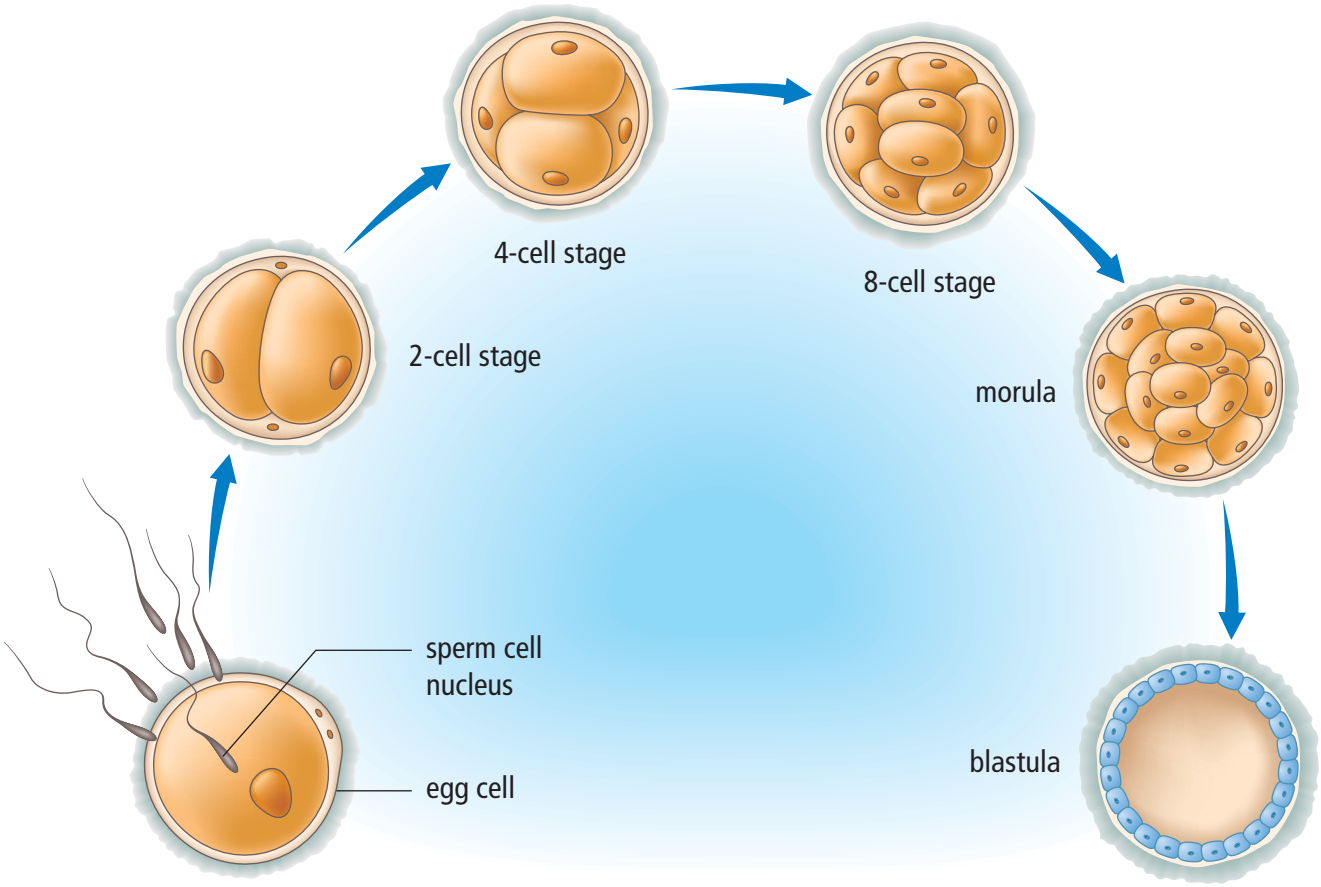


Figure 6.33 Mitosis and cell division are the basis of embryonic development.

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.

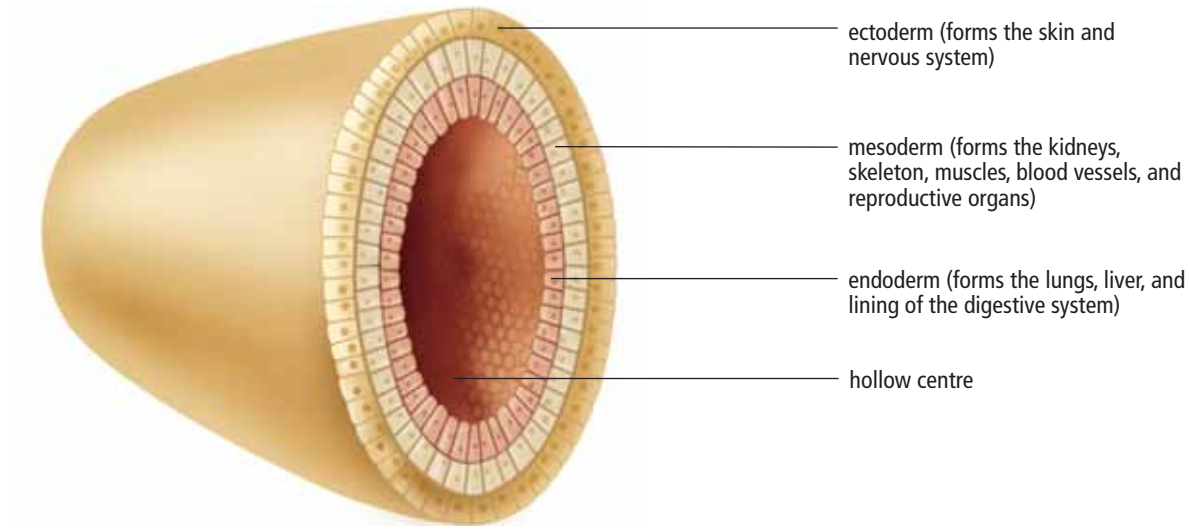


Figure 6.34 In the gastrula, cells are organized in three layers. Cells in these layers will eventually form organs.

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

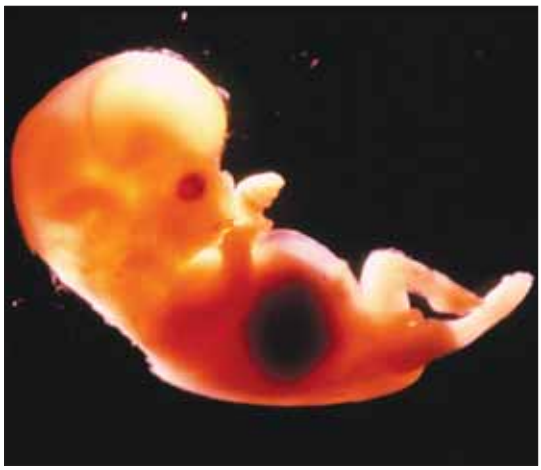


Figure 6.35C The fetus at 12 weeks

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

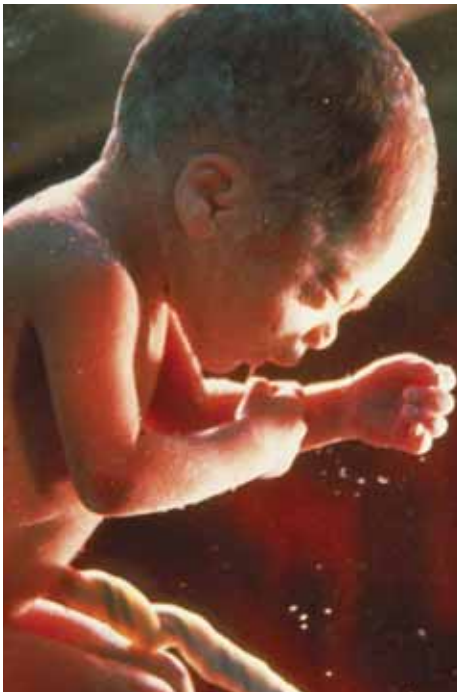


Figure 6.37 The fetus at eight to nine months

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.

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?