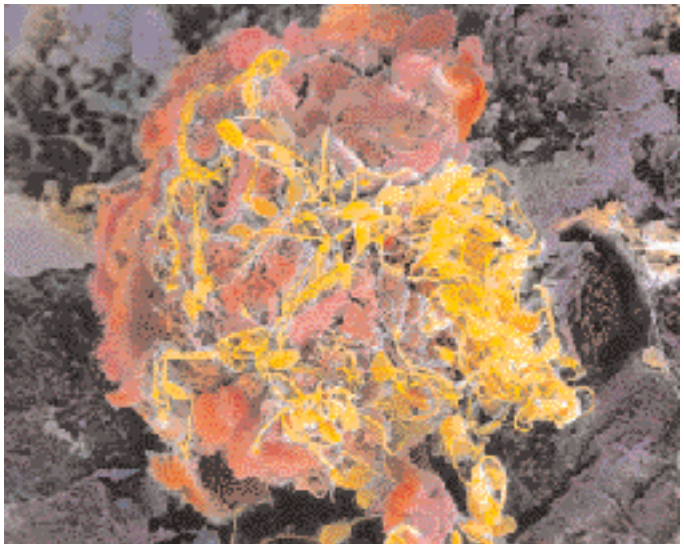
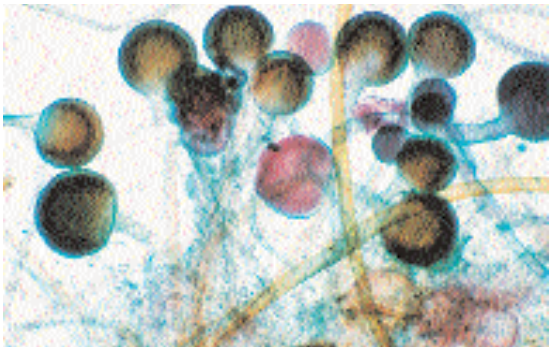
CHAPTER

8 Zygotes and Development

Getting Started



1. Only one egg cell and one sperm cell are needed to form a zygote. In fact, as soon as the egg is fertilized, it forms a barrier to keep all other sperm out. But both plant and animal males produce millions of sperm cells. Why are so many produced if only a single sperm is required?



2. Organisms develop in so many different ways. Look at the photographs and list some of the strategies for development that are represented. What are the advantages of each strategy? Can you identify any possible disadvantages? What are they?

3 The female sea turtle comes ashore once every two or three years to nest and lay her eggs. Some species travel as much as 3000 km from their birthplace to their feeding grounds. Then, they return to the beach where they were born. They dig holes, lay their eggs, cover them up with sand, and return to the ocean, abandoning the eggs. Why do the turtles travel so far to reproduce? Why do they lay so many eggs? The sea turtle produces many eggs, while humans usually produce a single offspring. What are the advantages of each strategy?

Reflecting

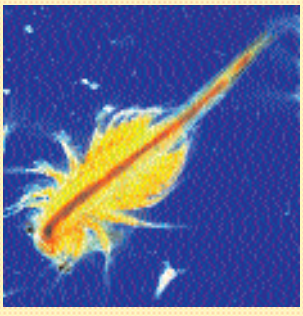
Think about the questions in 1, 2, 3. What ideas do you already have? What other questions do you have about zygotes and how they develop? Think about your answers and questions as you read the chapter.

Try This — Observing the Growth and Development of Brine Shrimp

Brine shrimp, related to shrimps and lobsters, have a simple life cycle. Eggs hatch into larvae. As they develop to adults, they shed their outer skeleton approximately 12 times. With each shedding, the brine shrimp not only get larger but also add body segments. Close examination will reveal that the number of hairs on their legs increases as they age.

Place 100 mL of a 4% salt solution into a 250-mL beaker. Add approximately 0.1 g of shrimp eggs to the water. Using a hand lens, examine the water for brine shrimp eggs each day until they hatch.

1. Describe the appearance of the eggs.
2. Construct a data table. How many days did it take for the eggs to hatch?
3. Describe the appearance of the brine shrimp as they develop.



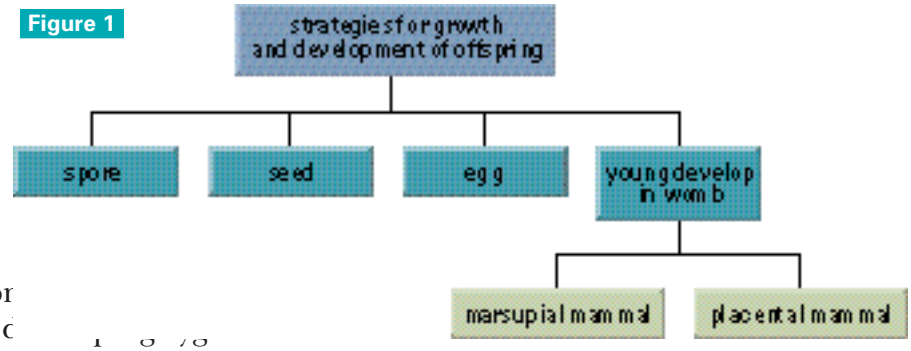
Survival and Development of Organisms

For a species to survive, its offspring must survive. Different organisms use very different strategies and combinations of strategies to ensure the survival of their offspring (**Figure 1**). Nevertheless, some general categories can be identified.

Key Strategies for the Survival of Offspring

- Some organisms produce a zygote that remains in suspended animation (i.e., does not develop) until environmental conditions become favourable. Water, food, and/or warmth can activate growth and developr
- Some organisms wrap their c an **embryo**—in a food package. This food supports immediate development, making the organisms less dependent upon environmental factors.
- In some organisms, the embryos develop within the adult organism, protected from unfavourable environmental conditions.
- The adults of some organisms protect and nourish their offspring after birth.

Figure 1



Spores

A **spore** is a reproductive body encased within a protective shell. If environmental conditions become unfavourable for life, the organism may produce spores that enter a state of suspended animation. Once conditions become favourable again, the spores germinate, and the organisms enter a growth phase.

Many different bacteria form spores, as shown in **Figures 2** and **3**, with each cell forming a single spore. The spore contains genetic material surrounded by a tough cell wall, which is resistant to heat, drying, boiling, and radiation. When conditions improve, the wall breaks down and an active bacterium emerges.

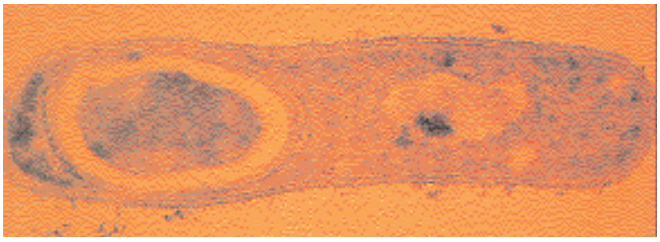


Figure 2
An electron microscope photo of a spore inside a bacterial cell

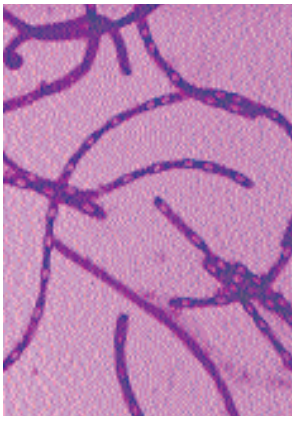


Figure 3
Anthrax is a disease caused by the spore-forming bacteria, *Bacillus anthracis*. Each of the rodlike filaments is a separate organism. The white, oval disks that appear in each of the filaments is a spore. The deadly disease affects sheep, cattle, and people. Spores can lie on the ground for many years, becoming active only when they enter an animal.

Fungi reproduce by way of tiny spores that are easily dispersed by wind. Once environmental conditions become favourable, cells in the spore begin to divide and grow.

A spore from the fungus that grows into bread mould can sit on a counter for months. If the spore finally lands on a food source, such as a sandwich, it germinates. If the sandwich sits in a locker for a few weeks, the conditions are ideal for growth. The warmth and moisture cause the fungus to grow into thousands of threadlike structures. Each thread develops a spore case, which can release thousands of spores (**Figure 4**).

Moss and fern plants also reproduce by way of spores (**Figures 5** and **6**). The spores grow into structures that produce male or female sex cells.

Figure 4
The black spots on the bread mould are spore cases.

Figure 5
The orange structure is a ripe spore case of a moss plant.

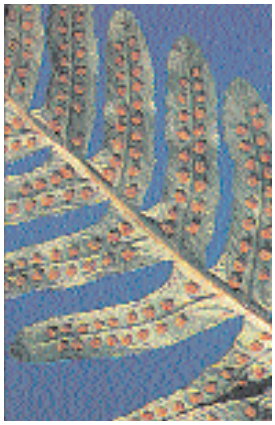


Figure 6
Spore cases are the brown structures found under the leaves (fronds) of fern plants.

Seeds

A seed contains the plant embryo wrapped in a protective package that contains food. Unlike spores, which must wait until environmental conditions become favourable, seeds bring nutrients to their environment and can get a head start on growth.

Needle-producing trees, such as pine, spruce, and fir, have exposed seeds in a conelike structure, as seen in **Figure 7**. Because the seeds are not protected, they are often described as "naked seed coats." Flowering plant seeds are enclosed and protected inside a fruit, formed by the ovary of the flower (**Figure 8**).

Figure 7
These pine seeds are not protected.

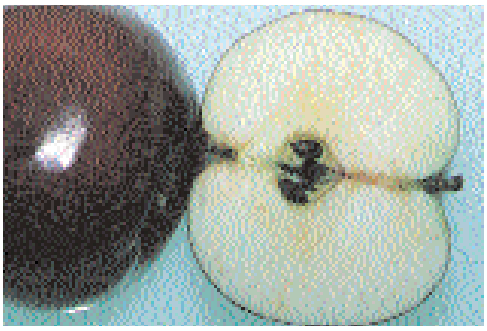


Figure 8
The apple seeds are protected within the fruit.

Eggs

The vast majority of animals lay eggs. An egg includes a zygote and some food, plus some mechanism for protection (e.g., a shell or a jellylike substance). Some organisms fertilize their eggs internally (e.g., insects, birds) before a tough shell is secreted. Others, usually aquatic animals (e.g., fish, frogs), fertilize the eggs externally.

The tapeworm, a parasite that lives in the intestines, produces thousands of eggs in each egg case (**Figure 9**). As an infected animal defecates, some of the egg cases break and eggs are released. A resistant coating prevents the eggs from drying up and sticks to blades of grass or other plant material. If another animal eats the grass, it swallows the eggs. In the intestines, they develop into adult tapeworms that can grow up to 20 m long.

For the tapeworm, the strategy of laying a large number of eggs is important, because only a few of the eggs will actually find their way into the body of another animal. Many other animals produce thousands of eggs for this same reason: few of their offspring survive to adulthood. Most of the others are eaten.

Reptile and bird eggs are especially well adapted for surviving on land. Their "amniotic" egg, shown in **Figure 10**, provides a self-contained environment for the developing embryo.

The spiny anteater and duckbill platypus are the only mammals that lay eggs (**Figure 11**). Like birds, they incubate the eggs outside the body. However, they nourish the young from mammary glands that secrete milk directly onto the fur.

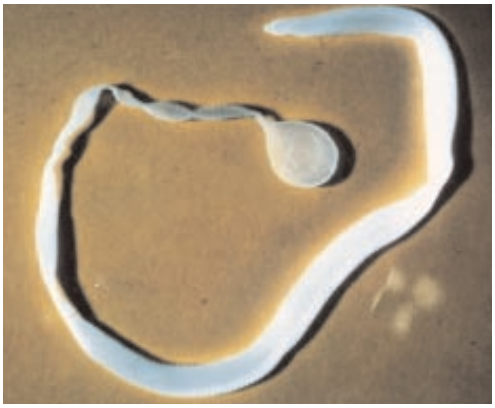


Figure 9

Each egg case produced by this tapeworm will contain thousands of eggs.

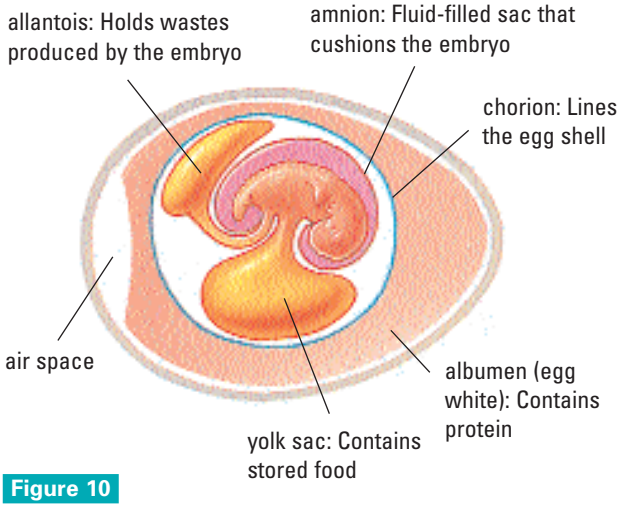


Figure 10

The amniotic egg is a protective, self-contained environment.

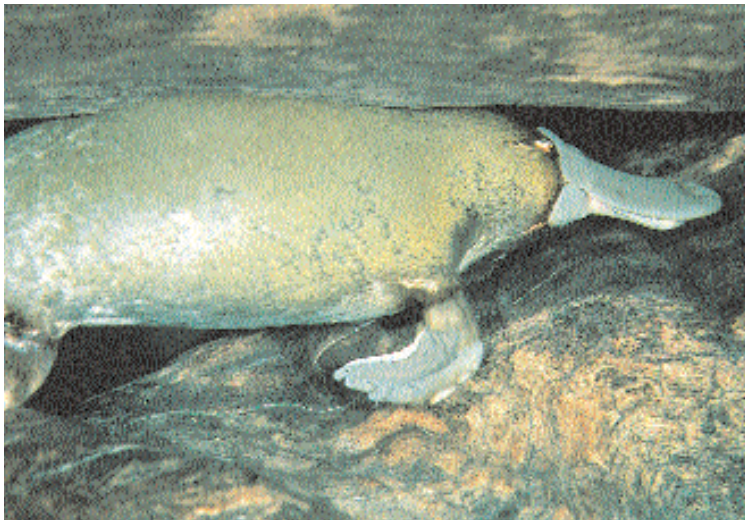


Figure 11

The spiny anteater (left) and the duckbill platypus (right) are mammals that lay eggs.

Marsupial Mammals

Marsupials (e.g., kangaroos, koalas, and opossums) are born tiny and immature (**Figure 12**). After emerging from the uterus, they crawl into a pouch and attach to the nipple of a mammary gland. Once they have grown too big to be carried, the offspring leave the pouch but may return for additional milk as long as the mother allows.

Figure 12

Opossums are marsupial mammals. Inside their mother's pouch, each of the young has its own nipple.

Placental Mammals

Most mammals, including humans, belong to a group called placentals (**Figure 13**). Their young develop in the uterus or womb. After the embryo implants in the endometrium, blood vessels from the mother and embryo grow side-by-side and form an organ called the **placenta**. Although the two blood supplies remain separate, oxygen and nutrients diffuse from the mother's blood into the embryo's blood. Wastes from the embryo diffuse into the mother's blood and are carried away to be excreted. The umbilical cord connects the embryo and the placenta.

In general, the offspring of placental mammals develop more slowly than the young of other animals and require greater long-term care. The mother provides the young with milk and protects them from danger.

Figure 13

Wildebeest are placental mammals. A young wildebeest must begin running shortly after it is born. If it doesn't, it might fall prey to hyenas.

Understanding Concepts

1. Identify an organism that uses each of the following strategies to ensure survival of their offspring. Describe the strategy more fully and explain why it is used.
   - **(a)** The zygote remains in suspended animation until environmental conditions become favourable.
   - **(b)** The zygote is wrapped in a food package.
   - **(c)** The young develop within the adult organism.
   - **(d)** The adult protects and nourishes the offspring after birth.
2. Identify three organisms each that produce spores, seeds, and eggs.
3. Compare reproduction by spores and seeds by listing the advantages and disadvantages of each strategy.
4. Compare the development of the zygotes of a bird, a frog, and a human, by listing the advantages and disadvantages of each strategy.

Making Connections

5. In Australia, the introduction of placental mammals has often caused problems for resident marsupial mammals. Research the impact on the ecosystem and hypothesize about why marsupial mammals aren't able to compete with placental mammals that have similar needs. (3A)

Challenge

How does changing the way animals reproduce affect the other species in the ecosystem? Consider this question as you think about your Challenge.

8.2 Investigation

SKILLS MENU
○ Questioning ● Conducting ● Analyzing
● Hypothesizing ● Recording ● Communicating
○ Planning

Examining Plant Embryos

One successful strategy for reproduction is the production of seeds. A seed is actually an embryo with packaged food. The food, usually in the form of starch, provides nourishment for the early growth of the young plant until it begins to manufacture its own food. The food in seeds also feeds humans around the world. Half the world's food comes from the seeds of just three plants—wheat, rice, and corn.

In this investigation iodine is used to identify starch. Starch turns a blue-black colour when iodine is added.

Question

Do seeds carry food?

Hypothesis

1 Write a hypothesis for this experiment.

Materials

- safety goggles
- gloves
- apron
- dry bean seeds
- bean seeds soaked in water for 24 h
- dissecting needle
- hand lens or dissecting microscope
- iodine solution
- paper towels
- coloured pencils
- corn seeds soaked in water for 24 h
- single-edged razor blade

Procedure

2 Obtain a dry bean seed and one soaked in water for 24 h. Use **Figure 1** to help you identify the various parts of the seed.

(a) Compare the appearance of the soaked and dry bean seeds.

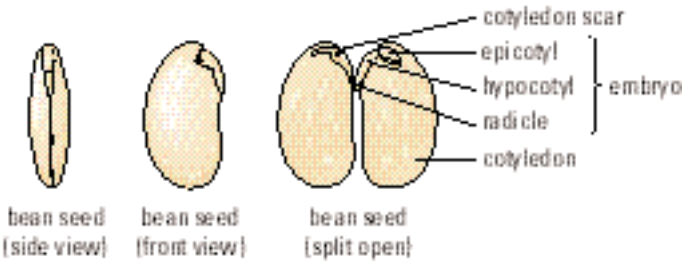


Figure 1
A bean seed

(b) Suggest a reason for at least one difference you observe.

3 Use your fingers to gently remove the seed coat from the soaked bean seed. Using a dissecting needle, pry the two sections of the seed apart. Locate the embryo and examine it with a hand lens or dissecting microscope.

(a) Draw a diagram of the embryo. Label (6C) the cotyledon, the hypocotyl, the epicotyl, and the radicle.

Caution: Exercise care when using the sharp dissecting needle.

4 Devise a test to determine which parts of (4B) the embryo contain starch. Test the embryo for the presence of starch.

(a) Describe the test you used for starch.

(b) On your diagram, use a coloured pencil to mark any areas where you obtained a positive test for starch.

(c) What function does the starch serve?

Caution: Iodine irritates eyes and skin and may stain.

5 Obtain a corn seed (kernel of corn) that has been soaked in water for 24 h. Lay the corn seed down with the embryo facing upward. Use **Figure 2** to help you identify the various parts of the seed. Carefully examine the seed.

(a) How does the corn seed differ from the bean seed?

(b) One side of the corn seed is lighter. This is the location of the embryo. Draw the embryo and label your diagram.

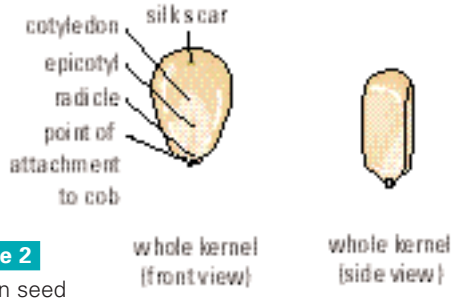
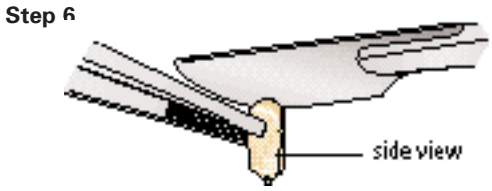


Figure 2
A corn seed

SKILLS HANDBOOK: (6C) Scientific Drawing (4B) Designing a Procedure

6 Using a razor blade, cut the seed in half lengthwise to expose the interior.



Use caution when using the razor blade.

7 Test various areas of the corn seed for starch using the same technique you used in step 4.

(a) Which areas have the greatest amount of starch? Use a coloured pencil to indicate these areas on your diagram.

Analysis and Communication

8 Analyze your observations by answering the following questions:

(a) Bean seeds are classified as "dicotyledons" and the corn seeds are classified as "monocotyledons." On the basis of your observations explain the meaning of the prefixes "mono" and "di."

(b) Your teacher will supply you with a diagram of a germinating bean seed, similar to **Figure 3**. Using a red coloured pencil, colour the radicle in each of the successive pictures. Repeat the procedure by colouring the hypocotyl with a blue pencil and the epicotyl with a green pencil.

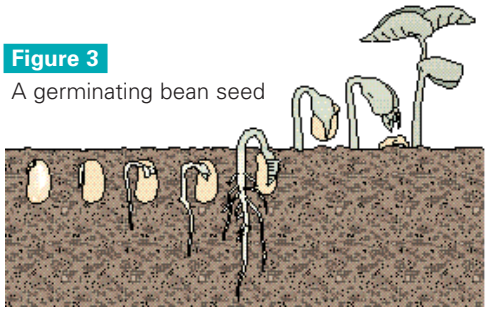


Figure 3
A germinating bean seed

(c) Your teacher will supply you with a diagram of a germinating corn kernel, similar to **Figure 4**. Using a red coloured pencil, colour the radicle in each of the successive pictures. Repeat the procedure by colouring the hypocotyl with a blue pencil and the epicotyl with a green pencil.

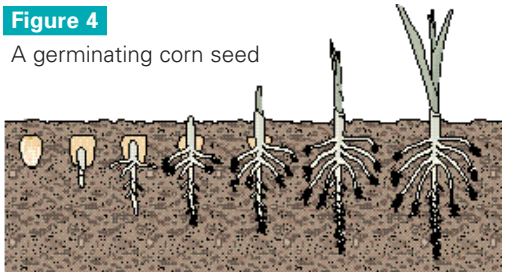


Figure 4
A germinating corn seed

(d) Examine the diagram of the germinating bean seedling and describe what happens to the cotyledon as the seedling grows.

(e) Why does the bean plant no longer need the cotyledon?

(f) Examine the diagram of the germinating corn seedling. Explain why the endosperm gets smaller as the plant grows.

Exploring

1. Find out more about the importance of a cotyledon by doing this experiment. In a tray of potting soil, plant three rows of bean seeds. In row 1, plant the entire seed. In row 2, remove one of the cotyledons and then plant the seeds. In row 3, remove both cotyledons and plant the embryos only. Measure and compare the growth rates of the plants.

SKILLS MENU
- Questioning
- Conducting
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- Planning

Germinating Seeds

Everything a new plant needs is found inside the seed: the embryo and a packaged food supply. Its protective coat resists the cold and prevents drying for many months or maybe even years. Each seed is specially adapted for specific environmental influences. Each embryo "knows" when it is time to start growing (germinating).

Most of the world's food crops are annual plants. Harvesting crops means taking the seeds and growing them anew each year (**Figure 1**). Knowledge of factors affecting seed germination is vital to food production.

In this investigation, you will design an experiment to determine how various environmental factors affect seed germination. Because not all seeds are the same, your conclusions must be restricted to the seeds you are studying.

Figure 1
Seeds, like this wheat grain, are one of Canada's most important products.

Question

1 Write an overall question for this (2A) investigation.

Hypothesis

2 Write a hypothesis for your group's research project.

Materials

- safety goggles
- apron
- gloves
- radish and tomato seeds
- bean and lettuce seeds
- other materials as required

Experimental Design

3 You will work in research teams. Each team will work on one of the questions in **Table 1**. Pairs of teams working on the same question will use either radish and tomato seeds or bean and lettuce seeds, and then share data.

4 (4B) Work with your team to design an experiment to investigate your problem. Work with other teams to ensure that you will be able to exchange data later. Read the following suggestions before you begin:

- Make sure that your seeds do not dry out.
- Check your seeds for mould that will slow growth and eventually kill the seeds. Remove seeds that show signs of mould. Always use clean tweezers to handle seeds, to reduce the risk of introducing mould.

Table 1 **The Research Questions**

A	How does temperature affect the germination and growth of seeds? Consider testing a warm environment, room temperature, and a low temperature.
B	Does light affect germination and growth of seeds? Consider using different light sources (artificial and natural) and a dark area.
C	How do plants grow in acidic conditions? Use different concentrations of acetic acid (vinegar) in water.
D	How do plants grow in basic conditions? Use different concentrations of dilute sodium hydroxide in water as the base.

Caution: Sodium hydroxide is corrosive. Wear gloves and safety goggles when using; avoid contact with skin.

SKILLS HANDBOOK: (2A) Controlled Experiments (4B) Designing a Procedure

5 Your design must include a complete list of materials and equipment and describe any safety precautions needed.

Wear safety goggles and a lab apron for the entire procedure. Even if your procedure does not require you to work with an acid or base, other people in the class will be. The entire work area must be safe.

6 You must identify your independent and dependent variables and describe how you will control other variables.

7 Your design must include a description of how you will measure your variables. Include sample tables for recording data.

8 Present your design to your teacher for approval.

Procedure

9 Conduct your investigation.

Analysis and Communication

10 Analyze your results by answering the following questions:

(a) What conclusions can you draw from your experiment?

(b) What other experiments might you need to perform to test your conclusions?

(c) If possible, present your data in graph form.

(d) How did your results compare with those of the other groups with your research problem? with your types of seeds?

(e) Can you draw any conclusions from the class data?

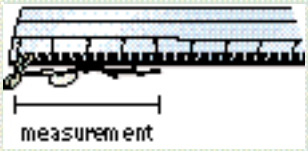
11 Prepare a complete written report. 8A

Making Connections

1. Did you notice the different lengths of the 7B seedlings? With enough data, you can determine the range of growth for a particular plant at a particular time. Construct a graph to represent the data in **Table 2**. What conclusions can you draw from the data? Why aren't all of the seedlings the same length if the environmental conditions are the same?

Table 2

Length of shoot (mm) after day 2	Number of plants
10	1
12	3
14	6
16	14
18	22
20	15
22	7
24	3
26	1



2. Why might scientists be interested in the answers to the questions your class researched?

Reflecting

3. If your team repeated the experiment, what would you do differently? Why would you change your approach?

Challenge

In this investigation you had to work in a team to design and conduct an investigation. What have you learned from this experience that might help you when you are working on your challenge?

Eggs and Embryo Development

Life begins as a single unfertilized egg which, when fertilized, becomes a zygote. As the zygote becomes an embryo, it undergoes many cell divisions by mitosis. Specific genes are turned "on" and others are turned "off" as the number of cells increases. Cells begin to differentiate into various tissues, and organs begin to develop.

Although animals vary greatly as adults, their initial stages of development are surprisingly similar. By observing the development of a frog embryo, you can begin to appreciate how a human embryo develops.

Materials

- small bowl
- unfertilized chicken egg
- pencil
- fertilized frog eggs (if available—spring only)
- microscope slide
- tweezers
- prepared slides: frog embryology set
- light microscope

Procedure

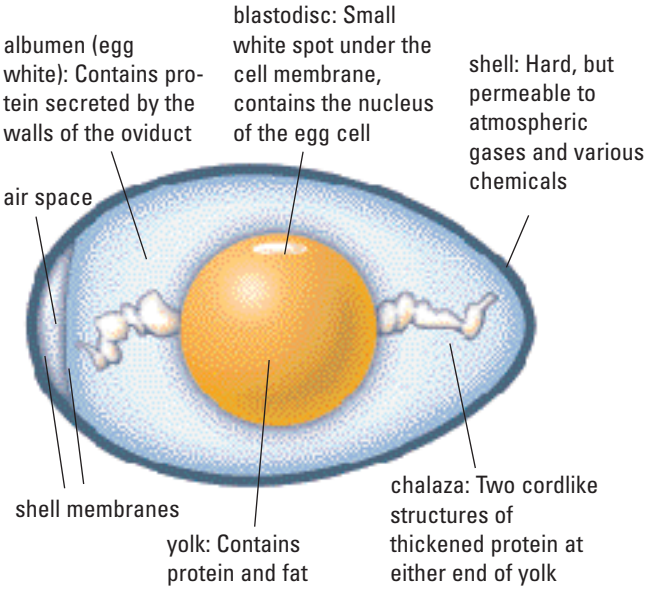
1 Fill a small bowl halfway with water. Gently crack the shell of an unfertilized chicken egg around its centre. Place the egg in the small bowl and gently break open the shell to release the contents.

Step 1

2 What you see is a single, large cell (the yolk) surrounded by the egg white. Carefully examine the egg cell. Use **Figure 1** to help you identify and locate the structures. You may have to gently turn the egg yolk to see the blastodisc. Also, examine the shell to find the egg membranes and air space.

Figure 1

The egg shell is fused to two cell membranes all around the egg. At the airspace at the blunt end, the two membranes are separated. Note the chalaza that connect the egg cell with the two ends of the egg. They probably act as shock absorbers.



(a) Often, the appearance of a structure provides clues to its function. Create a summary table similar to **Table 1**. Record the appearance and predict a function for each structure.

Table 1

Structure	Appearance	Predicted function
shell	?	?
shell membranes	?	?
air space	?	?
yolk	?	?
albumen	?	?
blastodisc	?	?

3 Using the tweezers, gently touch the yolk. Note the thin membrane that surrounds it.

(a) Gently puncture the membrane and describe what happens.

4 If living frog eggs are available (**Figure 2**), 5B place a single egg on a microscope slide and observe it with a microscope using low power.

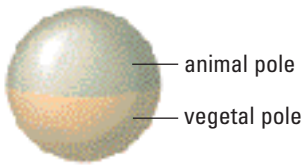
(a) Describe the appearance of the frog egg.

5 Obtain prepared slides of developing frog embryos and examine them using the low power of the microscope. Use **Figures 3**, **4**, and **5** to help you identify what you see.

(a) Make sketches of the slides you viewed. 6C Make sure to label your diagrams.

Figure 2

The fertilized frog egg can be divided into two regions. The lighter vegetal pole contains the yolk. The darker animal pole develops into the embryo.



Understanding Concepts

1. Unlike human mothers, chickens and frogs supply no food or oxygen to developing embryos after their eggs are laid.
   (a) How do these embryos get food?
   (b) How do they get oxygen?
2. How is the chicken egg different from the frog egg?
3. Why do frogs lay so many more eggs than chickens?

Exploring

4. The chalaza may help rotate the blastodisc to the top of the yolk. What is the advantage of having the blastodisc on the top of the egg?

Figure 3

After fertilization, the zygote undergoes several cell divisions, called cleavages, during which all the cells divide at the same time. a The first cleavage divides the zygote into two cells. b The next cleavage occurs perpendicular to the first and divides the zygote into four cells. The third cleavage divides the mass into eight cells.

a first cleavage, 2.5 h

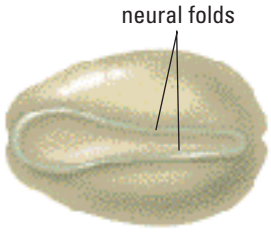
b second cleavage, 3.5 h

c eight-cell stage, 4.5 h

a blastula, 12 h

b gastrula, about 20 h

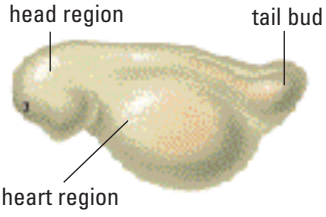
c yolk plug stage, 32 h



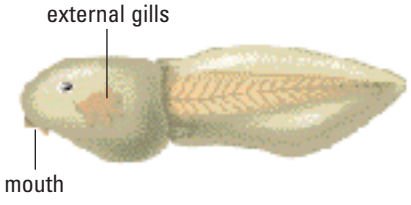
d embryo, 48 h

Figure 4

About 8 h after fertilization, the zygote, now called an embryo, resembles a raspberry. a The 64-cell stage is a hollow ball of cells. b In the next stage, some cells migrate toward the inside of the hollow mass. c A round structure called a yolk plug can now be seen protruding from the inner layer. d After 48 h, a groove called the neural fold appears along the outer surface of the embryo. Cells in this area will develop into the spinal cord and brain.



a heartbeat, 4 days



b circulation in gills, 6 days

Figure 5

By the fourth day after fertilization the embryo begins to look like a tadpole. a On day 4 beating of the heart is visible. b After 6 days, blood can be seen moving through the developing gills.

Human Conception and Pregnancy

During human intercourse, about 150 to 300 million sperm cells travel through the vagina into the uterus. However, only a few hundred actually reach the oviducts and the egg (**Figure 1**).

During fertilization (**Figure 2**), also called **conception**, the head of the sperm cell penetrates the cell membrane of the egg. Even though several sperm become attached to this membrane, only a single sperm cell penetrates the egg.

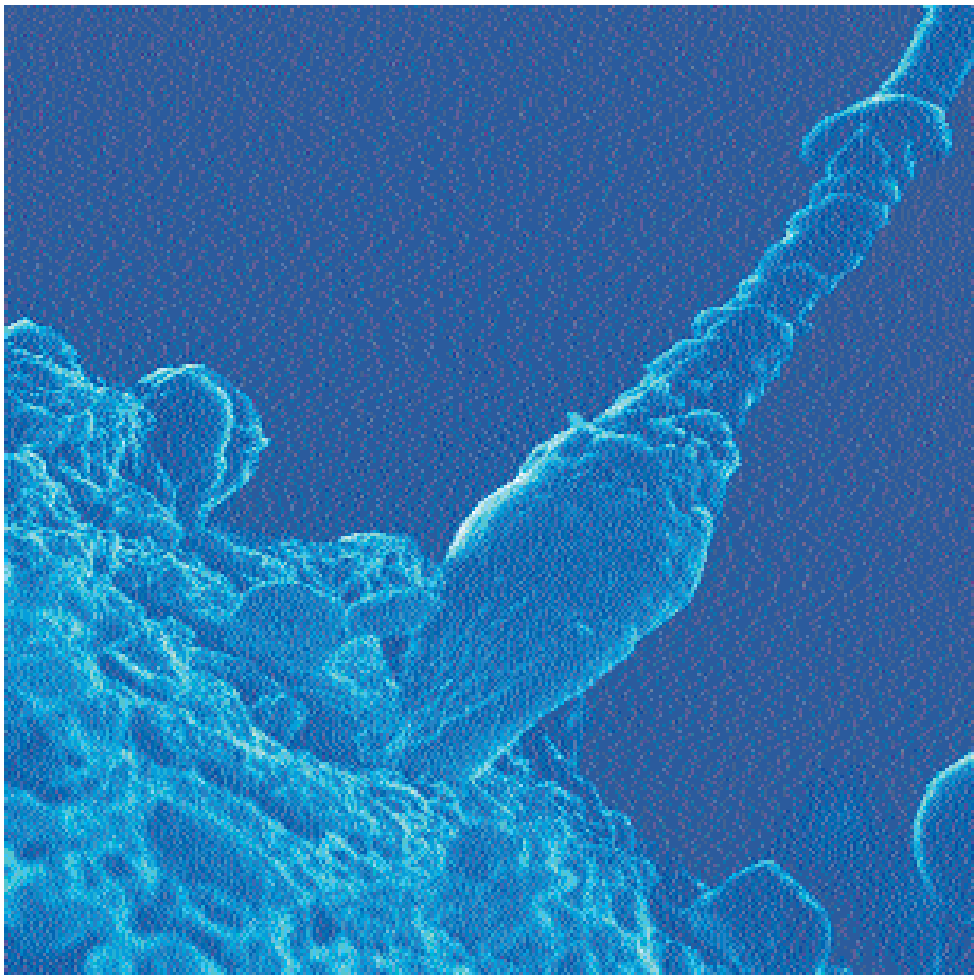


Figure 1
Human sperm cell and egg cell

Did You Know

Sperm cells can survive as long as five days in the oviduct of the female. The egg cell is capable of surviving only 48 h after ovulation if it is not fertilized.

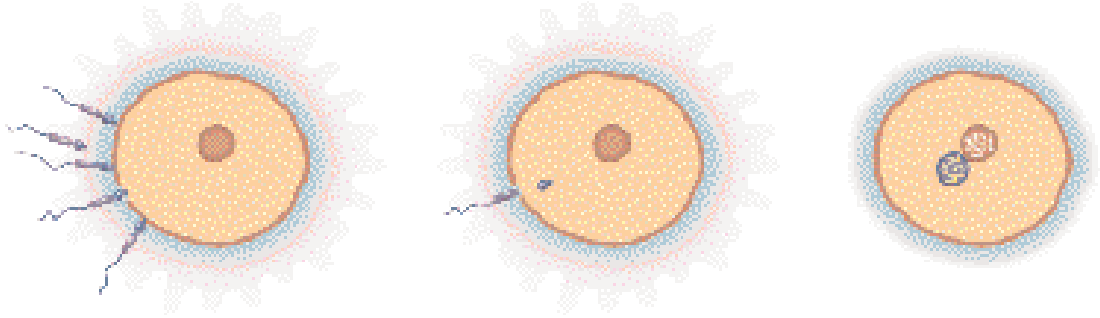


Figure 2
Fertilization

a Sperm cells attach to the egg cell. A single sperm cell penetrates the cell membrane.

b The mitochondria and flagellum of the sperm cell are pinched off by the cell membrane of the egg cell.

c The nucleus of the sperm cell finds the nucleus of the egg cell, and the 23 chromosomes from the sperm cell combine with the 23 chromosomes from the egg cell.

That sperm cell's nucleus combines with the egg's nucleus. The mitochondria and flagellum of the sperm cell are pinched off by the egg's cell membrane.

Within hours after fertilization, tiny hairlike cilia that line the oviduct move the zygote into the uterus. As it travels, it undergoes mitosis (**Figure 3**). Around the fourth day, a 16-cell mass enters the uterus where it floats freely for about two days (**Figure 4**). The dividing cell mass, which now has more than 100 cells and is a hollow sphere, implants in the wall of the endometrium. It is now called an embryo.

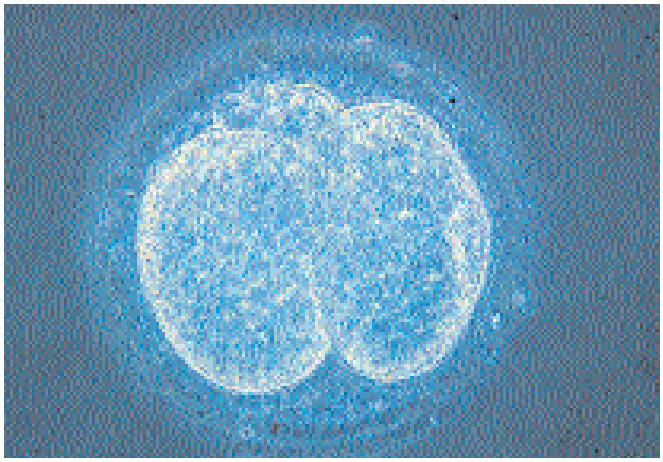


Figure 3

After conception, the zygote begins to divide rapidly. Here it has completed the first division.

Embryonic blood vessels and maternal blood vessels in the endometrium combine to form the placenta. Through the placenta, nutrients and oxygen diffuse from blood vessels of the mother into blood vessels of the embryo, while wastes diffuse from the embryo's blood into the mother's. The mother disposes of the wastes.

After about three months of pregnancy, the placenta begins producing estrogen and progesterone. High levels of progesterone, first from the corpus luteum and later from the placenta, prevent further ovulation. This means that once a woman is pregnant, she cannot conceive again until after the birth.

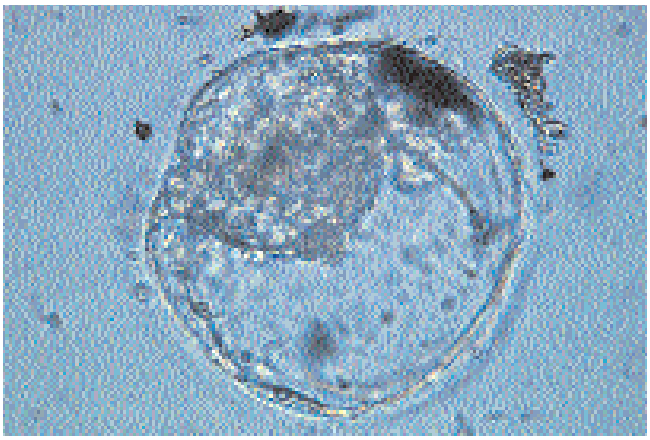


Figure 4

Cell division continues through the six days from conception to implantation.

Understanding Concepts

1. Describe the journey of the egg from ovary to uterus. How long does it take the fertilized egg to travel to the uterus?
2. How does the placenta form? What is its function?
3. The placenta begins secreting progesterone and estrogen after three months of pregnancy. Progesterone is responsible for the following functions:
   - maintains the glandular tissue of the endometrium;
   - inhibits ovulation;
   - inhibits contractions of the uterus.

   (a) Predict what would happen during pregnancy if the placenta became damaged and could not maintain progesterone levels. Provide reasons for your prediction.

   (b) Why don't pregnant women conceive again later in their pregnancy?

Human Reproductive Technology

Technology has a long history of medical inventions that have enabled people to live fuller lives. Crutches and splints were likely the first such inventions, allowing more mobility. Eyeglasses, developed in the mid-1600s, were one of the first technologies to assist a faulty organ. However, no technology has raised the interest and concern of people the way that reproductive technology has. Reproductive technology is not only changing the way that babies are born but the very laws that determine parenthood and responsibility. As research related to reproductive technologies continues to develop, controversial issues will arise. These issues will require us to debate how issues and personal beliefs relate to their use.

Many people are unable to have a baby. There are many reasons for this: a man may not produce enough sperm, a woman's oviducts may be blocked, the person's brain may not secrete enough hormones, a woman's follicles may not function properly. Some of these people go to fertility doctors in order to conceive a child.

Using Reproductive Technology

Fertility Drugs

Fertility drugs simulate the action of hormones from the pituitary (**Figure 1**). The drugs stimulate follicle development in the ovary, which makes it more probable that one or more egg cells may be released. Because fertility drugs increase the probability that multiple eggs will be released, the chance of having a multiple birth also increases.

Cytoplasmic Transfer

In cytoplasmic transfer, the cytoplasm from an egg from a younger woman is transferred into the egg cell of an older woman. It is believed that the transfer reduces the probability of genetic defects following fertilization.

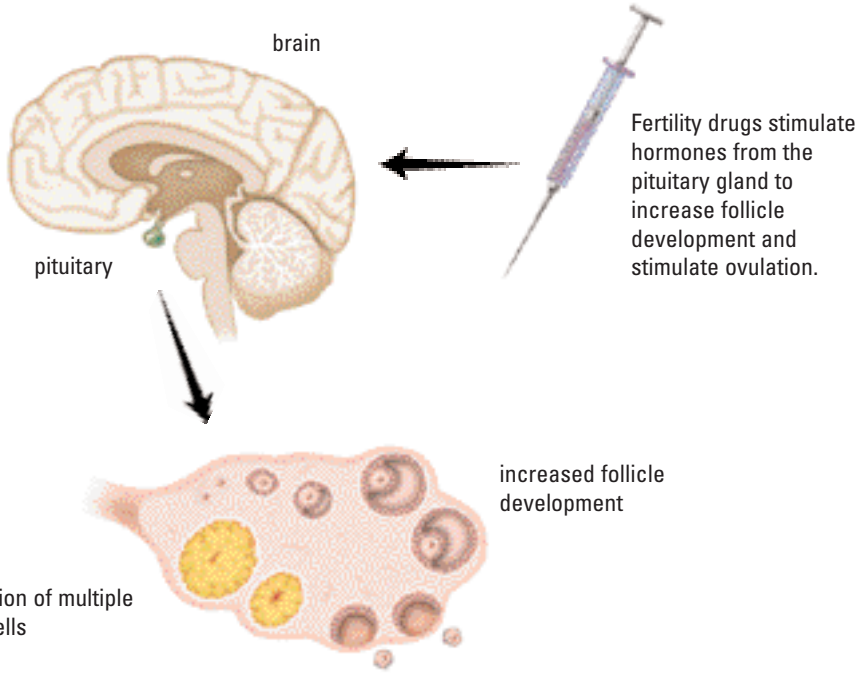


Figure 1
Fertility drugs

Intrauterine Insemination

Sperm cells are transferred directly into the oviducts of the woman following ovulation in intrauterine insemination (**Figure 2**). Normally, most sperm cells die as they travel through the uterus to the oviduct. Insemination ensures that sperm cells reach the egg in greater numbers.

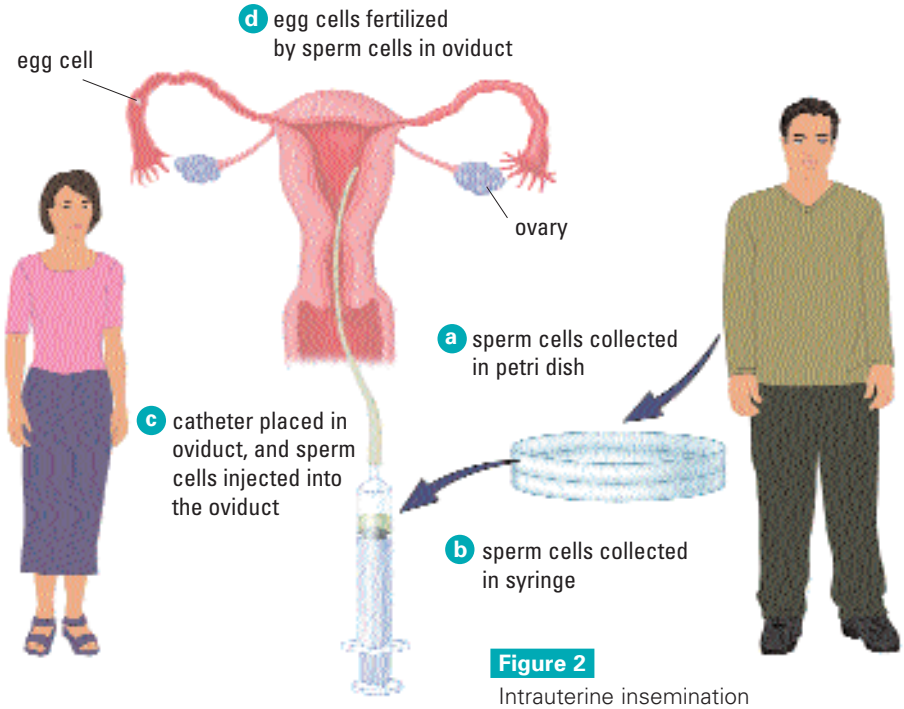


Figure 2
Intrauterine insemination

Gamete Intrafallopian Transfer

Gamete intrafallopian transfer involves the sperm and egg being inserted in the oviduct (or Fallopian tube). The technique is believed to increase the chances of successful fertilization by bringing sperm and egg cells together.

In Vitro Fertilization

The first step of in vitro fertilization (**Figure 3**) is the use of hormones to prepare the ovaries for ovulation. During ovulation, a physician inserts an instrument, called a laparoscope, into the woman's abdomen. A light in the laparoscope enables the physician to locate the ovary. A suction apparatus extracts mature eggs from the ovary. The eggs are placed in a glass petri dish and fertilized by the partner's sperm. Following a brief incubation period, one or more embryos are transferred into the uterus by a small catheter. If at least one of the embryos implants, a baby will be born nine months later.

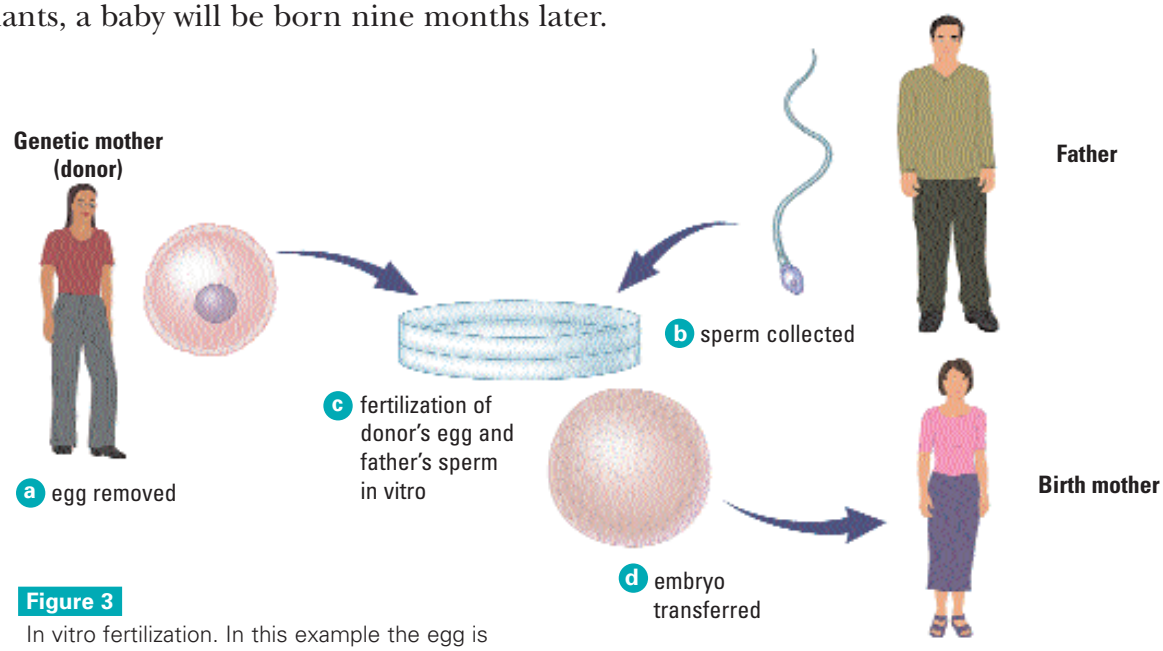


Figure 3
In vitro fertilization. In this example the egg is taken from a donor, but the genetic mother and birth mother can be the same person.

Egg Freezing and Egg Donations

Fertility drugs are employed to initiate multiple ovulations. Although a single egg may be fertilized, excess eggs are frozen. At a later date these eggs can be thawed and fertilized. Sometimes zygotes are frozen after fertilization. Some of the eggs or zygotes could be implanted into the same mother at a later date, or donated to another woman who either had no eggs in her ovary or was unable to ovulate.

Embryo Transfer

A woman with a defective cervix or uterus may ask another woman to give birth to her genetic child through embryo transfer (**Figure 4**). In this case, the egg from the first woman is combined with the sperm of her partner. Fertilization occurs in vitro. The zygote is transferred to a "surrogate" mother who carries the baby to term and then returns it to the genetic parents. This technology raises legal and ethical questions.

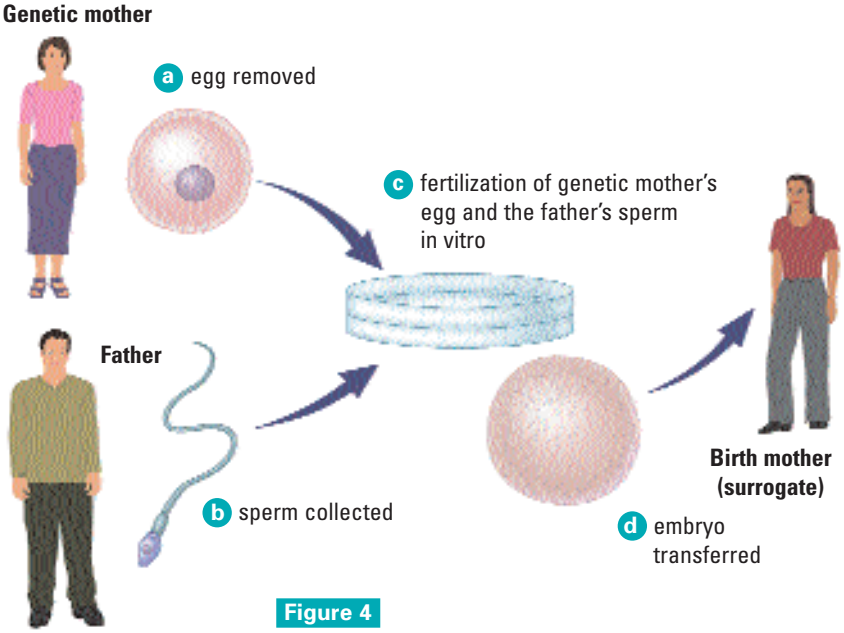


Figure 4
Embryo transfer

Understanding Concepts

1. Explain why the name "test-tube baby" is not accurate.
2. Why might in vitro fertilization be used?
3. Identify one disadvantage of using fertility drugs.
4. Reorder the random list of statements to illustrate the correct sequence of steps performed during in vitro fertilization.
   - Eggs are placed in a petri dish.
   - Eggs are extracted from the ovary.
   - Eggs are fertilized by sperm.
   - Hormone fertility drugs are given to the woman.
   - Embryo is transferred to the uterus.
   - Embryos are incubated.

Making Connections

5. A baby could have "five different parents" if some of these reproductive technologies were used. What legal and moral issues would this raise?
6. Reproductive technologies create controversy because of the ethical questions involved. Discuss issues related to each of the reproductive technologies described in this section. Prepare a summary paragraph outlining your point of view.

Challenge

You may want to create a scenario (a short "real-world" story) for each issue in your survey. This will allow the person being interviewed to better understand the meaning of the questions. If you chose to address issues involving the technologies in this section, what scenarios could you write?

For your display, you will need a central issue. What issues can you see in the technologies presented in this section?

The future technology in your story or play may be one of the technologies in this section. How will the characters in your story or play address the issues that relate to it?

Career Profile

Working to Improve Women's Health

Madeline Boscoe wears many hats: she is both the executive director of the Canadian Women's Health Network and the director of the Women's Health Clinic in Winnipeg.

Boscoe started her career in community-based health education programs geared toward women, particularly around family planning and prenatal care. This experience led her to a decision to become a registered nurse, training at the Vancouver General Hospital School of Nursing. Although today she uses little of her nursing training ("I learned most of my work on the job"), she feels that some background in nursing or a related area of medicine is important for a job in the health care field.

> "My work is about making a contribution to a better future."

In order to do her job, Boscoe draws on her communication skills: writing, conflict resolution, policy analysis, and strong "people skills, including networking." She advocates for better public policies in women's health care, ensuring that women have enough information to make informed choices with respect to their health. This information might include counselling or participating in experimental treatments.

Health advocacy, Boscoe believes, starts with looking at the health of the whole person, including economic health.

Exploring 3A

1. Research the background and training required to become a registered nurse.
2. Research which careers require a nursing training.
3. Might poverty be the enemy of good health? Write a report describing your views.
4. Choose one type of medical treatment that might be suggested by a doctor, and imagine that it is being offered to you. What kinds of information would you need to know before you decided whether or not to give consent for the treatment? What ethical issues would you need to consider?

Comparing Embryo Development

Embryology is the study of the development of an organism before hatching or birth. During the late 1800s, scientists noted a striking similarity between the embryos of different groups of vertebrate animals. Embryologist K. E. von Baer once wrote that because he had not labelled two similar embryos when he received them, he could not identify whether they were the embryos of lizards, birds, or mammals. Later, biologists suggested that embryos are similar because all vertebrates have a common ancestor. This does not mean that birds evolved from lizards, or mammals from birds; it means that the young forms of these organisms resemble the young of related species.

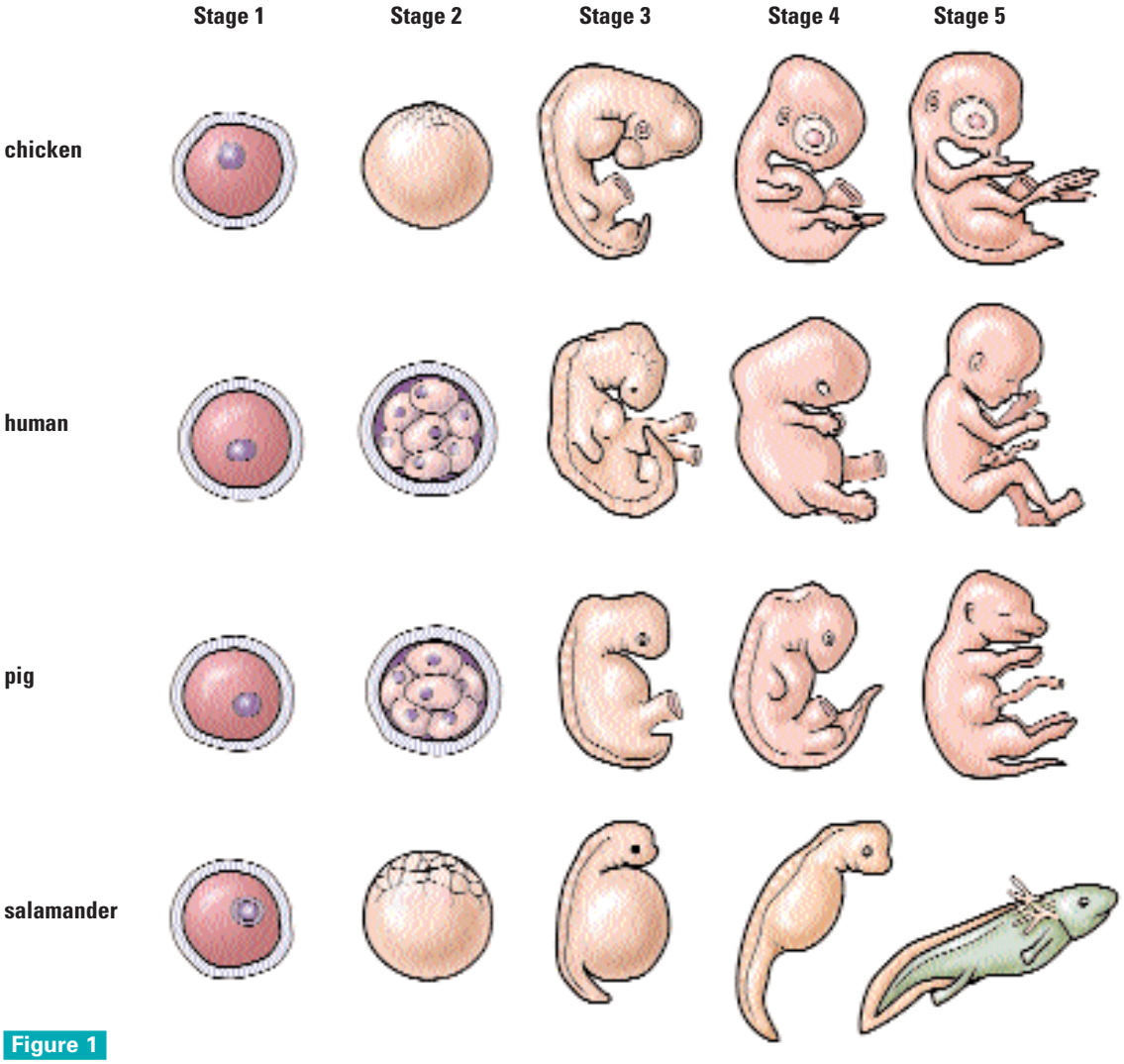


Figure 1
Embryo development in four species

Examine the embryonic development of the chicken, human, pig, and salamander shown in **Figure 1**.

The first stage of embryonic development is the fertilized egg, or zygote. The eggs of the different animals are very similar in shape and appearance. Small differences can be detected in the size of the eggs and the volume ratio of nucleus to cytoplasm. The second stage shown follows cell division of the zygote. This stage illustrates how a single cell is now a ball containing several cells.

(a) Which cell mass is most similar to that of the salamander?

(b) In what way does the cell mass of the human embryo differ from that of the chicken?

Embryos that develop in a uterus have a small yolk sac early in their development, but lose it later.

(c) Identify the yolk sacs of each embryo in stage 3 of **Figure 1**.

During stage 3, tiny gill slits can be seen in the sides of the neck. In fish, gill slits develop into gills. In mammals, they develop into parts of the ear. The backbone and tailbone can also be seen. The yolk sac in the egg-laying animals has shrunk as the animal grows. An umbilical cord is now visible in mammal embryos.

(d) Identify the gill slits, backbone, and tailbone in each embryo.

During stage 4, more differences can be identified among the organisms. Limb buds and a primitive brain and eyes can be seen.

(e) Identify the brain and eye for each embryo.

(f) Identify changes in the yolk sac of the salamander from stages 3 to 4. What has caused the change?

(g) Identify the limb buds in each embryo.

During stage 5, the embryos begin to look like the adult form. An ear can be seen in most of the embryos. Specialized structures such as the chicken's beak and wings, and the human's fingers, can now be seen. At this stage, a mammalian embryo is called a fetus.

(h) Which of the organisms spends time in a larva form?

(i) Which organism loses its tailbone?

Understanding Concepts

1. At which stage of development can you differentiate between the embryos of the chicken and the human? Explain your answer.
2. At which stage of development can you differentiate between the embryos of the pig and the human? Explain your answer.
3. Suggest an animal whose embryo would resemble a human embryo even more than the pig embryo. Provide reasons for your selection.

8.8

The Human Embryo

Your life began as a single cell about the size of the dot on an "i." In a mere 280 days (nine months), you grew into a baby about 50 cm long and with a mass of about 3 kg, composed of trillions of cells. Never again will you experience growth at such a rate, nor the number and diversity of developmental changes.

After the embryo implants in the endometrium of the uterus, it grows rapidly. By the fourth week of pregnancy the yolk sac, which has no nutrient value in humans, develops beside the embryo (**Figure 1**). A membrane, called the **amnion**, develops into a fluid-filled sac that insulates the embryo, protecting it from infection, dehydration, impact, and changes in temperature.

Blood vessels from the embryo and the mother's endometrium form the placenta. Nutrients and oxygen diffuse from the mother's blood into the blood of the embryo. Wastes diffuse in the opposite direction, moving from the embryo to the mother. The **umbilical cord** connects the embryo with the placenta.

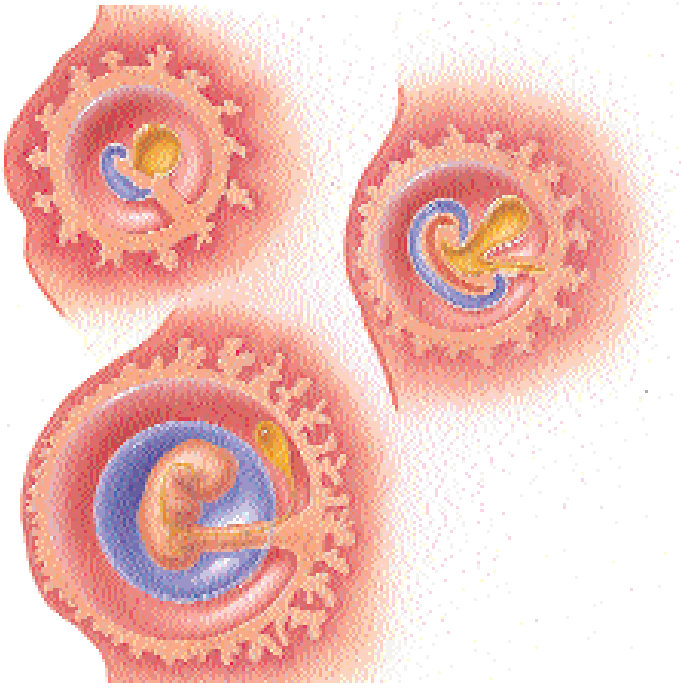


Figure 1
Formation of the membranes that protect the embryo

First Trimester

Human pregnancy can be divided into three **trimesters**, or three-month stages. The first trimester lasts from fertilization to the end of the third month (**Figure 2**). By the end of the first month, the embryo is 7 mm long, 500 times larger than the fertilized egg. The four-chambered heart has formed, a large anterior brain is visible, and limb buds with tiny fingers and toes have developed. A tail and gill arches, characteristics of all vertebrates, can be seen.

By the end of the second month, the cartilage of the embryo's skeleton begins to be replaced by bone and the embryo is now called a fetus. Most of the body parts have formed. The facial features continue to develop as the fetus now goes into a growth phase. Arms and legs begin to move and a sucking reflex can be seen.

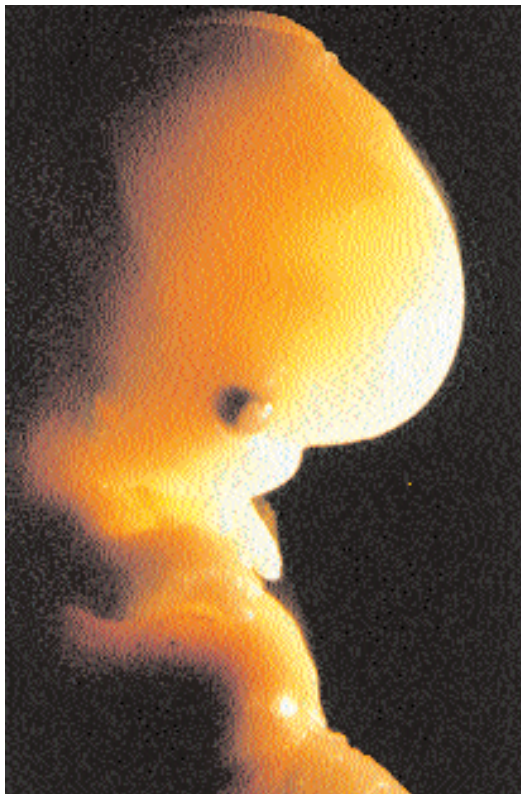


Figure 2
First trimester: A limb bud and the beginnings of the eye can be seen.

Second Trimester

By the second trimester (**Figure 3**), the 57-mm fetus moves enough to be felt by the mother. All the organs have formed and, like other mammals, soft hair covers the entire body.

Early in the fourth month the fetus begins to swallow amniotic fluid and hiccup. A month later, it may suck its thumb. By the sixth month, eyelids and eyelashes form. Most of the cartilage in the skeleton has been replaced by bone.

If the mother goes into labour at the end of the second trimester, there is a chance that the 350-mm, 680-g fetus will survive.

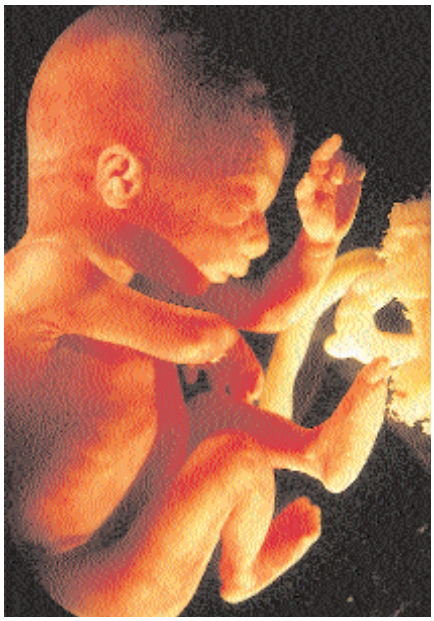


Figure 3
Second trimester: All of the organs and facial features are present, but the organs may not be fully functional.

Did You Know

When a mother smokes, the embryo receives many of the harmful chemicals through the placenta. Nicotine can constrict the blood vessels to the placenta, reducing the supply of oxygen to the embryo. This may explain why mothers who smoke give birth to small babies.

Third Trimester

During the third trimester (**Figure 4**), from the seventh month until birth, the fetus grows rapidly. The organ systems, established during the first two trimesters, begin to function properly. All that remains is to increase body mass. The average baby is approximately 530 mm long and has a mass of 3400 g at birth.

Understanding Concepts

1. Explain why some people claim that you have to swim before you learn to walk.
2. What function does the following serve?
   (a) the placenta
   (b) the umbilical cord
3. Differentiate between an embryo and a fetus.
4. Make a chart of the changes that occur during each trimester.
5. What is the function of the amnion?

Making Connections

6. The circulatory system is the first system to function in the embryo. Why do you think this happens?

Exploring

7. What are some of the early signs (3A) of pregnancy? Research pregnancy tests and how they work.

Figure 4
Third trimester: The fetus grows rapidly.

Fetal Alcohol Syndrome

The placenta acts as a barrier, preventing the mother's blood cells and large molecules from entering the circulatory system of the fetus. Smaller molecules, such as nutrients and oxygen, do move across the placenta (**Figure 1**). Unfortunately, some harmful agents, such as alcohol, are also small enough to cross the placenta. When a mother drinks alcohol, it crosses the placenta and enters the blood of the embryo.

The effects on the embryo are the same as those on the mother: alcohol depresses the functioning of the nervous system. Alcohol is also a poison. Like other poisons, it is broken down by the liver. Unfortunately, the liver of an embryo is not fully developed until the last few months of pregnancy, so alcohol cannot be broken down quickly. This means that alcohol remains harmful much longer in the embryo than it does in the mother. Not only can alcohol kill many embryonic cells, it may also change the genetic information in some cells, which can produce a mutation.

Fetal alcohol syndrome (FAS) is a host of birth defects associated with alcohol consumption by the mother. Symptoms of fetal alcohol syndrome include mental disability, abnormal facial features, central nervous system problems, behavioural difficulties, and growth deficiencies. It causes facial deformities such as a small head, thin upper lip, and small jaw bone. FAS can be mild or serious, depending on the amount of alcohol consumed by the mother.

It has been estimated that 60% to 70% of alcoholic women who become pregnant give birth to babies suffering from FAS. And evidence suggests that the problem is getting worse. A woman need not be an alcoholic to have an FAS child.

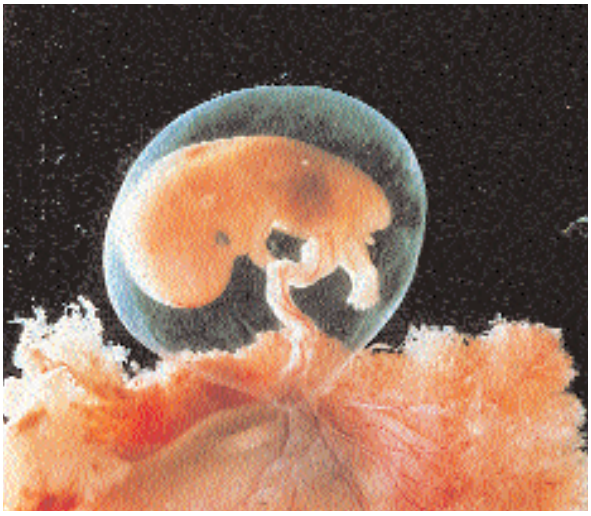


Figure 1
Alcohol and other drugs can pass from the mother's blood across the placenta into the embryo.

One study indicated that four times as many pregnant women admitted to "frequent" drinking in 1995 than in a similar 1991 study. Among 1313 pregnant women, 3.5% said they had an average of seven or more drinks a week or had consumed five or more drinks on at least one occasion in the previous month. According to the March of Dimes, alcohol is the most common cause of fetal damage in the country and the leading cause of preventable mental disability.

FAS: A Preventable Problem? 8B

Statement

Pregnant women should be required to have blood tests on a regular basis to monitor drinking problems.

Point

- FAS is the third most common reason for babies being born with mental disability in Canada and the United States. (The most common reasons for mental disability are genetic defects, which are not preventable.) Heart defects and defects of the nervous system are most common in FAS children. Any measure we can take to reduce this toll is acceptable.
- Despite a growing awareness that avoiding alcohol prevents FAS, about one-fifth of pregnant women continued to drink even after they learned they were pregnant. Education is not enough.

Counterpoint

- Most birth defects occur during the first three months of pregnancy, when the organs are forming. Should women also be monitored to ensure that they have a well-balanced diet, don't gain too much weight, or don't become depressed? Scientific studies have also linked many other factors to birth problems.
- The suspension of rights for any individual is a serious matter. All people would hope that mothers would recognize their responsibility, but legislation is not the answer. Changes in attitudes are best accomplished through education.

What do you think?

- In your group, discuss the statement and the points and counterpoints above. Write down additional points and counterpoints that your group considered.
- Decide whether your group agrees or disagrees with the statement.
- Search newspapers, a library periodical index, a CD-ROM directory, and, if available, the Internet for information on FAS and other preventable birth defects. 3A
- Prepare to defend your group's position in a class discussion. 3B

Birth

About nine months after the embryo was implanted, contractions of the muscles of the uterus signal the beginning of **parturition**, the process of birth (**Figure 1**). The cervix begins to dilate, or open up. The membrane surrounding the baby is forced into the vagina (also called the birth canal). Usually, the amniotic membrane breaks and amniotic fluid lubricates the canal. This event is often referred to as the "breaking of the water." Once the cervix has dilated enough, uterine contractions push the head into the birth canal followed by the rest of the body. In human babies, the head and shoulders are widest. Once they are free of the birth canal, the baby slips out easily. The baby is born. A short while later, the placenta is expelled from the uterus.

Immediately after birth, the baby still remains attached to the mother by the umbilical cord. Once the blood flow through the umbilical cord becomes restricted, the baby must begin breathing on its own. The umbilical cord is cut and tied off to prevent bleeding (**Figure 2**). Within a few weeks, the dead tissue from the umbilical cord dries and falls off the baby's abdomen, leaving the navel.

Hormones play a vital role in the birthing process. Prior to labour, the hormone relaxin is produced by the placenta. Relaxin causes the ligaments in the pelvis to loosen. This provides a more flexible passageway for the baby during birth. As labour starts, the hormone oxytocin is secreted by the pituitary gland. Oxytocin causes strong uterine contractions, which push the baby into the birth canal.

After the placenta is expelled, secretion of estrogen and progesterone stops. The levels of these two hormones in the mother's blood drop. If the mother does not breast feed, her menstrual cycle begins again within a few months after birth.

Figure 1

a cervical opening starts to enlarge

b amniotic sac breaks and fluid flows out

c uterine muscles contract to push the baby out

d baby emerges from the birth canal

Hormones and Lactation

At the beginning of puberty, estrogen stimulates breast development. During pregnancy, high levels of estrogen and progesterone prepare the breasts for milk production. Each breast contains about twenty lobes of glandular tissue, each supplied with a tiny duct that carries fluids toward the nipple (**Figure 3**).

Figure 2

The umbilical cord no longer functions after birth. It dries up and falls off.

At birth, the mother's pituitary gland in the brain secretes prolactin, another hormone (**Figure 4**). Prolactin stimulates the glands in the breast to begin producing fluids. Initially, the fluid produced is called colostrum. Colostrum contains sugar and proteins but lacks the fats found in breast milk. It also helps develop the baby's immune system. A day or two after birth, the prolactin stimulates the production of milk.

Milk production is stimulated by the baby's sucking action and the removal of milk. Many North American mothers who breast-feed prefer to end breast-feeding once their youngster begins developing teeth. In some countries, especially those with few available sources of protein, breast-feeding may continue for four or even five years.

Milk and the Mother

Milk production greatly increases the energy and nutrient requirements of the mother. Human milk contains about 50% more lactose (milk sugar) than cow's milk does. At the height of lactation, a woman can produce as much as 1.5 L of milk each day. A mother producing that much milk would need about 50 g of fat and 100 g of lactose each day to replace her losses. In addition, a breast-feeding mother needs 3 g of calcium phosphate each day. In order to have enough calcium and phosphate in her milk, the woman's body can start to take those minerals from her bones. Failure to replace the needed minerals results in a progressive deterioration of the mother's skeleton and teeth.

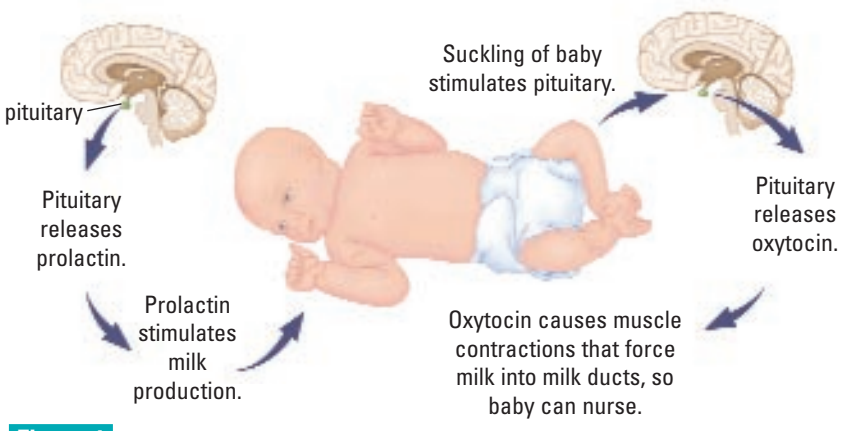


Figure 4
Milk glands, the baby, and hormones work together to ensure there is milk when the baby is hungry.

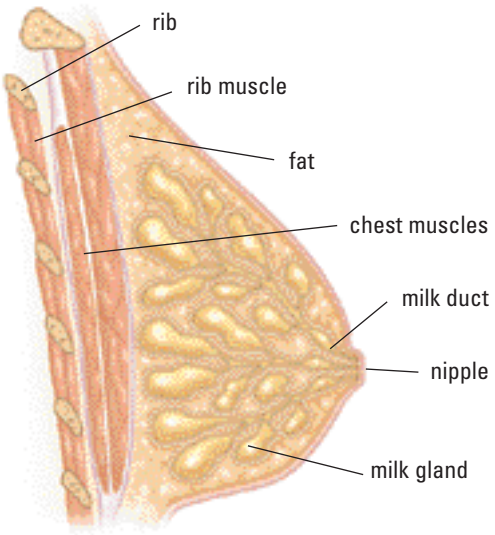


Figure 3
The mother's breast contains glands that begin producing milk shortly after the baby's birth.

Understanding Concepts

1. Summarize the four stages of labour shown in **Figure 1**.
2. Explain the functions of relaxin and oxytocin.
3. How does a sucking action stimulate the production of breast milk?
4. Occasionally a physician gives a pregnant woman who is past her delivery date an injection of oxytocin. What is the injection expected to do?

Making Connections

5. Why is it important for nursing mothers to eat a well-balanced diet?

Exploring

6. What is colostrum and why is it important for the newborn baby to drink it?

Chapter 8 Review

Key Expectations

Throughout this chapter, you have had opportunities to do the following things:

- Identify advantages and disadvantages of various strategies for the development of a zygote. (8.1)
- Describe the events of fertilization, the stages of embryo development, and the stages of birth. (8.4, 8.5, 8.7, 8.8, 8.10)
- Examine the structures within a seed and an egg that enable adaptation to a variety of environments, and organize, record, analyze, and communicate results. (8.2, 8.3, 8.4)
- Formulate and research questions related to reproductive technologies, and communicate results. (8.8, 8.9)
- Provide examples of technologies that help produce a baby, and discuss the ethical implications of using such technologies. (8.6)
- Explore careers that require an understanding of reproductive biology. (Career Profile)

KEY TERMS

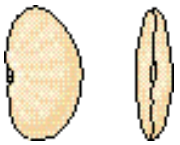
amnion	placenta
conception	spore
embryo	trimester
parturition	umbilical cord

Reflecting

- "Different organisms use very different strategies, and combinations of strategies, to ensure the survival of their offspring." Reflect on this idea. How does it connect with what you've done in this chapter? (To review, check the sections indicated above.)
- Revise your answers to the questions raised in Getting Started. How has your thinking changed?
- What new questions do you have? How will you answer them?

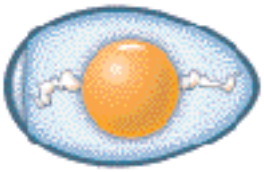
Understanding Concepts

1. Make a concept map to summarize the material you have studied in this chapter. Start with the word "zygote."
2. Provide examples of organisms that reproduce by way of
   (a) spores
   (b) seeds
   (c) eggs
   (d) zygotes developing within the parent
3. In plant reproduction, what advantages do seeds have over spores?
4. Draw and label the following diagram of a seed and indicate the function of the labelled parts.



5. Where is the food found in a seed? How is that food used by the plant? by the human population?
6. In the human female reproductive system, identify the
   (a) organ that is the site of implantation of the embryo
   (b) tissue that provides nourishment for embryo
   (c) tissue that secretes estrogen after ovulation
   (d) site of egg development and estrogen secretion
7. Trace the path of an egg from the ovary through fertilization to implantation. What happens to the egg if it is not fertilized?
8. Explain why pregnancy is not possible once a woman reaches menopause.

9. Draw and label a diagram of an egg and explain the function of each of the structures.

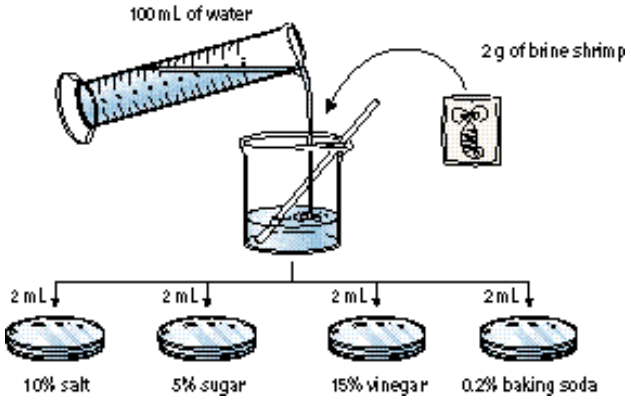


10. What causes fetal alcohol syndrome, and what are some of its symptoms?

11. Explain the functions of the hormones oxytocin and relaxin during birth.

Applying Skills

12. A group of science students decided to test different nutrients to determine which would speed the growth of brine shrimp. The following procedure was followed.



(a) Identify the independent and dependent variables.

(b) Write a hypothesis for the investigation.

(c) Identify any problems with the experimental design.

(d) How would you correct the problems you identified in (c)?

13. Some students decided to do an experiment to determine the effect of temperature on seed germination. The four groups, called A, B, C, and D, proposed different procedures, shown in **Figure 1**.

(a) Identify the question being investigated.

(b) Which procedure was the best experimental design to test the question?

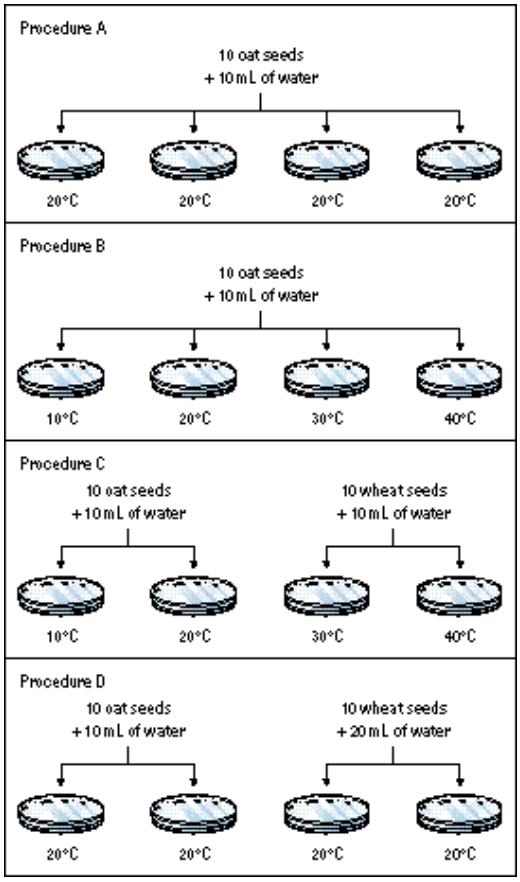
(c) Identify any errors in the other procedures.

(d) Identify the independent and dependent variables in procedure C.

(e) What question is being investigated in procedure D?

(f) Identify the variables that have been controlled in procedure D.

Figure 1



Making Connections

14. Compare in vitro fertilization with the normal course of events in human reproduction.

15. Indicate the advantages for each of the following reproductive strategies:

(a) A bacterium forms a spore with a resistant coating.

(b) An opossum produces eight embryos, but only six find their way into the pouch and attach to a nipple.

(c) The wildebeest gives birth to young that begin running next to the mother a few minutes after birth.

(d) The whooping crane lays two eggs. The first chick to hatch breaks the other egg. Only the first chick will survive.

(e) A parasitic worm produces hundreds of thousands of eggs. The eggs are released with the solid wastes of the host animal.

16. When the rabbit was introduced into Australia it quickly took over much of the habitat of the wombat (a marsupial). What makes the rabbit more successful than the wombat?

Challenge

Society and Reproductive Technology

When Dolly the cloned sheep was born (**Figure 1**), it set off an explosion of debate about the ethics of reproductive technology.

Scientists are making rapid advances in their understanding of reproduction, both in animals and plants. Out of those discoveries are rising new technologies that allow infertile people to have children, that allow genetic material from one organism to be transplanted into another, that allow doctors, drug designers, and seed makers to probe into reproductive cells and change them. Advances in science and technology are happening so rapidly that many people do not have access to the most recent information. Can an individual make a responsible decision about using these technologies without fully understanding their impact?

Figure 1
Dolly was the first mammal to be cloned using non-reproductive cells.

1 A Survey on Reproductive Technology

What do people believe about reproductive technology? What do they find acceptable and unacceptable? You will conduct a survey to determine public opinion on two or three issues surrounding reproductive technology, and then analyze and report your results. Are there differences in opinion based on age or gender beliefs? What other factors are involved?

Design and conduct a survey that includes:

- Brief descriptions of two or three issues around reproductive technology that you have chosen for study. The issues may be related to human reproduction or reproduction of food plants.
- A set of questions for each issue that probes the beliefs of the people you will survey.
- Completed questionnaires.
- A report that analyzes the data you have collected.

2 A Public Information Display

Before individuals can make responsible decisions about reproductive technology, they must have a clear understanding of the issues. You will prepare an information display that clearly presents an issue in reproductive technology in a way that is informative. Your display should also deal with any misconceptions that may exist in the minds of the public.

Design a display about an issue in reproductive technology in video, audio, or multimedia that includes:

- Basic information about a reproductive technology, presented in a way that is easy to understand. The display may deal with a technology used in humans or other animals or plants.
- Some of the misconceptions around the technology, and ways that help individuals deal with them.
- Different perspectives on the issue that involves the technology.
- A report explaining how you decided what information to include and why you chose to present it as you did.

3 A Futuristic Short Story or Play

The pace of development of new technology is increasing. Will the incredible rate of discovery and development continue? If it does, what kinds of reproductive choices and decisions will future generations face?

Write a short story or play related to the use of reproductive technology in the future that includes:

- A description, using scientific terms, of how the future technology works.
- Characters or situations that illustrate different perpectives on the issues related to the reproductive technology chosen.

Assessment

Your completed challenge will be assessed according to how well you:

Process

- understand the specific challenge
- develop a plan
- choose and safely use appropriate tools, equipment, and materials when necessary
- conduct the plan applying technical skills and procedures when necessary
- analyze the results

Communication

- prepare an appropriate presentation of the task
- use correct terms, symbols, and SI units
- incorporate information technology

Product

- meet established criteria
- show understanding of concepts, principles, laws, and theories
- make effective use of materials
- consider legal and ethical issues
- address the identified situation/problem

Unit 2 Review

Understanding Concepts

1. In your notebook, write the following sentences, filling in the blanks with the word or phrase that correctly completes the sentence. Use the words from this list: meiosis, mitosis, placenta, hermaphroditic, mutation, clone, interphase, metaphase, and conjugation.

(a) This phase of mitosis, called __?__, is identified by chromosomes lining up in the middle of a cell.

(b) The stage between divisions, called __?__, is marked by rapid growth, the duplication of genetic material, followed by another period of growth.

(c) The division process in which sex cells are formed is referred to as __?__.

(d) The division process in which a single cell divides into two identical daughter cells is referred to as __?__.

(e) If the nucleus is removed from one egg cell and replaced with the nucleus from an embryo, the offspring is a(n) __?__ of the cell that donates the nucleus.

(f) A change in a cell's genetic information is a(n) __?__.

(g) Animals that contain both male and female sex organs are said to be __?__.

(h) Bacteria exchange genetic information by way of plasmids in a process called __?__.

(i) The organ responsible for nutrient exchange between a human mother and fetus is said to be the __?__.

2. Indicate whether each of the statements (a) to (j) is TRUE or FALSE. If you think the statement is FALSE, rewrite it to make it true.

(a) The larger the organism, the larger is the size of its cells.

(b) If a fertilized egg from a mouse has 22 chromosomes, you should expect 22 chromosomes in the muscle cell of the same mouse.

(c) When plants such as strawberries reproduce by sending out runners, they reproduce without sex cells.

(d) If a sheep were cloned you would expect the offspring to be the same sex as the parent or original.

(e) All of the cells in the human body divide at the same rate.

(f) Human sperm cells have half as many chromosomes as unfertilized egg cells.

(g) Multiple human sperm cells fertilize a single egg cell simultaneously.

(h) Cancer cells divide at a faster rate than normal cells.

(i) Female aphids can give birth to male aphids through asexual reproduction.

(j) Fertilization of the human egg takes place in the ovary and the baby develops in the oviduct.

For questions 3 to 6, write the letter of the best answer in your notebook. Write only one answer for each question.

3. The purpose of meiosis is to

(a) produce offspring

(b) duplicate DNA

(c) produce daughter cells with the same chromosome number as the mother cell

(d) produce sex cells with half the chromosome number as the mother cell

4. A human sperm cell contains

(a) 23 chromosomes of which two are X chromosomes

(b) 46 chromosomes of which two are Y chromosomes

(c) 23 chromosomes of which one is X or Y

(d) 46 chromosomes of which one is X or Y

5. Normal chimpanzee cells have 48 chromosomes. Which one of the following statements about chimpanzee cells is correct?

(a) muscle cells have 24 chromosomes

(b) a zygote would have 96 chromosomes

(c) a cell following meiosis I would have 24 chromosomes

(d) a cell following meiosis I would have 48 chromosomes

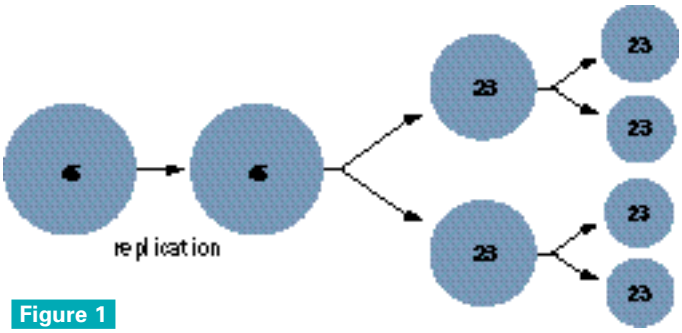


Figure 1

6. The process in **Figure 1** would occur in the
   (a) brain
   (b) heart
   (c) liver
   (d) ovary

Use the information below to answer questions 7 and 8.

A science class decides to design an experiment to test the effect of pH on seed germination.

Problem: How does pH (acidity) affect the growth of germinating seeds?

Materials:

- various pH buffer solutions
- 4 petri dishes
- 40 seeds per group
- ruler

Design: Germinating seeds were placed in petri dishes. Different pH solutions were provided. The length of the seedling was measured daily.

Three groups submitted different proposals, as shown in **Figure 2**.

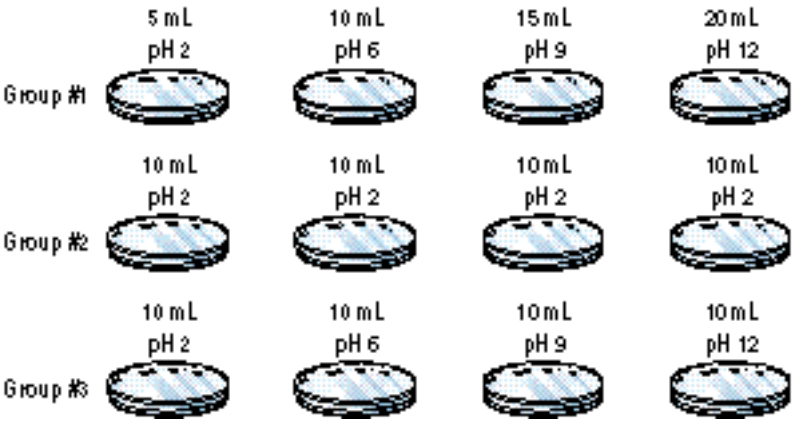


Figure 2

7. The best proposal was provided by
   (a) group 1, because a wide range of pH was used and various amounts of solution were added.
   (b) group 2, because everything was kept constant.
   (c) group 3, because only pH was changed.
   (d) group 1 and group 3 are equally good, because a wide range of pH was used.

8. The appropriate independent and dependent variables for the problem stated above would be:
   (a) independent variable = amount of solution used,
   dependent variable = type of seeds.
   (b) independent variable = number of petri dishes used,
   dependent variable = pH solutions used.
   (c) independent variable = different pH solutions used,
   dependent variable = length of seedlings.
   (d) independent variable = same pH solutions used,
   dependent variable = length of seedlings.

9. The nutrient starch would be found, in greatest quantity, in the area of **Figure 3** labelled
   (a) 1 (d) 4
   (b) 2 (e) 5
   (c) 3

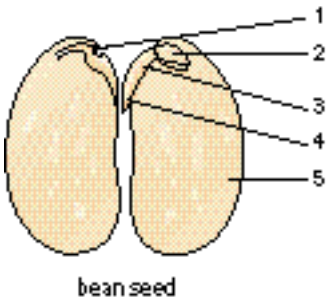


Figure 3

Use **Figure 4** below to answer questions 10 and 11.

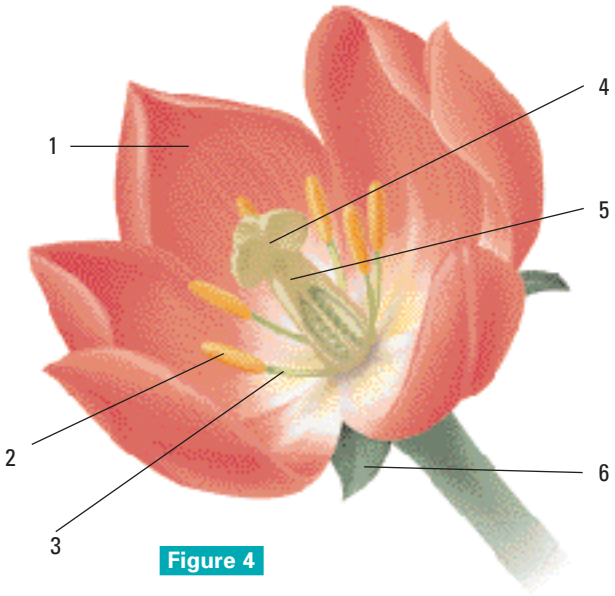


Figure 4

10. The male parts of the flower can be identified as structures

(a) 1 and 6

(b) 1 and 2

(c) 2 and 4

(d) 5 and 6

(e) 2 and 3

11. The female structure that receives pollen from an insect during cross-pollination is labelled

(a) 1

(b) 2

(c) 4

(d) 5

(e) 6

Applying Skills

12. John Needham boiled flasks containing nutrient meat broth for a few minutes in order to kill the microbes. The broth appeared clear after boiling. The flasks were then tightly sealed and left for a few days and the murky contents were examined under a microscope. The broth was teeming with microorganisms.

(a) Does this mean that the broth had spontaneously created microorganisms? Give your reasons.

(b) What changes would you make to Needham's experimental procedure before accepting his data?

13. A scientist wanted to determine if age affects body mass. The scientist hypothesized that body mass increases with age. To test this hypothesis, five people from each age group were selected at random. Their body mass was recorded. The results are provided in **Table 1** below.

Table 1

Age group	Average body mass (kg)
20 - 29	60 kg
30 - 39	65 kg
40 - 49	72 kg
50 - 59	75 kg
60 - 69	68 kg

The scientist concluded that the older a person becomes, the greater their body mass. Critique the experimental design used by the scientist. What additional information would you want to collect before accepting the conclusion?

14. Use **Figure 5** to answer the following questions.

(a) In which phase of the cell cycle does growth occur?

(b) In which phase of the cell cycle do double-stranded chromosomes become single-stranded chromosomes?

(c) In which phases of the cell cycle is the cell undergoing cell division?

(d) In which phase of the cell cycle is the cell duplicating genetic information?

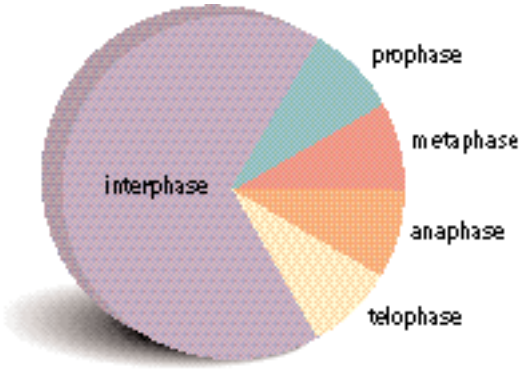


Figure 5

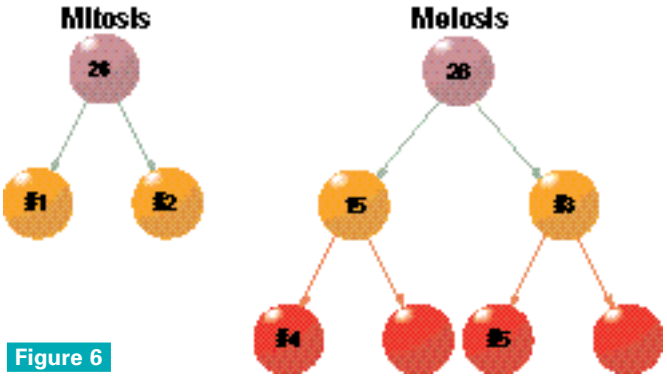


Figure 6

15. **Figure 6** compares mitosis and meiosis in a cell that contains 28 chromosomes.
    (a) How many chromosomes would be found in cell 1?
    (b) How many chromosomes would be found in cell 3?
    (c) If nondisjunction did not occur, how many chromosomes would be found in cell 3?
    (d) How many chromosomes would be found in cell 4?
    (e) Which cells shown in the diagram above would have a haploid chromosome number?

16. **Figure 7** outlines the events that take place during the female menstrual cycle.
    (a) Use **Figure 7** to describe the events of the female menstrual cycle during the flow phase, follicular phase, and luteal phase.
    (b) If a woman wanted to become pregnant, which time during the cycle would be best for fertilization?
    (c) Which hormone is produced by follicle cells?
    (d) Which hormone(s) is produced by the corpus luteum?
    (e) How would the diagram differ if a woman reached menopause?

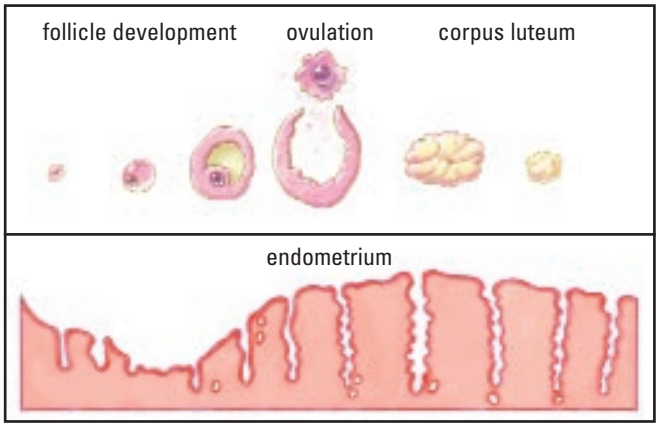


Figure 7

Making Connections

17. Describe the effects of both parents using drugs and alcohol on the conception and development of their fetus.

18. Many people exposed to nuclear radiation from the Chernobyl nuclear disaster developed tumors. Some of these cancers are the result of chromosomal damage. High intensity radiation causes chromosomes to break apart, and small fragments become scattered throughout the nucleus.
    (a) Why would the fragmentation of chromosomes affect cell division?
    (b) Suggest a method that can be used to detect these changes in chromosomes.

19. In intrauterine insemination, sperm cells from the donor or partner are transferred by way of a catheter into the oviducts of the woman following ovulation.
    (a) Suggest one reason why this technique might be employed.
    (b) Provide one reason why someone might object to this technology.

20. Fertility drugs can be employed to initiate multiple ovulations, and excess eggs can be frozen. At a later date these eggs can be thawed and fertilized. Some of the eggs could be implanted back into the same mother at a later date or given to another woman who either had no eggs in the ovary or was unable to ovulate.
    (a) Suggest one reason why this technique might be employed.
    (b) Provide one reason why someone might object to this technology.