Unit
# 1A

Chapter 15
# Reproduction and the human life cycle

**Figure 15.1** Human life continues from one generation to another

## Unit content

**Body systems**
The body is organised from cells to tissues, organs and systems. The major body systems are the digestive, excretory, skeletal, muscular, respiratory, circulatory, nervous, endocrine, immune, and reproductive systems and are related to life processes. The human life cycle occurs in a sequence of stages.

Organisation:
- hierarchy of organisation in the body
- location of organs associated with each body system in the body.

Functions:
- function of each organ system related to life processes.

The human life cycle:
- from gamete to birth and through to death
- systems change during the life cycle
- death determination.

Reproduction is necessary for the continuation of our species. As individuals die, new individuals must replace them. Not all members of a species have to reproduce. However, some members must, otherwise the species would gradually die out.

Humans reproduce sexually. Sexual reproduction involves the joining together of a male sex cell and a female sex cell. These sex cells, called **gametes**, are produced in specialised sex organs. The joining of a male gamete and a female gamete is called **fertilisation**. It results in a single cell, called a **zygote**, from which the new individual develops.

The reproductive system of humans is different from the other systems of the body. The organs making up the system in the female are quite different from those of the male. In this chapter we examine the structure and function of the male and female reproductive systems.

## Male reproductive system

The main function of the male reproductive system is to produce the male gametes, the **sperm**, and to transfer them to the body of the female. Sperm are produced in the male sex organs, the **testes**. Production and development of sperm requires a temperature that is about 2° Celsius lower than normal body temperature. Therefore, to allow sperm production to take place the testes are located in a skin-covered pouch called the **scrotum** (see Fig. 15.2). Because the testes lie outside the body cavity in the scrotum their temperature is slightly less than body temperature.

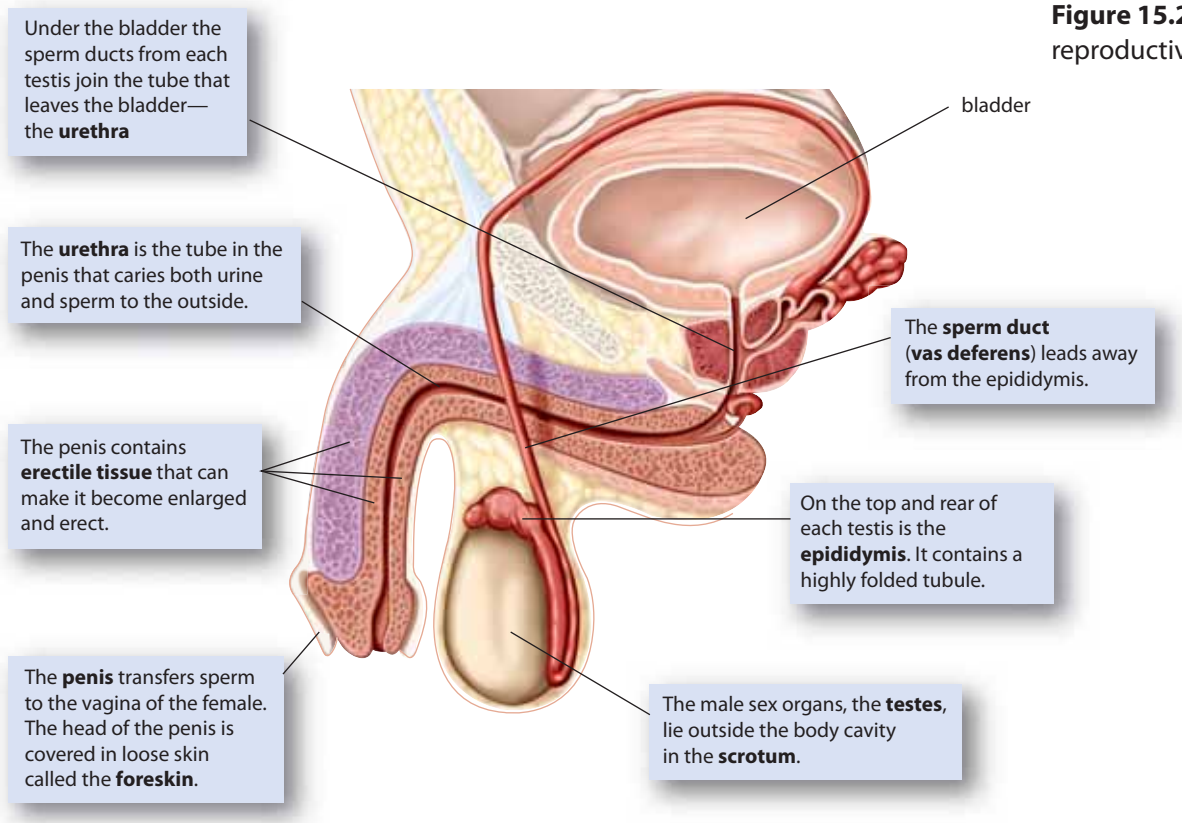


**Figure 15.2** The male reproductive system

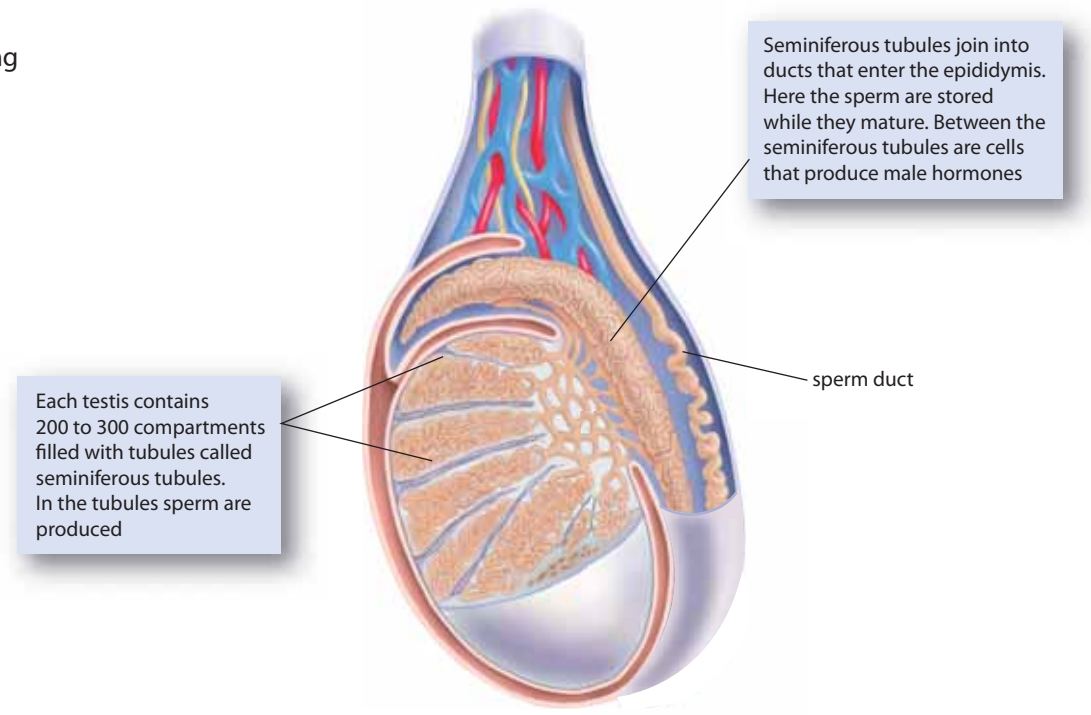


**Figure 15.3** Section through a testis, showing the system of tubules

There are a number of glands that are part of the male reproductive system. These glands produce **semen**, a liquid that provides nutrients and aids the transport of sperm. The glands are the seminal vesicles, and the prostate and bulbo-urethral glands (see Fig. 15.4):

- The **seminal vesicles** are behind the urinary bladder. They are a pair of pouch-like organs about 5 cm in length. The thick fluid that they secrete is rich in sugars and provides a source of energy for the sperm.

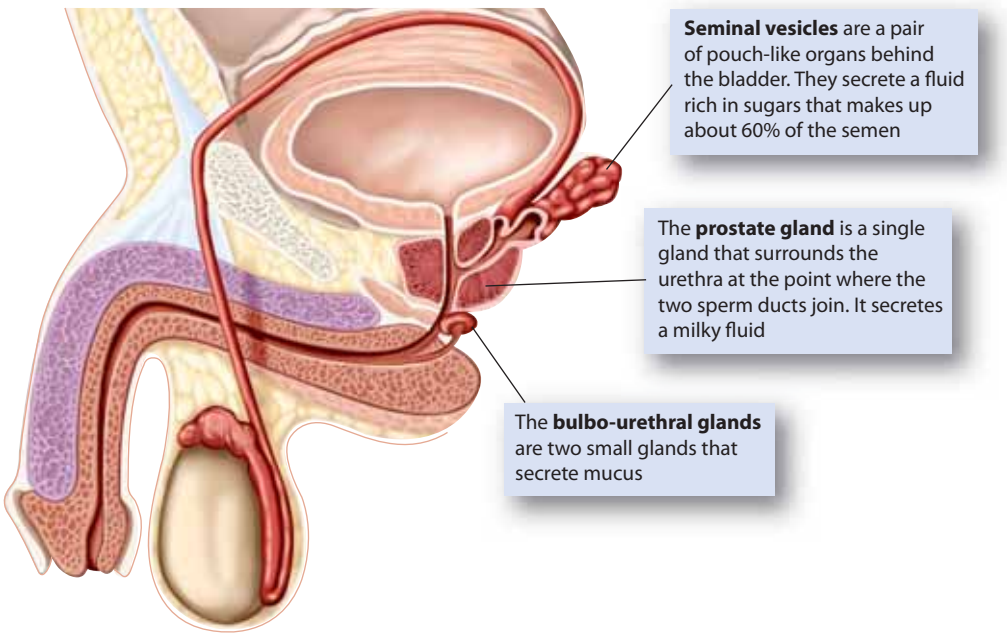


**Figure 15.4** The glands involved in semen production

- The **prostate gland** is where the two sperm ducts join the urethra. It is a single gland, shaped like a doughnut, which surrounds the urethra just below the bladder. It secretes a thin, milky fluid that also becomes part of the semen.
- The **bulbo-urethral glands** are two small pea-sized organs. They are located on either side of the urethra just below the prostate gland. A duct from each gland carries clear mucus to the urethra. This mucus acts as a lubricant to aid the insertion of the penis into the vagina.

The **penis** is the male organ that transfers semen from the male to the female. Passing through the penis is the **urethra**, a tube that carries urine and sperm out of the body. The urethra ends as a slit-like opening at the tip of the penis.

Inside the penis is connective tissue that has a very rich blood supply. This **erectile tissue** has a large number of sponge-like spaces. These fill with blood when the male is sexually aroused. The penis then enlarges, stiffens and becomes erect. It is only when the penis is erect that it can be successfully inserted into the vagina.

## Female reproductive system

The **ovaries** are the female sex organs. It is in these organs that the female gametes, the **ova** (or eggs), are produced. Each ovary is oval-shaped and about 3 cm in length. Unlike the testes, they are located completely within the body, one on each side of the abdominal cavity. Ligaments support the ovaries within the cavity. Figure 15.5 shows the location of the ovaries and the reproductive organs that are associated with them.

For more information on the human reproductive system go to:

- http://www.biotopics.co.uk/human2/reprsy.html
- http://kidshealth.org/parent/general/body_basics/male_reproductive.html
- http://kidshealth.org/parent/general/body_basics/female_reproductive_system.html

Each ovary is composed of a mass of connective tissue that is surrounded by a layer of cells containing numerous **germ cells**. Each germ cell is enclosed in a **follicle**, and has the potential to develop into an egg. (How these germ cells develop into eggs is discussed in Chapter 16.) As a follicle matures, it moves to the surface of the ovary and eventually breaks open. This release of the egg is called **ovulation**. The internal structure of the ovary and ovulation are shown in Figure 15.6.

When the egg leaves the follicle it enters the funnel-like opening of the uterine tube. The uterine tube carries the egg towards the uterus.

## Sexual intercourse

For fertilisation, male sperm need to be brought into contact with the female egg. In some animals fertilisation takes place in water outside the bodies of the male and the female. In humans and other mammals fertilisation is internal. Sexual intercourse transfers sperm from the body of the male to the female.

To allow sperm to be transferred from the male and be deposited in the vagina of the female, the penis must become enlarged and firm, a condition referred to as an **erection**. An erection results from blood filling the erectile tissue of the penis. The rush of blood into the penis is triggered by sexual arousal. Once erect, the penis can be inserted into the female vagina.

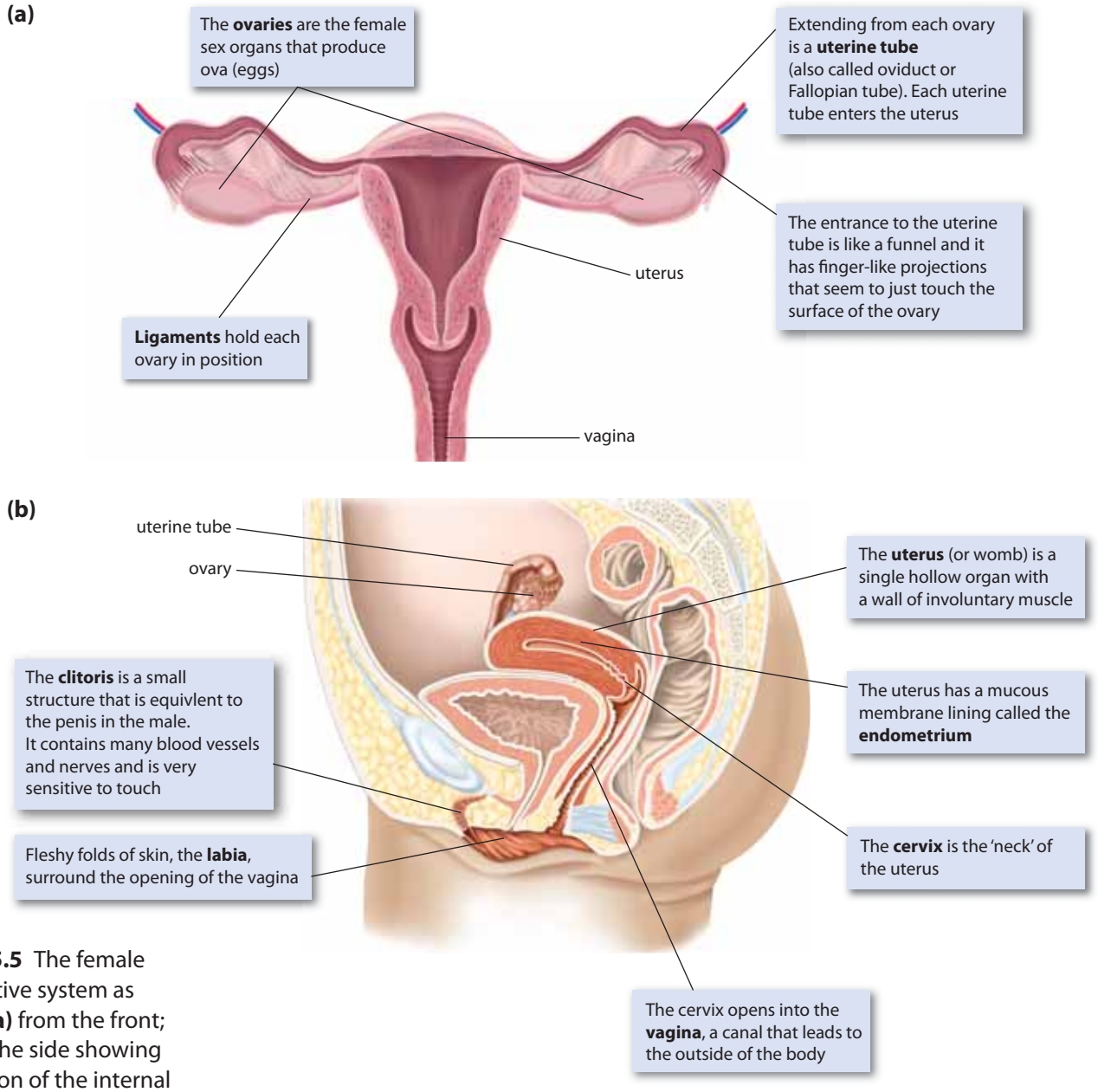


**Figure 15.5** The female reproductive system as viewed: **(a)** from the front; **(b)** from the side showing the position of the internal organs

Sexual stimulation of the penis within the vagina results in rhythmic contractions of the epididymis, the sperm duct, the seminal vesicles and the prostate gland. These contractions push the contents of the ducts and glands through the urethra and out of the body. This is called an **ejaculation**. The fluid that is ejaculated is the semen, which contains sperm. As the semen is ejaculated, the heart beats faster, blood pressure and breathing rate increase, and the male experiences intense pleasure. These responses are called an **orgasm**.

Besides the sperm, semen contains the secretions from the seminal vesicles, bulbo-urethral glands and prostate gland. The semen provides the sperm with a fluid in which to swim and also provides nutrients for the sperm.

The rhythmic stimulation of the clitoris and vagina during sexual intercourse can bring about an orgasm, or **climax**, in the female. Female orgasm is similar to that of the male, with the exception that there is no ejaculation in the female. For fertilisation to occur, there is no need for a female to have an orgasm. It is still not known whether female orgasm helps fertilisation in any way.

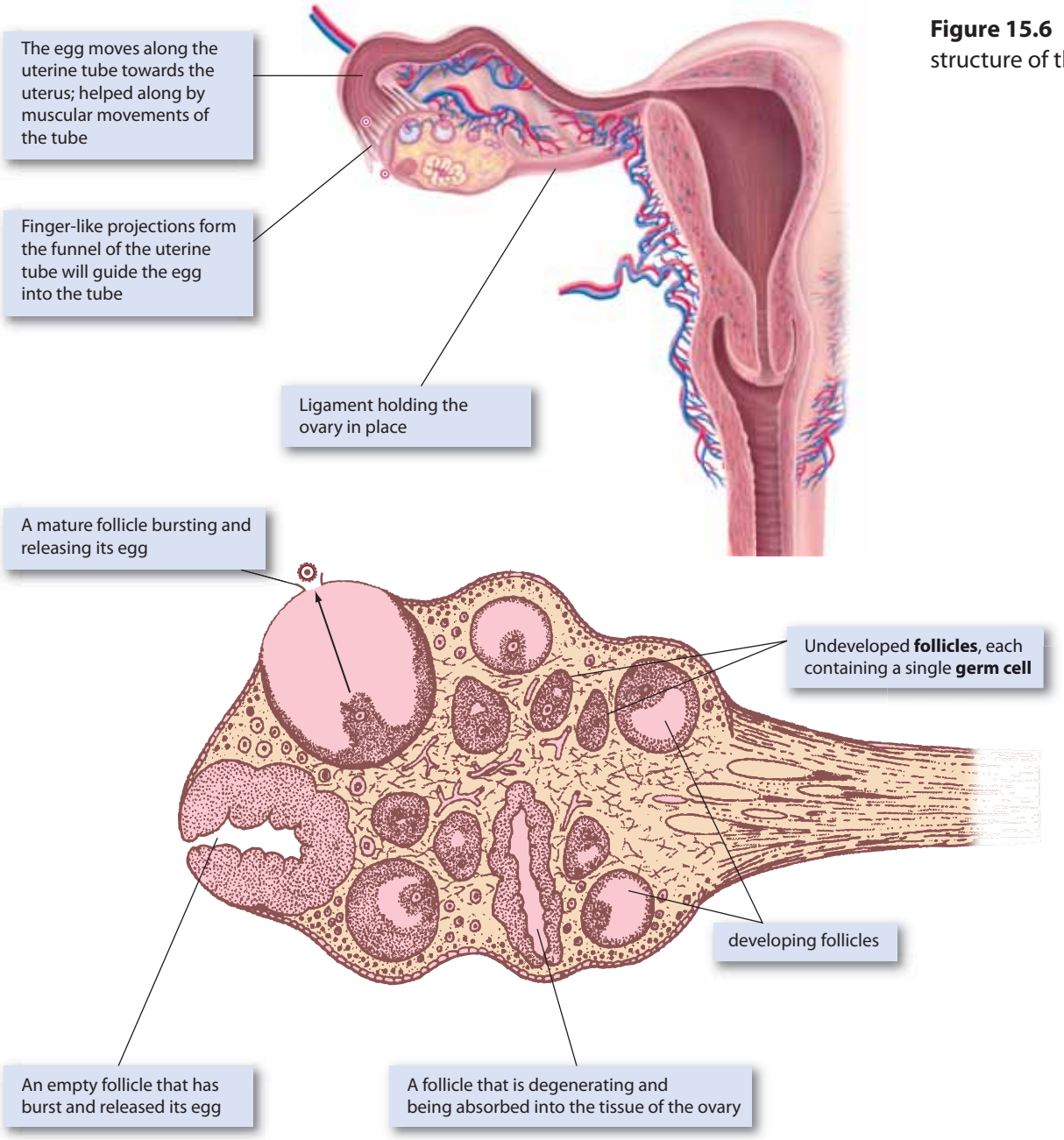


**Figure 15.6** Internal structure of the ovary

## Fertilisation

During sexual intercourse the sperm travel from each epididymis of the male, through the sperm duct, to the entrance of the urethra. With the semen, the sperm then move through the urethra to be ejaculated from the penis into the vagina. The sperm are deposited in the vagina at the entrance to the uterus. Once within the vagina, the sperm swim in the semen through the cervix, through the body of the uterus and into the uterine tubes. It only takes a few minutes for the sperm to reach the upper parts of the uterine tubes. Muscular contractions of the uterus and uterine tubes are thought to help sperm move through the female reproductive tract (see Fig. 15.7).

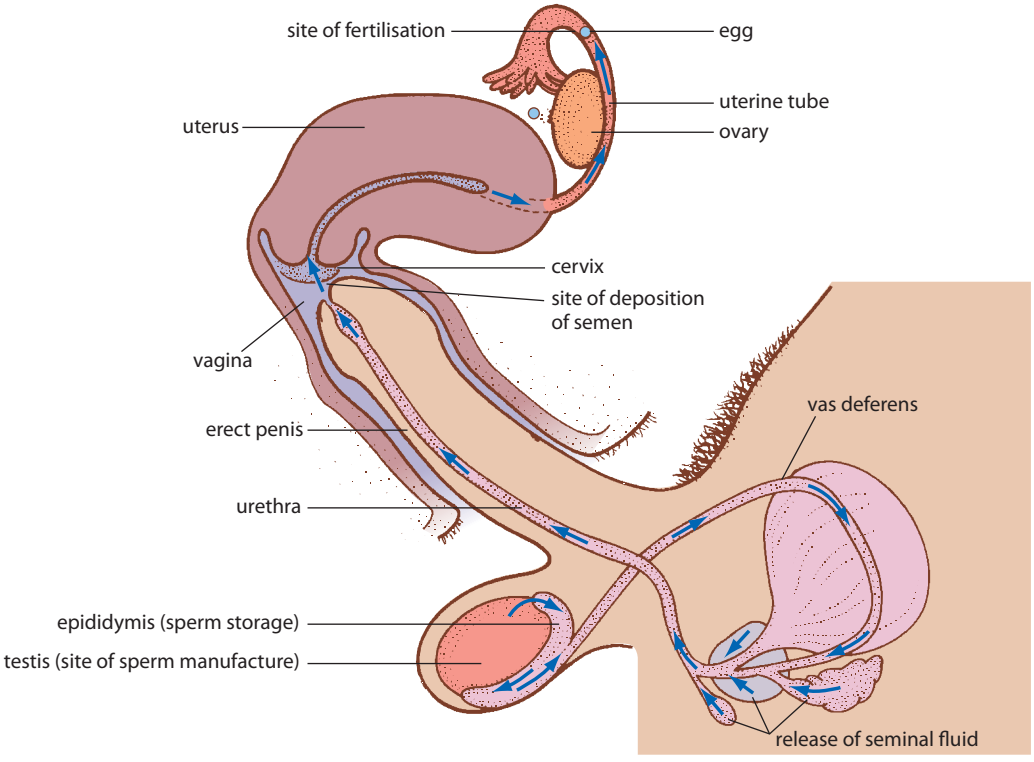


**Figure 15.7** The pathway taken by the sperm during sexual intercourse

For an explanation of fertilisation go to http://lgfl.skoool.co.uk/viewdetails_ks3.aspx?id=462 and click on 'human fertilisation'

Only a few thousand of the hundreds of millions of sperm deposited into the vagina during sexual intercourse actually reach the uterine tubes. The death rate of sperm is high and is one reason why large numbers of sperm are required if fertilisation is to occur. Fertilisation normally occurs in the uterine tubes when the egg is about one-third of the way down the tube. Since being expelled from the ovary, the egg has been transported towards the uterus by muscular contractions of the uterine tube, along with the beating action of cilia (see Fig. 15.7).

A layer of cells surrounds the mature egg (see Fig. 15.8). In the tips of the sperm is a chemical capable of breaking down the substances that hold the cells around the egg together. The amount of chemical contained in a single sperm is extremely small. It is only when several thousand sperm surround the egg that there is enough chemical to loosen the cells. A single sperm is then able to enter and fertilise the egg. This is another reason why large numbers of sperm are required if fertilisation is to occur. Once one sperm has entered the egg, a membrane forms around the egg. This membrane prevents the entry of any more sperm. When the head of the sperm is in the egg it joins with the female nucleus to form a single nucleus. Fertilisation is complete, and the fertilised egg is called a **zygote**.

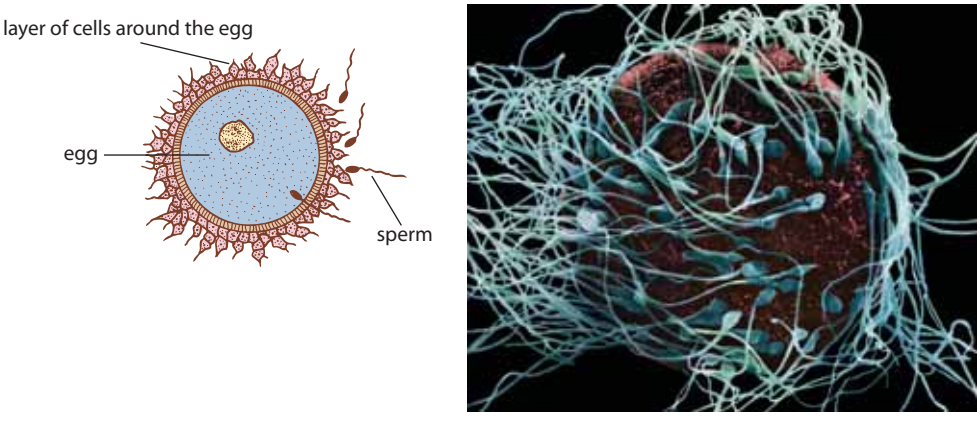


**Figure 15.8** Fertilisation

# Stages in the human life cycle

A cycle is something that goes around and around—it repeats itself time after time. We refer to the human 'life cycle' because a person is born, grows to maturity, reproduces and another individual is born to begin the cycle again. One cycle of a human life commences with the formation of a zygote and ends when the individual dies. Changes take place continuously throughout a person's life, but to make it easier to follow we will look at the cycle in four distinct phases: embryo and foetus; infancy and childhood; adolescence and adulthood; old age and death.

## *Embryo and foetus*

Immediately following fertilisation in the uterine tube the zygote begins to divide. As it moves along the tube to the uterus, cell division continues to occur. By the time it reaches the uterus a hollow ball of cells has formed. A group of cells within the ball eventually becomes the **embryo**.

Two to three days after reaching the cavity of the uterus, the ball of cells sinks into the soft uterine lining. This process is called **implantation**. The developing embryo then gets its nutrients for growth and development from the glands and blood vessels of the lining.

Cell division and growth occur rapidly. After one month of growth the muscle segments on either side of the tube that is to become the brain and spinal cord can be clearly seen (see Fig. 15.9). During the fifth week the arm and leg buds start to appear. By the end of the embryonic period (Week 8) the embryo has a recognisably human form (see Fig. 15.10). All organs are present, although many are not fully functional. From this stage onwards the term **foetus** is used to describe the developing individual. The foetal period, from the ninth week through to birth, is characterised by a great increase in size and by the organs becoming more mature (see Fig. 15.11).

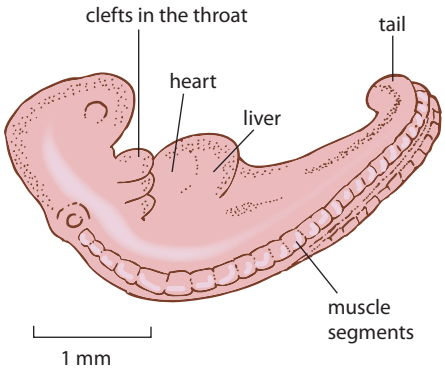


**Figure 15.9** A human embryo at the end of the fourth week

**Figure 15.10** An eight-week-old human embryo

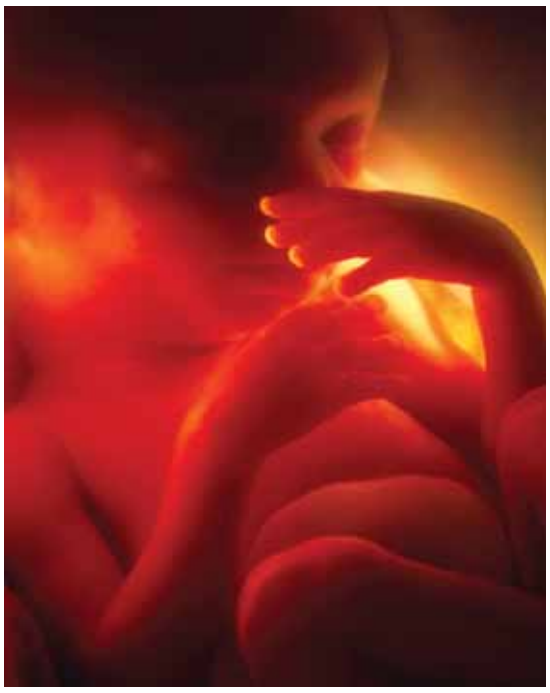

**Figure 15.11** A 20-week-old foetus

**Figure 15.12** A newborn baby

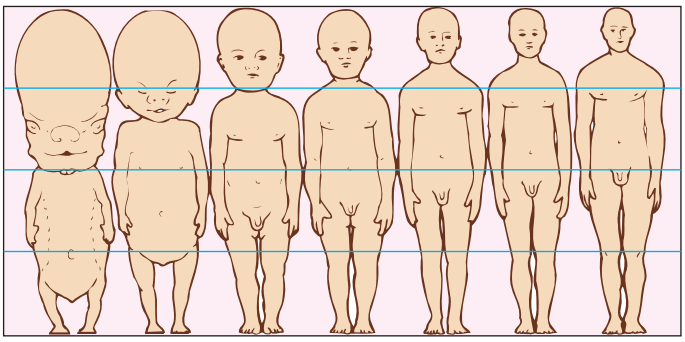


**Figure 15.13** Changes in form and proportion of the human body

## Infancy and childhood

There is a great range in the size and weight of babies at birth (see Fig. 15.12). However, on average, full-term babies are 50 cm long and weigh 3.3 kg. Their body proportions are a lot different from what they will be when they reach adulthood. Look carefully at Figure 15.13. Notice how the head of a newborn child makes up a quarter of its overall length, while the legs are only one-third.

During the first year of the child's life, rapid and extensive growth changes take place. Weight almost triples and body length increases by over one-third. However, not all parts of the body grow at the same rate. For example, from about two months of age, the legs grow rapidly, while the head and face grow more slowly. The proportion of the head to overall body length is a good indication of the changes that occur over time in the human life cycle. A two-month-old foetus has a head about one-half the total body length. At birth this has changed to about one-quarter, and by the time adulthood is reached, the head makes up only about one-tenth of total body length (see Fig. 15.13).

Physical growth is remarkably fast during the first few years of life. However, by the age of 6, growth has begun to slow. Males, on average, are slightly taller than females until they reach their tenth year. After that age, the average female is slightly taller than the average male until about the age of 15. The pattern for weight is similar to that for height. From the age of 15, the body proportions of both males and females are much the same as those of adults.

## Adolescence and adulthood

From the age of 10 or so, a number of physical, social and sexual changes begin to occur in a child. These changes result in the child taking on the appearance and behaviour of an adult. This period is referred to as **adolescence**. The first phase of adolescence is puberty. **Puberty** is the time during which a person develops sexual maturity. By the end of puberty a person is able to reproduce.

The ages at which children enter puberty are highly variable. However, the sequence of events that takes place is fairly constant. The first, and often most noticeable, change is referred to as the **adolescent growth spurt**. Starting at the age of 10 or 11, the relatively constant rate of growth during childhood changes. There is a rapid increase in height and weight that occurs earlier in most females than in most males.

If you look at a group of young people in their early teens you will see a wide range of physical shapes and sizes. Depending on the age of the group, the females may be a little taller, on average, than the males. This is because females start their growth spurt about two years earlier than males, usually between their eleventh and

fourteenth years. However, their overall height gain is usually not as great as in males. In males, the later start means they are usually a little taller than females before their growth spurt begins, and growth of up to 10 cm a year may occur. As a result, by the end of the growth period, most males are taller than most females. However, it must be kept in mind that the increase in growth rate that occurs during adolescence varies considerably from one person to another. The age at which it starts, the amount of growth and how long it goes for are all highly variable.

During early adolescence changes to the internal organs also take place. The heart almost doubles in size, while total blood volume increases. At the same time, the lungs increase in size and capacity. This enables an adolescent to breathe more deeply and more slowly. Such increases give the adolescent much greater stamina, and often result in a marked improvement in sporting ability.

Puberty results in changes to the reproductive system. An increase in the size of the testes and scrotum occurs in males usually some months before the growth spurt begins. About a year after the testes begin to grow, the penis begins to lengthen and thicken. Pigmented pubic hair also becomes noticeable around this time. In females, breast development is the first clear sign that changes to the reproductive system are taking place. Breast development is soon followed by the appearance of pigmented pubic hair. As these changes are taking place, the ovaries, uterus and vagina begin to increase in size and the lining of the vagina starts to thicken.

Puberty is also the beginning of the period when adolescents start to take on the necessary skills for life in modern society. This period of 'growing up' takes several years until the individual is accepted as an adult member of society. Adulthood is usually the longest phase of the human life cycle. During this period people often have children and take on the responsibilities of parenthood. For a woman, pregnancy results in changes to her organ systems to allow her baby to develop. At the end of the child-bearing years, further changes take place in women's reproductive systems. These changes, usually beginning between age 45 and 55, take place over a number of years. They result in ovulation ceasing all together.

See the human life cycle at http://www.oum.ox.ac.uk/thezone/animals/life/produce.htm#human

## Old age and death

As a person gets older there is a gradual decline in the performance of organ systems. This gradual decline with age is called **senescence**. There is no one age at which the decline begins, and there is a great amount of individual variation. For example, a person at the age of 70 may appear and perform like the average 50-year-old, and vice versa. However, a number of general trends are noticeable as a person gets older.

- Muscle size and strength both diminish from a peak at around the age of 30 or so.
- Bone tissue becomes lighter and more brittle.
- Joints do not move as freely as in young people, and the cartilage covering the ends of bones becomes thinner.
- A decrease in lung capacity leads to less oxygen being available to the cells and tissues of the body.
- Blood pressure rises as the heart works harder to overcome the loss of elasticity in the walls of blood vessels.
- Heart disease, strokes and cancer are more likely to occur in older people.
- A decrease in blood flows means the kidneys no longer work as efficiently.
- Older people find it harder to adjust to environmental temperature changes.

- The skin begins to dry out and become wrinkled.
- Older people are more likely to catch a disease than younger people.
- Older people find it harder to cope with stress, both physical and emotional.

As the body ages, it becomes less able to fight disease. In humans, unless a person dies as a result of an accident, death usually results from infection, heart attack, stroke or cancer. Often it is a combination of two or more of these.

A person in the last phase of life passes through a number of steps before death occurs. During the first stage, the person begins to breathe very rapidly, the heart beats faster and the muscles contract. The heart then stops beating and the brain loses consciousness.

During the second stage of dying, the hairs in the skin become erect, the pupils dilate and the bowel and bladder both empty. In the third and final stage the temperature of the skin falls, followed by a loss of heat from all internal organs. The organs of the body cease functioning at different rates. The brain is the first to stop functioning, and most authorities now consider this as the time of 'death'. Many other organs retain their ability to function after 'brain death'. These organs can be used for transplantation to prolong the life of another person.

# Working scientifically

## Activity 15.1 The male reproductive system

The reproductive systems of most mammals are similar in structure and function. Examining the reproductive structures of a male rat will help you to understand the human reproductive system.

Your teacher may wish you to dissect a rat yourself, may demonstrate the dissection, or may refer you to a video or photographs for this activity.

### You will need (if doing the dissection yourself)

A male rat; dissecting board; dissecting instruments; string; hand lens or magnifying glass; disposable gloves

### What to do

Your teacher will show you how to tie the rat firmly to the dissecting board.

1. Identify the features on the outside of the rat that are involved in reproduction—the scrotum containing the testes, the penis and the opening of the urethra at the tip of the penis.
2. Follow your teacher's instructions to open one side of the scrotum to see the testis. This will involve cutting through the skin around the base of the penis and continuing the cut down through one side of the scrotum. Use a blunt probe to gently lift the testis clear of the scrotum.
3. You will now be able to identify the sperm duct and epididymis as well as the testis. Use a hand lens, or magnifying glass, to see the tiny tubules inside the testis and the tubules that make up the epididymis (see Fig. 15.14).

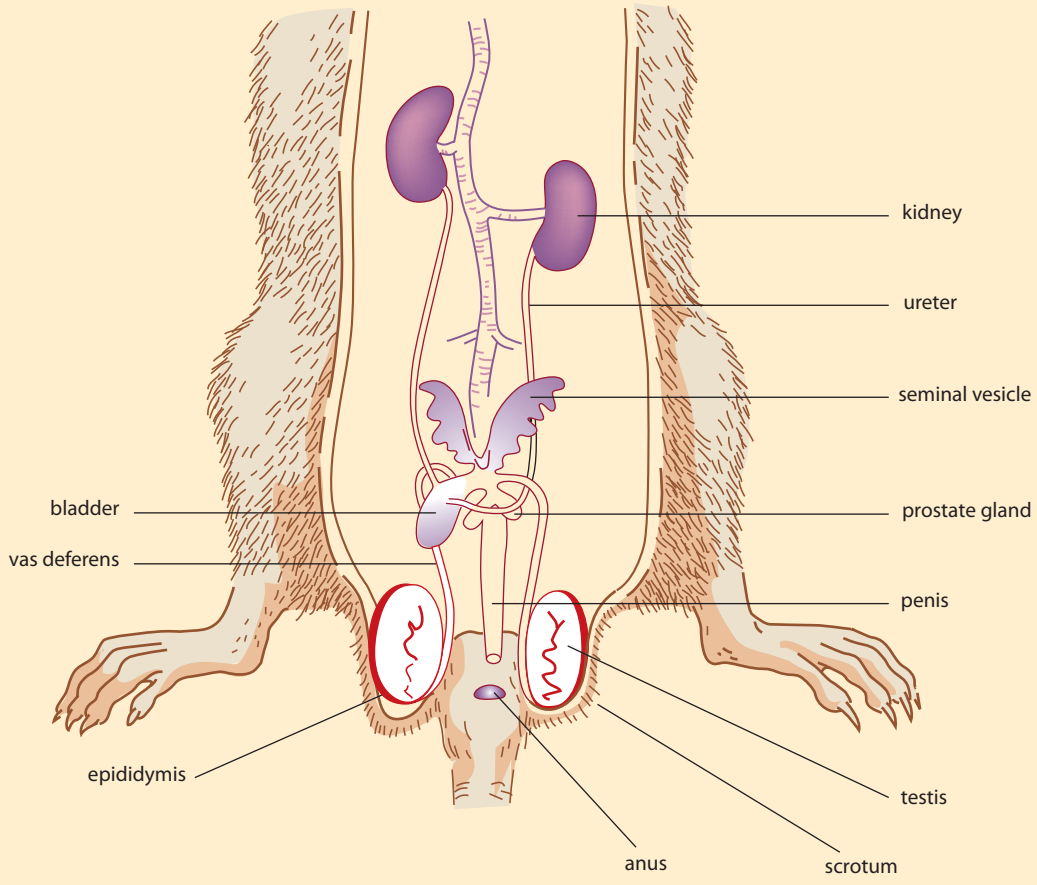


**Figure 15.14** The male rat showing the reproductive system (the alimentary canal is not shown in this diagram)

4. Clear the skin away from the rear part of the belly of the rat. Trace the sperm duct away from the epididymis so that you can see where it enters the body cavity.
5. Find the urinary bladder. If the rat is not preserved this will appear as a semi-transparent bag containing clear fluid. Near the bladder the two sperm ducts, one from each testis, join together to form the urethra.
6. Near the point where the sperm ducts join you will be able to see two white, elongated glands with a crinkly appearance. These are the seminal vesicles. The prostate gland, although present in the rat, is very difficult to see.

### Studying your observations

1. Draw a diagram of the dissected rat, labelling all the structures that you have identified.
2. On your diagram use arrows to show the path of the sperm and semen during ejaculation.
3. What differences are there between the reproductive structures of a male rat and a male human? Make a list of the differences.

## Activity 15.2 The female reproductive system

As for the male, there is much you can learn by looking at the reproductive structures of the female rat. There are, however, a number of important differences between female rats and humans.

This activity could be done at the same time as Activity 15.1 so that the male and female reproductive systems can be compared.

Your teacher may wish you to dissect a rat yourself, may demonstrate the dissection, or may refer you to a video or photographs for this activity.

## You will need (if doing the dissection yourself)

A female rat; dissecting board; dissecting instruments; string; hand lens or magnifying glass; disposable gloves

## What to do

Your teacher will show you how to tie the rat firmly to the dissecting board.

1. Identify the features on the outside of the rat that are involved in reproduction—the sexual opening and the mammary glands. In addition, locate the urethra and the anus. Figure 15.15 may help with your identification.
2. Count the number of nipples on the underside of the abdomen.
3. Follow your teacher's instructions to open the abdomen so that you can see the reproductive organs. There may be some fat inside the abdomen. Do not try to remove it, but you may need to push it aside so that the reproductive organs can be easily seen.
4. Locate the vagina.
5. Locate the two uteri that extend from the vagina up each side of the abdomen.
6. At the front end of each uterus is a very short uterine tube that you will find difficult to see.

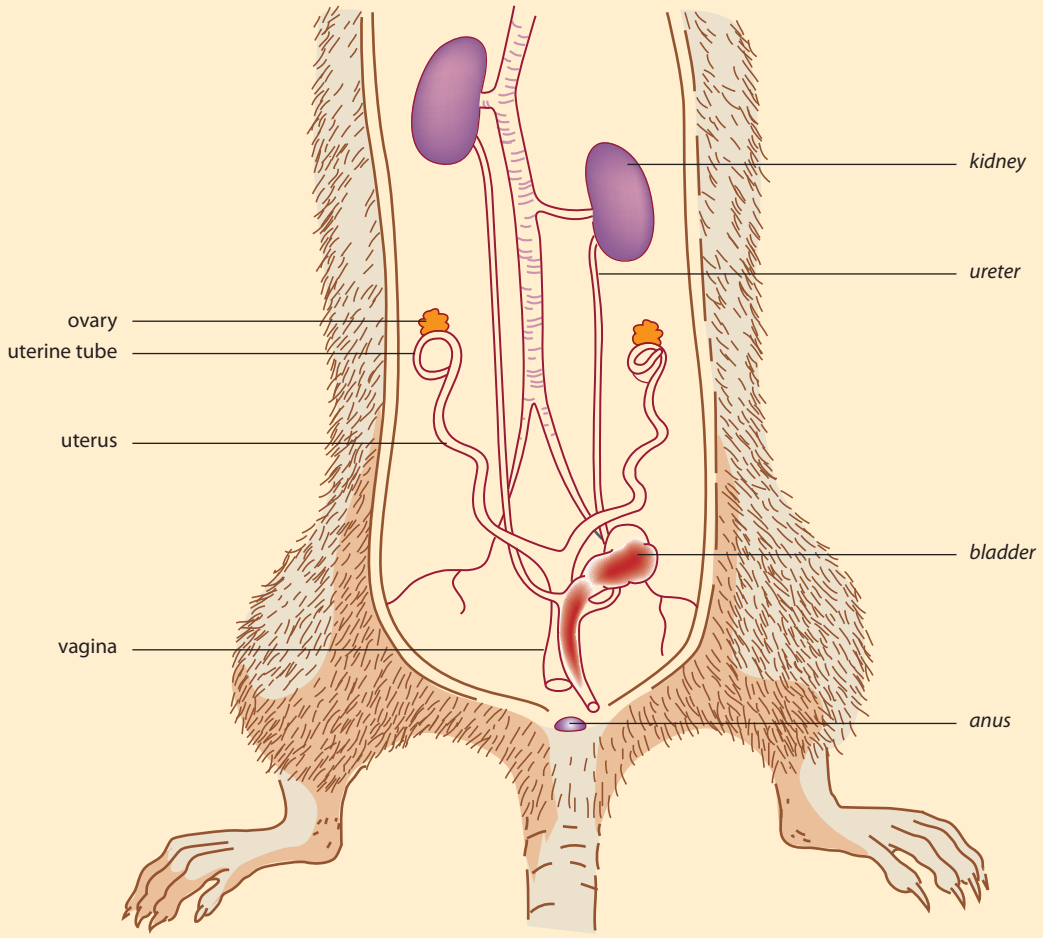


**Figure 15.15** The female rat showing the reproductive system (the alimentary canal is not shown in this diagram)

7. Also at the end of each uterus is a small, round, orange-coloured structure. This is the ovary.
8. It may help to insert a blunt probe into the vagina to trace the pathway sperm would take.
9. Find the urinary bladder. If the rat is not preserved this will appear as a semi-transparent bag containing clear fluid.

### Studying your observations

1. Draw a diagram of the dissected rat, labelling all the structures that you have identified.
2. On your diagram use arrows to show the path of an egg after ovulation has taken place.
3. Use a different coloured pencil to show the path of the sperm and semen after they have been deposited in the vagina.
4. What differences are there between the reproductive structures of a female rat and a female human? Make a list of the differences.
5. Of the differences that you have noted, which ones are because the rat has a number of offspring at one time?

## REVIEW QUESTIONS

1. Draw a diagram of the male reproductive system and label the testis, scrotum, penis, sperm duct, tubules in the testis, urethra, prostate gland, bulbo-urethral glands and seminal vesicles.
2. Make up a table with one column for the parts of the male reproductive system that are listed in question 1 and a second column describing the function of each of those parts.
3. Explain why the testes are located in the scrotum.
4. Describe the internal structure of a testis, and say where the sperm are produced.
5. List the glands that secrete the fluid that makes up the semen and describe the location of each.
6. Draw a diagram of the female reproductive system and label the ovary, uterus, uterine tubes, cervix, vagina, endometrium, labia and clitoris.
7. **(a)** How are the ovaries held in position inside the abdomen?
   **(b)** What is the function of the uterine tubes?
8. Describe the functions of the vagina.
9. Describe the role of the male's erection and ejaculation in sexual intercourse.
10. List the structures through which the sperm pass from the time they are made in the tubules in the testis to the time fertilisation takes place.
11. The egg is surrounded by cells when it leaves the ovary. Describe how sperm break down the cell layer to allow fertilisation to occur.
12. **(a)** What is fertilisation?
    **(b)** Describe the events that take place in humans so that fertilisation can take place.
    **(c)** Where does fertilisation normally occur?
    **(d)** What is a zygote?
13. **(a)** Why are large numbers of sperm necessary for fertilisation?
    **(b)** Besides sperm, what else is part of the semen?
14. Distinguish between a foetus and an embryo.

15. **(a)** Define adolescence.
    **(b)** Distinguish between the terms 'adolescence' and 'puberty'.
16. Describe the changes that take place in the reproductive system during puberty.
17. Briefly outline the three stages of dying.

## APPLY YOUR KNOWLEDGE

1. Reproduction is necessary for the continuation of the human species. However, is it necessary for all members of a species to reproduce? Give reasons for your answer.
2. If the tubules in the testis were uncoiled and stretched out they would be about 800 m in length. List as many reasons as you can to explain why such a great length is needed in the tubules.
3. Frogs release sperm and eggs into water where the sperm fertilise the eggs. In humans fertilisation occurs inside the body of the female. Describe the structures in both male and female humans that allow internal fertilisation to occur.
4. Draw a diagram of the female reproductive system and mark in:
   **(a)** the place where sperm are deposited
   **(b)** the path the egg follows to unite with the sperm
   **(c)** the path taken by the sperm to unite with the egg
   **(d)** the site where fertilisation takes place
5. A human egg cell has a diameter of about 100 micrometres (0.1 mm). A sperm cell (without the tail) is only 10 micrometres (0.01 mm) long. Suggest reasons for this big difference in size between the male and female gametes.
6. As people get older, they are more likely to suffer from diseases. Suggest a number of reasons to explain this.
7. The media frequently has articles about people who have had their quality of life greatly improved as a result of receiving a donated organ. Sometimes, as in the case of kidney transplants, a relative or close friend may have donated the organ. However, in many cases the organs have come from someone who was registered as an 'Organ Donor' and on their death, the organs were used to extend the lives of others. Find out how people can become an organ donor in Australia, and how important organ donation is in extending the lives of others.