5.1 Overview

Sex is fascinating. It has to be! It is the basic foundation for the continuation of life for most organisms on Earth. It can also be dangerous, desperate and competitive, as many insects and spiders would agree. The changes that occur at puberty in humans can be scary and exciting. But they all have the same purpose. They are the means by which you become an adult with the potential of passing on your genetic information to your offspring. It is all a part of the cycle of life. Around and around we go …

5.1.1 Think about reproduction

- How fast can a sperm swim?
- Why is a dinner date a bad idea for a male red-back spider?
- What do a clitoris and a penis have in common?
- Can sperm build up and burst your testicles?
- If females have about 400 000 eggs at birth, is there a possibility that they can have that many children?
- How big is an 8-week-old fetus?
- Which contraceptives work the best?
- What’s a ‘test-tube baby’?
- Which foods contain the swollen ovaries of plants?
- Which vertebrates were the first to have a penis?
- Do ‘virgin births’ really exist?
- What is a hermaphrodite?

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Numerous videos and interactivities are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the concepts covered in this topic.
5.1.2 Your quest
Perhaps you’ve noticed you’re changing
During puberty, your body goes through some interesting, exciting and, sometimes, scary changes.

Investigate
1. In teams, find out the answers to the five questions asked by the students shown below.
2. Share and discuss your findings with those of other teams.

INVESTIGATION 5.1
What’s happening?
AIM: To increase awareness of changes during puberty

Method and results
1. In teams of two or more, sketch a figure of a girl and a boy on separate sheets of paper.
2. Add labels to show the changes for each during puberty.
   • Compare and discuss your figures with those of other teams in the class.
3. Make any changes or additions you wish to your diagram.

Discuss and explain
4. (a) As a team, suggest changes and possible additions to your diagrams.
   (b) As a class, collate examples of changes and possible additions to your diagrams.
5. (a) Suggest reasons why these changes occur.
   (b) As a class, suggest reasons why these changes may occur.
5.2 Private parts

We’ve all got private parts. Let’s find out where they are and what they do.

5.2.1 Gamete factories …

Although testes and ovaries may look different, these two organs have the same job. They both make gametes.

Sperm are made in the testes of a male when he is sexually mature. Testes hang from the body within the scrotum to maintain sperm at a temperature of about 3 °C below that of the rest of the body. This temperature difference is essential for successful sperm production. Tight underwear or jeans can increase the temperature of the testes and so increase the number of damaged sperm produced.

### Parts of the male reproductive system

<table>
<thead>
<tr>
<th>Part</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testes</td>
<td>Produce sperm cells</td>
</tr>
<tr>
<td>Scrotum</td>
<td>Where the testes are located. Keeps the testes at a slightly lower temperature than body temperature.</td>
</tr>
<tr>
<td>Vas deferens</td>
<td>The tube through which sperm cells travel from the testes to the penis</td>
</tr>
<tr>
<td>Prostate gland</td>
<td>Secretes some of the liquid that is added to sperm cells to form semen. The fluid secreted by the prostate gland is alkaline and contains many chemicals including enzymes. It plays an important role in keeping sperm cells alive once they enter the female reproductive system.</td>
</tr>
<tr>
<td>Seminal vesicle</td>
<td>Also contributes some of the liquid that makes up semen. The fluid produced by the seminal vesicle contains proteins, enzymes, sugar, vitamin C and other substances. The sugar provides a source of energy for sperm cells.</td>
</tr>
<tr>
<td>Urethra</td>
<td>The tube inside the penis through which semen leaves the male’s body</td>
</tr>
<tr>
<td>Penis</td>
<td>The penis swells during sexual arousal. Semen containing sperm cells is ejaculated (released) from the penis into the vagina.</td>
</tr>
</tbody>
</table>
The male reproductive system

- Bladder
- Seminal vesicle
- Prostate gland
- Sperm duct (or vas deferens)
- Anus
- Urethra
- penis
- Testes
- Scrotum

The female reproductive system

- Fallopian tube
- Ovary
- Uterus
- Cervix
- Anus
- Vagina
- Bladder
- Urethra
- Clitoris
- Vulva
- Hymen
Ova (the female’s sex cells) are made in the ovaries. Females are born with about 400,000 eggs, or ova, in their ovaries. These eggs are in sacs called follicles. Usually only one ovum (plural = ova) is ripened and released into the fallopian tube (or oviduct) each month, once the female is sexually mature.

Fallopian tubes are about the diameter of a human hair. They form a tunnel in which the sperm and ovum meet and are hence the site of fertilisation. Damage to these tubes can prevent the sperm and egg from meeting.

If the fertilised egg does not move down into the uterus, but remains in the tube, an ectopic pregnancy may result.

### Parts of the female reproductive system

<table>
<thead>
<tr>
<th>Part</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovaries</td>
<td>Produce ova. One egg is produced about once a month from one of the ovaries.</td>
</tr>
<tr>
<td>Fallopian tubes/oviducts</td>
<td>Tubes through which ova must travel to reach the uterus. Fertilisation occurs in the fallopian tubes.</td>
</tr>
<tr>
<td>Uterus</td>
<td>About the size of a pear when not pregnant. It is where the embryo implants and is ‘home’ for the developing baby. The uterus lining is called the endometrium.</td>
</tr>
<tr>
<td>Cervix</td>
<td>The passageway between the vagina and the uterus. During childbirth the cervix dilates (opens up) to allow the baby to come out of the uterus. A ‘Pap smear’ involves scraping some cells from the cervix’s lining to check for any pre-cancerous changes.</td>
</tr>
<tr>
<td>Vagina</td>
<td>Elastic tube that connects the uterus to the outside world through which semen enters the female’s reproductive system. During birth, babies are pushed out of the uterus and pass through the vagina to enter the world.</td>
</tr>
<tr>
<td>Clitoris</td>
<td>Swells during sexual arousal and becomes highly sensitive when erect</td>
</tr>
</tbody>
</table>

Ova (the female’s sex cells) are made in the ovaries. Females are born with about 400,000 eggs, or ova, in their ovaries. These eggs are in sacs called follicles. Usually only one ovum (plural = ova) is ripened and released into the fallopian tube (or oviduct) each month, once the female is sexually mature.

Fallopian tubes are about the diameter of a human hair. They form a tunnel in which the sperm and ovum meet and are hence the site of fertilisation. Damage to these tubes can prevent the sperm and egg from meeting.

If the fertilised egg does not move down into the uterus, but remains in the tube, an ectopic pregnancy may result.

### HOW ABOUT THAT!

Did you know that not all plants or animals have separate sexes? Some invertebrates are both male and female at once. These interesting combinations are called hermaphrodites. This enables an individual to achieve greater reproductive efficiency than if it was just the one sex.

Snails have been around for 600 million years and have developed intriguing methods of reproduction. Each snail has an organ called an ovotestis, which makes both sperm and eggs, and a single tube to carry both the sperm and the eggs.

After a complex courtship in which hermaphrodite snails rear up, each pressing its muscular foot against its partner, and stroking each other with their tentacles, they simultaneously insert their sex organ into the other’s body. In this manner, each snail gives sperm to the other and each has its eggs fertilised.
HOW ABOUT THAT!

Amazing sperm

Sperm cells are less than half a millimetre long. Viewed through a microscope lens, spermatozoa (sperm, for short) remind you of tadpoles — a big head and a thin, whippy tail. They form in the testes, but only when the temperature is just right — a few degrees lower than body temperature. This is where the scrotum — a natural thermostat — does its job. It shrivels and scrunches up closer to the body when you are cold (keeping sperm warmer) and hangs away from your body when you are hot (cooling them down).

5.2 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. Put the following words into sentences:
   (a) testes, scrotum, sperm
   (b) ovaries, ova, follicles
   (c) vas deferens, fallopian tube, ovaries, testes
   (d) ovum, fallopian tube, sperm, fertilisation, ovary.

2. Explain why tight underwear is not recommended for males.

3. What is an ectopic pregnancy?

4. Draw a table as shown below. Classify the following organs and list them in the correct column of your table.
   fallopian tube, penis, urethra, testes, prostate gland, bladder, uterus, seminal vesicle, ovary, vas deferens, scrotum, cervix, vagina

<table>
<thead>
<tr>
<th>Found in males only</th>
<th>Found in females only</th>
<th>Found in both males and females</th>
</tr>
</thead>
</table>

5. Match each organ with its function. There may be more than one organ with the same function.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Seminal vesicle</td>
<td>A. Produces gametes</td>
</tr>
<tr>
<td>b. Ovary</td>
<td>B. Where the baby grows and develops</td>
</tr>
<tr>
<td>c. Scrotum</td>
<td>C. Where fertilisation occurs</td>
</tr>
<tr>
<td>d. Testes</td>
<td>D. Keeps the testes slightly cooler than the rest of the body</td>
</tr>
<tr>
<td>e. Prostate gland</td>
<td>E. The passageway between the vagina and the uterus</td>
</tr>
<tr>
<td>f. Uterus</td>
<td>F. Produces some of the liquid found in semen</td>
</tr>
<tr>
<td>g. Cervix</td>
<td></td>
</tr>
<tr>
<td>h. Fallopian tubes</td>
<td></td>
</tr>
</tbody>
</table>
Think and discuss
6. Construct Venn diagrams to compare the following pairs:
   (a) ovaries and testes
   (b) vas deferens and fallopian tubes
   (c) penis and clitoris
   (d) seminal vesicles and prostate gland
   (e) uterus and vagina.

Investigate, think and discuss
7. Suggest why women with blocked fallopian tubes are unable to have babies.
8. Carefully observe the male and female reproductive figures on page 198.
   (a) Identify three organs for each gender and state their function.
   (b) Suggest how the structure of each organ suits it for its function.
9. What is a hermaphrodite? Suggest possible advantages and disadvantages of this condition.
10. Male turtles have quite a bit in common with a human male. Carefully observe the figure above showing
    the reproductive system of a male turtle. Construct a Venn diagram that identifies the similarities and
    differences between the two systems.

Investigate and create
11. (a) Construct a model of the reproductive system of:
    (i) a human
    (ii) another animal of your choice.
    (b) Describe how they are similar and how they are different.
    (c) Design and create a third model that has the best features of each.
12. Imagine that you are a sperm or an egg. Find out more about how you are produced, stored and used in
    sexual reproduction.
    (a) Write a dramatic story about your life.
    (b) Construct puppets, animated cartoons or ‘fancy dress’ actors to recreate your story as a play.
13. Find out more about sperm and ova and represent your findings in the following formats.
    (a) Venn diagram
    (b) PMI chart
    (c) Flowchart
5.3 Why the changes?

Perhaps you have noticed that you are changing. Have you noticed any hairs in places where they weren’t before, changes in your body shape or height, changes in your interests …?

5.3.1 Changes can be very exciting

Changes that you may currently be aware of are indications that you are becoming an adult. These physical changes are called puberty. The term ‘puberty’ comes from the Latin word pubertas, which means adulthood.

The main purpose of the changes that occur in puberty is to enable you to start producing children. Your sex organs grow and develop. Males begin to produce sperm and females begin to develop the ova they were born with. When combined, these gametes can produce babies.

5.3.2 We are all different

It’s okay for the changes to occur at different times and at different rates, because everyone is different. We are all individuals. People reach puberty at different ages. Girls reach puberty between the ages of 8 and 17 years, and boys between 10 and 18 years.

A message from your brain to your sex glands triggers all of these changes. When these glands get the message, they produce substances called hormones. These hormones travel around your bloodstream and trigger lots of changes.
5.3.3 Some common questions

Q: Why am I getting more pimples?
A: The sex hormones (testosterone, for example) make the glands in the skin produce extra oils. This can cause the pores in the skin to become blocked and may result in pimples.

Q: What causes the changes in a boy’s voice during puberty?
A: The voice box, or larynx, gets bigger, making the voice deeper. Males develop a larger larynx so they develop deeper voices. The squeak often heard during this time of change is due to the muscles of the larynx getting momentarily out of control. Although female voices can also change, the final result is not usually so noticeable.

Q: In which new places am I likely to grow hair during puberty?
A: If you are female, it’s likely to be around your pubic region and under your arms. Males may notice an increase in these regions and also on their legs, arms, faces and chests.

Q: What are wet dreams?
A: These dreams happen to a boy during sleep and result in ejaculation of semen. They are quite normal (although not all boys have them) and are an indication that you are becoming sexually mature.

Q: What is a breast bud?
A: This is a little button of tissue just under the nipple from which the breast develops. Sometimes boys also get breast buds, but in their case they go away and do not develop.

HOW ABOUT THAT!

Sperm by the millions
The average amount of semen produced during an ejaculation (about a teaspoonful) contains about 200–500 million sperm cells! You might think it would take a long time for the testes to make 400 million sperm. Not so. Some 200 million sperm cells are manufactured each day by a fertile adult male. That’s around 73 billion sperm cells in a year!

Q: What role does the male hormone testosterone play in puberty?
A: Testosterone:
• is needed for sperm production
• not only enlarges the penis, testes and scrotum, but also increases their sensitivity
• increases body muscle bulk and promotes growth
• deepens the voice
• stimulates growth of body and facial hair
• increases interest in sex.

Q: Can sperm build up and burst your testes?
A: No, unused sperm are stored for a while and then reabsorbed into your body. New sperm replace them.
Q: At what age do females get periods and how long do they last?

A: Most girls experience their first period between the ages of 11 and 14, although others may have it up to two years earlier or later. The first menstrual period is called **menarche**.

A period generally lasts about four to six days, with varying amounts of discharge over this time. The discharge contains cells from the lining of the uterus that was built up in preparation for a baby.

A **menstrual cycle** is the time from the first day of one period to the first day of the next. It is usually about 28 days, but this varies in different women. It is quite common for a menstrual cycle to be irregular at first — until the body settles into its own pattern.
Q: **What is ovulation?**

A: Although all the eggs or ova are present at birth, it is only during puberty that they begin to ripen. Each month, one ovum matures and is released from the ovary into the fallopian tube. The release of the ovum is called ovulation. This continues about every 28 days until the woman enters menopause.

Q: **How many eggs are girls born with and about how many develop?**

A: Girls are born with about 400,000 eggs. Only about 400 of these will mature and be released during her menstrual cycles; the others will not mature.

Q: **What are periods?**

A: Each month, the lining of the uterus prepares itself for the fertilised egg. If the egg is not fertilised, the uterus lining is shed through the vagina. This monthly discharge, or shedding, is called **menstruation**, or a period. Sometimes there may be some discomfort or abdominal cramps during the first few days of your period. If you are having periods, it is a sign that you are also ovulating. This means that you are physically able to get pregnant and have a baby.

Q: **FSH, LH, oestrogen and progesterone: What are they?**

A: FSH (follicle-stimulating hormone), LH (luteinising hormone), oestrogen and progesterone are all hormones. FSH and LH are hormones that make ova develop in girls’ ovaries and begin sperm production in boys’ testes. Oestrogen and progesterone are produced in the ovaries. They are the most important female hormones and are involved in changes in the lining of the uterus. The hormones control the menstrual cycle as shown in the diagram on previous page.

**HOW ABOUT THAT!**

The feeling of ‘being in love’ is not a product of the heart. That happy, dreamy feeling experienced when you ‘fall in love’ is partly due to a chemical produced in your brain, called phenylethylamine. As chocolate also contains phenylethylamine, it is no wonder many people describe themselves as ‘chocolate lovers’.

**HOW ABOUT THAT!**

Why do men produce sperm and women produce eggs? Dr Josephine Bowles at the Institute for Molecular Bioscience, University of Queensland, has been researching this question — and she has found an answer. A substance called retinoic acid, a relative of vitamin A, triggers a special type of cell division called meiosis. This results in the production of female gametes or ova. Cells in the testes of the developing male fetus produce a protein that degrades this substance, and so meiosis does not occur and sperm are produced rather than ova.
5.3 Exercises: Understanding and inquiry

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Use a table to give definitions of the following terms: puberty, menstruation, ovulation, menarche, menstrual cycle, hormones, testosterone, breast buds.
2. Which hormones are responsible for triggering sperm production in males and ovum development in females?

Think and reason
3. Use the illustration of menstruation and other information in this section to answer the following questions.
   (a) What is ovulation?
   (b) On what day in a 28-day cycle is ovulation likely to occur?
   (c) At which time in the cycle is sperm most likely to meet (and fertilise) an egg?
4. Describe the changes in oestrogen and progesterone levels throughout the menstrual cycle.
   (a) Which hormone is found in the highest concentration just before ovulation?
   (b) Which hormone is found in the highest concentration when the uterine lining is thickest?
   (c) At which time would the lining provide the best ‘home’ for a fertilised egg?
5. Translate the graph on page 204 into a 28-day calendar.

Think and discuss
6. Suggest why the hips become ‘fleshier’ and the pelvic bones widen in females during puberty.
7. After puberty, the testes continue making sperm for the rest of a man’s life. How is this different from gamete production in a woman? What are the consequences of this?
8. If a female has menstrual cycles, is she potentially able to have babies? Explain.
9. Why aren’t all menstrual cycles, penises and breasts the same?

Investigate
10. Write down ten questions you have about puberty or reproduction. Use a variety of texts and resources to find the answers. Report the findings to your friends.

Create
11. Construct a crossword with your own clues and answers from information found in this section.
12. Write and act out a play to demonstrate the menstrual cycle. Include the following stages: egg ripening, ovulation, movement of the unfertilised egg into the fallopian tube and through the uterus, and both the egg and the uterine lining being shed through the vagina.
13. Get everyone in the class to write down two to five questions about the changes that occur during puberty and reproduction in a ‘Dear Ethel’ magazine format. After your teacher has collated these, select at least two to investigate. Report your findings by compiling a class ‘Dear Ethel’ magazine.
14. Copy and complete the table below. Use this table to help you construct an ‘information wheel’ about the human menstrual cycle.

<table>
<thead>
<tr>
<th>Day in cycle</th>
<th>Key events</th>
<th>Hormonal changes</th>
<th>Possible images to include</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>28</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
5.4 Getting together

Let’s talk about sex. Sexual reproduction is not something to be embarrassed about, but something incredible and fascinating.

5.4.1 Snap!

In sexual reproduction offspring result from the joining of a male reproductive cell and a female reproductive cell. These reproductive cells are called gametes and are made in the reproductive organs. In animals, male gametes are called sperm and female gametes are called ova or egg cells.

Reproductive systems are designed to bring the male and female gametes together. The joining of sperm and egg cells is called fertilisation. This process mixes the genetic material from the nucleus of each parent and results in the formation of a zygote.
Meeting outside …
In some animals, especially those that live or breed in water such as fish and amphibians, fertilisation occurs outside the female’s body. This is called external fertilisation. In this situation, the female releases her unfertilised eggs into the water to be fertilised by the male’s sperm, which are also released into the water.

Meeting inside …
In animals that live and breed on land, internal fertilisation occurs. This keeps the gametes inside the body so there is no chance of dehydration occurring. In this situation, sperm are introduced into the female by a process called copulation (or sexual intercourse).

Some differences between internal and external fertilisation

- **External fertilisation**
  - Egg fertilised outside female’s body
  - Of successful fertilisations, many may be lost or struggle to survive.
  - Examples: fish and amphibians

- **Internal fertilisation**
  - Egg fertilised inside female’s body
  - May be retained and develop within female
  - May be enclosed in a protective shell and released
  - Examples: humans, birds

Sexual reproduction involves fusion of gametes.

- Offspring result from joining (fusion) of a male and a female reproductive cell.

- **Male gamete**, e.g. sperm
- **Female gamete**, e.g. ovum

- **External fertilisation**
- **Fertilisation**
- **Internal fertilisation**

- **Zygote**
5.4.2 Ova

Like sperm, ova are produced by a special type of cell division called meiosis. Unlike sperm, however, the ova that will be released throughout the female’s reproductive years are already present at her birth. This brings differences in terms of epigenetics — an exciting new branch of science that involves studying the effect of our experiences on the expression of our genetic information.

Although the resulting zygote will contain a mixture of the genetic material (nuclear DNA) from the nucleus of both the sperm and the ovum, it will contain the genetic material from mitochondria (mitochondrial DNA or mtDNA) only from the mother’s ovum. mtDNA forms the basis of many new genetic and evolutionary studies.

5.4.3 Sperm

In humans, the sperm are mixed with a nutrient-rich fluid before their release, or ejaculation, from the male’s penis. This combination of fluid and sperm is referred to as semen. The sperm make up less than one per cent of the semen. An ejaculation may release about 400 million sperm. Sperm are made up of three distinctive parts: the head, the mid-section and the tail. Swishing its tail, and powered by the mid-section, the sperm swims like a tadpole at about 4 mm per hour to reach its goal — the egg.

**Success, at last!**

Upon reaching a ripe egg, hundreds of sperm surround it and try to break through. The sperm release an enzyme that dissolves the covering of the egg and enables one of them to penetrate it. Once a sperm has done this, no other sperm can get through. The successful sperm then sheds its body and tail, and the head containing the nucleus continues to move towards the nucleus of the ovum to join with it. Because the nucleus contains the genetic information from the parents, this is the point at which the information is mixed. Once this has occurred, the resulting zygote begins its growth into a new individual. The amazing thing about all of this is that we all started this way. Wow! Imagine having been both a sperm and an egg cell. Isn’t that incredible?
5.4.4 Two or more?

Sometimes in the very early stages of division following fertilisation the embryo splits in two, so that two identical offspring are produced. This happens in the case of **identical twins**. They will always be the same gender as they both have the same genetic make-up.

Usually, only one ovum is released at a time. However, if several are released, twins or more can result from fertilisation by different sperm. In this case, the babies are not identical because they have different genetic combinations. These are called **fraternal twins**.

The use of fertility drugs and treatments has resulted in an increase in the number of multiple births. This is because fertility treatments can affect ovulation, so that more than one egg is released at a time. Some of these drugs can increase the chance of twins by 25 times and of triplets up to 350 times!
HOW ABOUT THAT!
Which animal has the longest sperm? Not an elephant, whale or human, but a fruit fly. Fruit flies of the species *Drosophila bifurca* have sperm about 5.8 cm long! That’s about 20 times longer than their own body and around 1000 times longer than human sperm.

5.4 Exercises: Understanding and inquiring
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Define the term ‘sexual reproduction’.
2. Put the following words into a sentence: gametes, sperm, ovum, zygote, fertilisation.
3. Describe the difference between external and internal fertilisation.
4. Draw a labelled diagram of a sperm.
5. Describe the events that take place when the sperm reach a ripe ovum.
6. Explain the difference between identical and fraternal twins.
7. Construct a flowchart that includes ovulation, ejaculation and fertilisation.

Think and discuss
8. Construct a Venn diagram to compare sperm and egg cells (ova).
9. With a partner or in a team, discuss the following questions:
   (a) Why is internal fertilisation generally more efficient than external fertilisation?
   (b) Why doesn’t fertilisation occur each time a couple have sexual intercourse?
   Send a team member to other teams to share your discussion points.

Investigate
10. Find out more about the gametes of at least four different animals. Display your findings either as models or as diagrams on a poster.
11. There is a theory that, by wearing tight jeans, human males may affect the development of their sperm. Find out if there is any scientific evidence to support this theory.
12. Carefully observe the graph right on the incidence of multiple births in Australia.
   (a) Suggest reasons for any patterns in the graph.
   (b) Suggest what the graph would look like if this year’s data were added. Provide supporting information for your suggestion.
13. Research further into either epigenetics or mitochondrial DNA and share your findings with others.

Investigate and create
14. Write a story, play or poem about the successful sperm, from ejaculation to when it fertilises the ovum.
15. Design a board game that incorporates information about sperm and eggs.
16. Draw a descriptive timeline that includes: ovulation, ejaculation, sexual intercourse, the various stages of the sperm’s travels through the female’s reproductive tract, and fertilisation.

Incidence of multiple births in Australia since 1980 (as a percentage of total number of pregnancies)

![Graph showing incidence of multiple births in Australia since 1980](image)

Source: Based on ABS data.
5.5 Making babies

Multiplication is the name of the reproductive game. Sometimes one and one can make three!

5.5.1 The first eight weeks
Conception occurs when the egg cell and sperm unite to form a zygote. When the zygote has divided into many more cells, it is known as an **embryo**. About ten days after fertilisation, the embryo completely embeds itself in the uterus lining (endometrium). This process is called **implantation**.

5.5.2 ‘After eight’
In humans, at about eight weeks, when the embryo has developed a distinct head, arms and legs, it is called a **fetus**. The fetus obtains its nutrients and oxygen through a special organ called the **placenta**. This organ is connected to the mother’s blood vessels through the uterus. The placenta also absorbs fetal waste products and acts as a barrier against harmful substances. The unborn child continues to develop inside a sac.
that is filled with fluid (called amniotic fluid) for the rest of its time within the uterus. The total time spent in the uterus is often called the gestation period. In humans, this is usually about 40 weeks. If a baby is born before 37 weeks, it is called premature and usually requires extra care and assistance.

### Approximate size of a fetus at different stages of development

<table>
<thead>
<tr>
<th>Development (weeks)</th>
<th>Length (cm)</th>
<th>Mass (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>7.5</td>
<td>18</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>140</td>
</tr>
<tr>
<td>40</td>
<td>51</td>
<td>3400</td>
</tr>
</tbody>
</table>

### A human embryo at 32 days

### A human embryo at 52 days

5.5.3 Giving birth

Three stages are involved in giving birth to a baby. Giving birth is referred to as labour because it can be a lot of hard work for the mother. During the first stage, the cervix gradually widens. In the second stage, the woman feels a strong urge to push with each contraction of the uterus. During this stage the baby is born through the vagina, or birth canal. Usually the baby is born head first. Sometimes the baby is born bottom or feet first; this is referred to as a breech birth and is often more difficult. The third stage lasts from the baby’s delivery until the placenta is delivered.

In some cases, the baby or mother need extra assistance. A caesarean may be performed in which doctors surgically remove the baby by cutting through the mother’s abdomen to her uterus.
(a) **First stage**  
Uterus begins to contract at regular intervals that get closer and closer together. These contractions begin pushing down on the baby. At some point, the sac holding the amniotic fluid breaks; the fluid leaks out of the mother’s vagina.

(b) **Second stage**  
The mother gets a fierce urge to push (a bit like with a bowel motion) every time the uterus contracts. Bit by bit, this pushes the baby further down the vagina (birth canal).

(c) **Third stage**  
The placenta is delivered after the baby is born. By this stage of the pregnancy it is a flattish, dinner-plate-shaped organ that looks a bit like a large piece of liver.

**HOW ABOUT THAT!**

**Oxytocin — the ‘trust’ hormone**  
Hormones can have a variety of effects on our bodies. **Oxytocin** is an example of a hormone that not only has the potential to change how we feel, but also has important reproductive roles. This hormone causes the uterus to contract during childbirth and has a key role in breastfeeding. When a baby suckles on the mother’s nipple, oxytocin is released in the mother, triggering the ‘let down’ response in which milk is released for the baby.

Oxytocin is also thought to be involved in the promotion of trust, love, empathy and social recognition. It has been described as the ‘cuddle chemical’, as it is released when mothers cuddle their babies. The release of oxytocin may assist in the formation of bonds not only between mothers and their babies, but also between people in close relationships.

With trust comes power! Nasal sprays containing oxytocin have been marketed as ‘trust sprays’. These are being advertised as having commercial value as they may contribute to feelings of trust in potential clients and customers. The development of oxytocin nasal sprays also provides an opportunity for researchers to investigate the potential use of this hormone in the development of treatments for specific autism spectral disorders (ASD) and in treatments to increase empathy and learn successful face recognition.
5.5 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Outline the differences between a zygote, an embryo and a fetus.
2. List the following in the correct order: birth, fertilisation, ovulation, growth, implantation.
3. Identify the part of the female reproductive system in which the fetus develops.
4. Explain why sexual intercourse doesn’t always result in fertilisation and pregnancy.
5. Describe the difference between:
   (a) fertilisation and implantation
   (b) fraternal and identical twins.

Using data
6. Construct a graph, using information in this section, to show the changes in length of the embryo from 2 to 8 weeks, and the length and weight of the fetus from 8 to 40 weeks.

Investigate
7. Research and report on one of the following: endometriosis, prolapse of the uterus, cervical cancer, hysterectomy, ectopic pregnancy.
8. Research and report on one of the following antenatal tests: ultrasound scanning, amniocentesis, chorionic villus sampling.
9. (a) Investigate the commercial availability and uses of the hormone oxytocin.
    (b) In your team, construct a PMI chart based on your findings.
    (c) Discuss the ethics and issues regarding the use of oxytocin in conditions not involving childbirth and breastfeeding.
    (d) If you were on an ethics committee or governing body, what regulations would you suggest be considered concerning the availability and use of synthetic versions of hormones (such as oxytocin)?
    (e) Organise your team’s discussion and findings into a format that enables it to be shared with others.

Think and create
10. Make scale models of the fetus at each age shown in the table on page 213.
11. Correctly match each key event with its day of occurrence in the menstrual cycle.

<table>
<thead>
<tr>
<th>Day</th>
<th>Key event</th>
<th>Day</th>
<th>Key event</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Implantation</td>
<td>16</td>
<td>Fertilisation</td>
</tr>
<tr>
<td>15</td>
<td>First cell division</td>
<td>23</td>
<td>Ovulation</td>
</tr>
</tbody>
</table>

12. Suggest why menstruation must stop during pregnancy. What would happen if this were not the case?
13. Construct storyboards for the following:
    (a) how you have changed between birth and ages two, four, six, eight and ten, and your current age
    (b) the ‘life of a sperm’ or the ‘life of an egg’
    (c) how you could tell a Year 3 primary student ‘the facts of life’.
14. Read through the information in the ‘Week by week’ article below. See section 5.12 in your Resources section for more information on storyboards and Gantt charts.
    (a) Mind map what you consider to be the key points.
    (b) Construct storyboards to show:
        (i) the changes experienced by the mother
        (ii) the baby’s development.
    (c) Construct a Gantt chart to sequence your key points.

Week by week pregnancy
Week 0–4
You… One of your eggs is fertilised by a sperm, resulting in the formation of a zygote. At this stage conception has occurred — although you may not be aware of it.
And your baby... The zygote divides to form a collection of cells known as a blastocyst. About 3–7 days later, the developing blastocyst moves down the fallopian tube to embed into the lining of the uterus. At this stage, the blastocyst is about 0.23 mm long.

**Week 5**

You... may experience tiredness, breast tenderness and need to urinate more often.

And your baby... is only about 1.25 mm long. During this week differentiation into ectoderm, mesoderm and endoderm occurs.

**Week 6**

You... may be feeling nauseous (and possibly vomiting), have sore or tender breasts, fatigue, constipation and need to urinate more frequently.

And your baby... is now called an embryo and has a beating heart, although it’s still reliant on your blood supply. By the end of this week the neural tube will have closed, later to develop into a brain. Although only between 2–4 mm long, development can be affected by alcohol, nicotine and other chemicals.

**Week 7**

You... Although there may not be any external signs of your pregnancy, quite a lot is happening internally! You may feel quite tired and nauseous in the mornings (morning sickness).

And your baby... During this week, your baby grows significantly from 4–5 mm to 11–13 mm. The brain begins to form and develop, the heart begins to form valves, digestive systems begin to take shape and limbs are visible.

**Week 8**

You... Your clothes may become tighter around your torso as your uterus is increasing in size.

And your baby... is now 14–20 mm long and a face is beginning to take shape. A nose tip, nasal passage, ear openings, fingers and toes are visible. Lungs are developing and a skeleton is starting to form.

**Week 9**

You... Your clothes are getting even tighter as your waist continues to thicken. Your uterus has grown from the size of your fist to that of a grapefruit.

And your baby... About 22–30 mm in length, even though eyes are still forming, now eyelids and tiny external ears are forming and are visible.

**Week 10**

You... Changes in your hormone levels may result in mood changes and feeling more emotional.

And your baby... 31–42 mm in length, all organs are present and most of the major structures have formed.

**Week 11**

You... Due to the baby’s rapid growth, you may feel very tired. You may also feel your uterus above your pubic bone.

And your baby... is about 44–60 mm in length with a head that takes up almost half of this length! This is a period of rapid growth; eyes are formed, face completed, and bones and ribs appear.

**Week 12**

You... may feel better as morning sickness improves. Your breasts may be getting larger and there is more thickening of your waist.

And your baby... is around 60 mm, nails and teeth are beginning to form, nervous system continues to develop, digestive system and external genital organs are growing. Around this time, a heartbeat can be detected.

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Learnon Resources — Online Only

Complete this digital doc: Worksheet 5.5: Inside the womb
Searchlight ID: doc-18734
5.6 To breed or not to breed

Science as a human endeavour

Conception involves the production of a zygote and its implantation into the wall of the uterus. Techniques that prevent this happening are called contraception.

5.6.1 Preventing pregnancies

Contraceptives are the devices or substances used to prevent unplanned pregnancies. There are two main types of contraceptives: those that prevent fertilisation taking place and those that prevent the fertilised ovum from implanting in the uterus.

The ‘cafeteria approach’ to contraceptives enables people to weigh all the risks, benefits, advantages and disadvantages, and to find out which type best suits them.
The World Health Organization estimates that, worldwide, half of all pregnancies are unplanned. The information that follows gives you the facts about a variety of contraceptives. Quite often, television shows and magazines introduce sexual activity to young adults without giving them the full story. This can deliver a distorted message. But remember, the most effective method of contraception of all is to not have sexual intercourse!

5.6.2 New and improved products

Throughout history, people have tried to find methods that would enable them to have sex but not make babies — for example, people have tried swallowing tadpoles in spring, using lemons as a ‘diaphragm’ and using pig intestines as condoms. Because there is still no such thing as the perfect contraceptive, many new products are being invented and tested.

For women, some of these include transdermal patches that stick on the skin and release hormones, vaginal pills that dissolve into spermicide when inserted into the vagina before intercourse, and the Filshie clip, a type of fallopian tube clamp. In some countries, even a female condom is available.

New products for men include testosterone injections or implants to reduce sperm levels, anti-fertility vaccines that regulate sperm and testosterone production, sperm duct plugs that inject liquid plastic into the vas deferens, chemical sterilisation, and gossypol, a chemical that reduces sperm production.

5.6.3 In for the long haul

There are various long-acting contraceptive methods available. Once ‘introduced’, these require no further action by the user for a long time. A disadvantage of most is that they require medical intervention for insertion and removal. Examples include:

- **Depo injections**: Also known as Depo-Provera, this is a hormone injected into the user’s buttock muscles that prevents ovulation for about three months.
- **Implants**: A contraceptive implant (about the size of a matchstick) called Implanon is inserted under the skin of the inner, upper arm and prevents ovulation for about three years.
- **Hormone releasing intra-uterine devices (IUD)**: A Mirena is a T-shaped plastic device that releases hormones, acting directly on the lining of the uterus to make it thin and unreceptive to implantation of the fertilised egg. It also changes the fallopian tube lining, the mucus produced by the cervix and can stop ovulation in some women. It provides continuous contraceptive protection for about five years.
‘Mapping’ contraceptives — are some types of contraceptives better than others?

Will the future include contraceptive drugs that disable sperm or inhibit sperm production?
5.6 Exercises: Understanding and inquiring
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Identify which methods of contraception:
   (a) prevent the sperm from reaching the egg
   (b) prevent the release of the egg.
2. Construct a table that has six columns, with headings for: the type of contraceptive, a summary of how it works, who uses it (male or female), suggested advantages, suggested disadvantages, and a prediction of how many pregnancies may occur if 100 sexually active, fertile couples were to use it.

Think
3. After a vasectomy:
   (a) does a male still produce sperm
   (b) what does the ejaculate contain?
4. After a tubal ligation, does a woman:
   (a) still ovulate
   (b) menstruate?
5. Suggest why some contraceptives may be more effective than others.

Investigate and discuss
6. Research a method of contraception and present your findings to your team or class as a poster, PowerPoint presentation or concept map.
7. Find out about four of the following types of contraceptives and then present your findings with your team as a poster, PowerPoint presentation or concept map.
   • Combined oral contraceptive pill
   • Progesterone-only pill (or the mini pill)
   • Depo-Provera (injectable contraceptive)
   • Hormonal implants
   • Morning-after pill
   • Today sponge
   • Lng-Levonova IUD
   • Vaginal ring
   • Female condoms
8. Find out the advantages and disadvantages of each type of contraceptive listed above. Present your findings as a matrix. Compare and discuss your findings with others in the class.

Create
9. Design a ‘future’ contraceptive, using your imagination and knowledge of reproductive systems. Decide how you would scientifically test the safety, effectiveness and popularity of your contraceptive. Produce a brochure that promotes your invention.

learnon RESOURCES — ONLINE ONLY

Watch this eLesson: Methods of contraception: This elesson will help you understand the many different forms of contraception and how effective they are in preventing conceptions.
Searchlight ID: eles-0127
5.7 Reproductive technologies

Science as a human endeavour

Making babies is not always easy and simple. Not everyone can make their own babies.

The term infertility describes the inability to conceive or carry a pregnancy to a live birth. About 20 per cent of all couples are infertile. One of the commonest causes of infertility is the inability of either the male or the female to produce gametes. Such a person is sterile.

Some of the other reasons couples may not be able to have children are listed in the table below. Reproductive technologies have been developed to help people overcome some of these problems.

<table>
<thead>
<tr>
<th>Type of problem</th>
<th>Definition/reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gametes</td>
<td>Sperm or ova are not produced in sufficient quantity or quality.</td>
</tr>
<tr>
<td>Impotence</td>
<td>Some men cannot maintain an erection during sexual intercourse.</td>
</tr>
<tr>
<td>Blockage or damage</td>
<td>Some women may have blockages in their reproductive system (e.g. fallopian tubes), preventing fertilisation.</td>
</tr>
<tr>
<td>Miscarriage</td>
<td>The zygote or embryo is not maintained until the full term of the pregnancy.</td>
</tr>
</tbody>
</table>

5.7.1 Artificial insemination (AI)

This technique involves injection of sperm into the woman’s uterus close to the time of ovulation. The sperm may be collected from her partner, or from another male if her partner is sterile. Artificial insemination is also used in agriculture in the production of prime farm animals, and in the breeding programs for endangered species.
5.7.2 In-vitro fertilisation (IVF)

In IVF, the sperm and the egg are fertilised outside the female’s body. The fertilised egg is incubated until it develops into an embryo, which is then introduced into the female’s uterus.

In this technology, eggs are surgically removed using a needle, laparoscope and forceps. A laparoscope has the lens of a microscope. To improve the chances of success, the woman is often treated with drugs that cause super-ovulation, resulting in several ova maturing at the same time (instead of one, as is usually the case). It is possible to freeze any fertilised eggs that are not used so that they may be available at a future time. This could enable ‘twins’ to be born years apart. Some women may use donor eggs (ova from other women).

The removed egg is then fertilised outside the mother’s body in a small glass tube or dish. The sperm used is treated to remove its outer protein coat (an event that usually occurs in the female’s reproductive tract). The fertilised egg is incubated in the laboratory until it is at the two- or four-cell stage. A four-cell embryo is obtained about 35–46 hours after fertilisation.

The embryo is then placed into the woman’s uterus for implantation. Babies born using this technique are often referred to as test-tube babies. In 1980, Australia’s first IVF baby, a girl, was born in Melbourne; the first frozen embryo baby was also born in Melbourne, in 1984.

Some women are unable to maintain the growing embryo inside their uterus. A woman may, for example, be born without a uterus. The development of IVF technology has also opened up the field of surrogacy. In this situation, eggs are surgically removed from one woman and fertilised using IVF techniques. After this they are placed into another woman who undergoes the pregnancy.
5.7.3 Testing the unborn child

There are a variety of technologies that can be used to test genetic composition and development. Some of these can be performed when the new life is in its very early stages. Pre-implantation genetic diagnosis (PGD) may be used to diagnose and exclude genetic abnormalities in embryos before potential implantation.

Other techniques, such as ultrasound, amniocentesis and chorionic villus sampling can be used at later stages of development. These techniques enable the gender and a variety of abnormalities to be identified.

During amniocentesis, a fine needle is inserted into the amniotic sac of the fetus at around 14–16 weeks of the pregnancy and a small amount of fluid is drawn out to be tested.

In chorionic villus sampling, cells from the developing placenta are removed for testing at around 10–12 weeks of pregnancy.
HOW ABOUT THAT!
Cadence Minge, a University of Adelaide researcher, was a winner of South Australia’s Young Investigator of the Year award in 2007. Her research provided scientific evidence that high-fat diets could cause infertility in obese women. Her investigation involved using mouse eggs and showed that diets high in fat caused damage to eggs stored in the ovaries. She also found that a particular protein called PPAR-gamma could reverse the effects, but warned that it should not be considered a ‘quick fix’ for infertile women.

Cadence Minge (Winner of South Australia’s Young Investigator of the Year award in 2007)

HOW ABOUT THAT!
There are many different types of reproductive technologies. While assisted reproductive technologies (ART) can be used to treat infertility, other types (such as contraceptives) may be used to reduce fertility. Other types of reproductive technologies may be used to determine the likelihood of developing a particular genetic disease or to increase the number of offspring with particular features.

Example of reproductive technologies

- Cryopreservation of sperm, oocytes and embryos
- Intracytoplasmic single sperm injection (ICSI)
- In-vitro fertilisation (IVF)
- Contraception
- Pre-implantation genetic diagnosis (PGD)
- Tubal embryo transfer (TET)
- Artificial insemination (AI)
- Cloning
- Gamete intrafallopian transfer (GIFT)
- Zygote intrafallopian transfer (ZIFT)

What’s the difference between a GIFT and a ZIFT? Which of the reproductive technologies in this figure increase fertility and which decrease it? What’s cryopreservation and why bother with it?
5.7 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. Discuss the techniques that would help a couple reproduce if:
   (a) the male was infertile
   (b) the male was impotent
   (c) the female had blocked fallopian tubes
   (d) the female had a history of miscarriages.

2. Distinguish between:
   (a) artificial insemination and in-vitro fertilisation
   (b) ultrasound and amniocentesis.

3. Outline, in point form, the steps involved in IVF.

4. What are ‘test-tube’ babies? Is this an adequate name for them? Explain.

Think, investigate and discuss

5. In groups of four or more, discuss each issue statement in the table below.
   (a) Write a list of people’s ‘gut reactions’ or immediate responses to each statement.
   (b) Make a list of arguments for, and a list of arguments against, each statement.
   (c) Suggest what factors influenced your opinions on these issues.
   (d) Did the opinions differ between members of your group? Suggest reasons why.
   (e) Report your findings back to the class, or organise a debate.
   (f) Write a summary paragraph about the class’s overall response to each statement.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Issue statement</th>
<th>Your opinion (Explain your response with arguments for and against the issue.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>• Sperm should be used only from males with a high IQ, blue eyes and red hair.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• All women should be artificially inseminated with sperm selected by their parents.</td>
<td></td>
</tr>
<tr>
<td>IVF</td>
<td>• The IVF program is too expensive and should be abandoned.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• IVF technology should be used to build a superior race.</td>
<td></td>
</tr>
<tr>
<td>Donor gametes; surrogacy</td>
<td>• Donors and surrogates should be anonymous and have no rights over the offspring produced.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sperm should be collected from all males at the age of 18 and only this is to be used for fathering children.</td>
<td></td>
</tr>
<tr>
<td>Frozen embryos</td>
<td>• These embryos should be available to other couples if they are not used within six months.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• These embryos should be developed so that they provide a supply of blood and organs for transplants.</td>
<td></td>
</tr>
<tr>
<td>Ultrasound; amniocentesis</td>
<td>• These tests should be made compulsory for all women. Any abnormalities should result in immediate removal of the fetus.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• These techniques should be used to select the gender of the child.</td>
<td></td>
</tr>
</tbody>
</table>

6. Who should decide who is entitled to access these technologies? Discuss this with your team and report back to the class.

7. What are the risks linked to reproductive technologies?

8. (a) Find out about the South Australian Young Investigator of the Year award and outline examples of scientific research that winners have been involved in.
   (b) Find out more and report on one of these research areas.
5.8 Reproduction issues

Science as a human endeavour

Research in the area of reproductive technology has brought rapid change. There is a big difference between what is scientifically possible and what is socially acceptable.

The news snippets in this section provide examples of situations where the use of reproductive technology has raised ethical, social, legal or economic issues. Each snippet is a summary of a news story that was either published in a newspaper or was presented on the news.

9. (a) Find out similarities and differences between the fields of obstetrics and gynaecology.
   (b) Select a topic that interests you in the area of reproductive technologies, and investigate and report on research in that field.

10. Research and report on the scientific contributions of two leading reproductive technology pioneers:
    (a) Carl Wood (IVF pioneer, assisted reproductive technology)
    (b) Alan Trounson (IVF and stem cell pioneer).

11. Developments in reproductive technology rely on scientific knowledge from different areas. Find examples that provide evidence for this claim.

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**MOTHER URGES LEGALISATION OF SURROGACY**

Surrogacy is when a woman carries and delivers a baby for a childless couple. In some cases sperm from the father is used to artificially inseminate the surrogate mother. In other cases an embryo from the childless couple is produced by IVF and then transferred into the womb of the surrogate. In commercial surrogacy the surrogate is paid, sometimes large amounts of money, to carry the child. Altruistic surrogacy does not involve the exchange of money. A friend or sister might carry a child for a couple for example, and not expect payment in return. In 2008, altruistic surrogacy was legal in all states except Queensland where women could be fined or sent to jail for acting as a surrogate. A 2010 Act made altruistic surrogacy legal in Queensland.

**INDIA’S BABY FARMS**

Indian clinics specialising in surrogacy are offering rich childless couples from around the world the opportunity to use a poorer Indian woman as a surrogate. The women are paid to act as surrogates. They live together while they are pregnant, and they receive regular health checks and have all their meals prepared. For American couples (another country where commercial surrogacy is legal) the cost of an Indian surrogate is much less than an American surrogate.

Dr Kakoli Ghosh Dastidar works in a clinic in India where local women are paid to act as surrogates for other couples.
FREEZING EGGS IS ‘HIGHLY EXPERIMENTAL’

The option of freezing some eggs is increasingly offered to women for a variety of reasons. Treatment for certain types of cancer can make women infertile or damage their eggs. Having some eggs collected and frozen before starting cancer treatment would give these women a chance to have children after they recover from the cancer. For women who have not met the right partner or do not yet feel ready to be mothers by the time they reach their late thirties, egg freezing might offer the possibility of extending their reproductive years. The chance of producing a baby from frozen eggs is not very high at this stage. In 2007 the American Society for Reproductive Medicine calculated that for every 100 frozen and thawed eggs only 2 to 4 pregnancies would result. Eggs are more difficult to freeze than semen or embryos because they contain more water and ice crystals can form inside the egg.

A human egg (below) shown next to the tip of a thin glass pipette

RIGHT TO USE DEAD HUSBAND’S SPERM

A UK woman confirmed that she was pregnant by her dead husband’s sperm. Her husband died from meningitis in 1995. Some sperm samples were collected and frozen. She was told that she could not use the sperm samples for artificial insemination because her husband had not given his consent in writing before he died. She went to court and won the right to use the semen samples.

Semen can be collected from a recently deceased man and frozen for later use, but is it ethical to do so?

DESIGNER BABIES

Professor Julian Savulescu, an ethicist from Oxford University, argues that parents should be able to use genetic testing combined with IVF to choose the genetic characteristics of their children. Currently it is possible to test embryos created by IVF to find out which carry certain disease-causing genes. Embryos found to carry the genes are not implanted. Professor Savulescu argues the technique should be further developed to allow parents to select genes for anything ranging from hair colour to intelligence or sporting ability.

Should parents have the right to select certain characteristics in their children?
A Victorian couple sued doctors at an IVF clinic. The couple decided to use IVF to conceive their child because they wanted to avoid giving birth to a child with haemophilia. The mother knew she was carrying a gene for haemophilia. Haemophilia is a disease where blood does not clot properly. A person who has severe haemophilia will usually require a transfusion of a special component of blood any time they have even a minor injury such as a cut or bruise. If a woman is a carrier for haemophilia, she does not have haemophilia herself. If she has a daughter and the father does not have haemophilia, the daughter will not have haemophilia either. If the same couple have a son, however, there is a 50 per cent chance that he will have haemophilia.

The couple used IVF because they wanted the doctors to test the embryos to find out whether they were boys or girls before transferring them to the mother’s womb. The doctors made a mistake and transferred a male embryo. The couple gave birth to a son who has severe haemophilia.

The couple sued the doctors who carried out the IVF treatment. They argued that the unexpected arrival of a boy caused them shock and anxiety. They also wanted to be compensated for the cost of medical treatment for their son as well as the pay they lost as a result of not being able to go to work when their son needed treatment.

### 5.8 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**

1. Distinguish between the following terms:
   (a) surrogacy, artificial insemination and IVF
   (b) commercial surrogacy and altruistic surrogacy.
2. Outline some situations where women may consider having their eggs frozen.
3. Explain what the chance is of producing a baby from a frozen egg. Why is the success rate so low?

**Think**

4. Discuss whether there should be an age limit for IVF treatment. Should this age limit apply to the mother only or to both parents? Justify your answer.
5. Create a PMI chart about the following statement: A woman should be allowed to use her dead husband’s sperm to conceive a child.
6. Using IVF and genetic testing it is currently possible for parents to choose certain characteristics in their children. The technology can be used to screen out certain genetic diseases and to select the sex of the child. In the future it may be possible to select a much greater number of characteristics.
   (a) Discuss whether this particular technology is harmful or beneficial.
   (b) Should parents be allowed to select any characteristics for which there is a test available or should there be restrictions on the characteristics that parents can select? Justify your answer.
   (c) IVF and genetic testing are expensive procedures, so they may not be available to poorer couples. Explain how this could have an impact on society.

**Investigate**

7. Use EBSCO or another database to locate other news stories about reproductive technology. Summarise the key points in each article.
5.9 Stem cells: A source of issues

Have you heard or read about the issues regarding stem cells? What’s the stem of the trouble? What are stem cells and why are people arguing about them?

5.9.1 What are stem cells?
Stem cells are unspecialised cells that can reproduce themselves indefinitely. They have the ability to differentiate into many different and specialised cell types. Stem cells in a fertilised egg or zygote are totipotent — they have the ability to differentiate into any type of cell. The source of the stem cell determines the number of different types of cells that it can differentiate into.

The ability to differentiate into specific cell types makes stem cells invaluable in the treatment and possible cure of a variety of diseases. For example, they may be used to replace faulty, diseased or dead cells. The versatility of stem cells is what makes them very important.

5.9.2 What are the sources of stem cells?
Embryonic stem cells can be obtained from the inner cell mass of a blastocyst. Blastocyst is the term used to describe the mass of cells formed at an early stage (5–7 days) of an embryo’s development. Embryonic stem cells are pluripotent and can give rise to most cell types; for example, blood cells, skin cells, nerve cells and liver cells.
**Somatic stem cells** can be obtained from bone marrow and umbilical cord blood. Stem cells obtained from the bone marrow are often referred to as **adult stem cells**. These cells are **multipotent** and can develop into many kinds of blood cells.

Embryonic stem cells are removed from the blastocyst and cultured to produce different cell types.
The umbilical cord is the cord that connects the unborn baby to the placenta. This is how the baby gets nutrients and oxygen while it is still inside its mother’s body. This cord contains stem cells that can develop into only a few types of cells, such as blood cells and cells useful in fighting disease. **Umbilical cord stem cells** can be taken from this cord when the baby is born.

### 5.9.3 Can stem cells be made to order?

While the information in your genetic instructions tells your cells which types of cells they should become, scientists have also been able to modify the ‘future’ of some types of cells. By controlling the conditions in which embryonic stem cells are grown, scientists can either keep them unspecialised or encourage them to differentiate into a specific type of cell. This provides opportunities to grow replacement nerve cells for people who have damaged or diseased nerves. Imagine being able to cure paralysis or spinal cord injury. In the future, stem cells may also be used to treat and cure Alzheimer’s disease, motor neurone disease, Parkinson’s disease, diabetes and arthritis.

### 5.9.4 So what’s the problem?

The source of embryonic stem cells raises many issues. Embryonic stem cells can be taken from spare human embryos that are left over from fertility treatments or from embryos that have been cloned in the laboratory. Some argue that this artificial creation of an embryo solely for the
The purpose of obtaining stem cells is unethical. There has also been concern about the fate of the embryo. In the process of obtaining stem cells, the embryo is destroyed.

Some parents have decided to have another child for the sole purpose of being able to provide stem cells for a child who is ill or has a disease. In this case, the blood from the umbilical cord or placenta is used as the source. Some suggest that this is not the ‘right’ reason to have a child and that children should not be considered to be a ‘factory’ for spare parts for their siblings.

HOW ABOUT THAT!

Professor Alan Trounson is an Australian scientist who has spent a great part of his working life perfecting the technique for creating embryos outside the human body. He was part of the team that produced the first test-tube baby in Australia in 1980. He has also done a lot of work on embryonic stem cells. In 2000, his team showed that it was possible to produce nerve cells from embryonic stem cells.

He was recently appointed as the president of a Californian institute that specialises in stem cell research. It is the best-funded facility of its kind in the world, so Trounson will have the best technologies at his disposal to move stem cell research forwards.

5.9 Exercises: Understanding and Inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. What are stem cells?
2. Distinguish between the terms ‘totipotent’, ‘pluripotent’ and ‘multipotent’.
3. Outline the importance of stem cells.
4. List sources of stem cells.
5. Outline issues regarding stem cell research.
6. Describe a scientific contribution made by the Australian scientist Professor Alan Trounson.

Investigate, share and discuss

7. Investigate some of the following questions.
   (a) Which inherited genetic diseases are potentially treatable with stem cells?
   (b) How many different kinds of adult stem cells exist and in which tissues can they be found?
   (c) Why have adult stem cells remained undifferentiated?
   (d) What are the factors that stimulate adult stem cells to move to sites of injury or damage?

8. In a team, discuss the following questions to suggest a variety of perspectives.
   (a) Is it morally acceptable to produce and/or use living human embryos to obtain stem cells?
   (b) Each stem cell line comes from a single embryo. A single cell line allows hundreds of researchers to work on stem cells. Suggest and discuss the advantages and disadvantages of this.
   (c) If the use of human multipotent stem cells provides the ability to heal humans without having to kill another, how can this technology be bad?
   (d) Parents of a child with a genetic disease plan a sibling whose cells can be used to help the diseased child. Is it wrong for them to have another child for this reason?

9. Find out how stem cell research is regulated in Australia and in one other country. What are the similarities and differences of the regulations? Discuss the implications of this with your team mates.
10. Investigate aspects of stem cell research and put together an argument for or against the research and its applications. Find a class member with the opposing view and present your key points to each other. Ask questions to probe any statements that you do not understand or would like to clarify. Construct a PMI to summarise your discussion.

11. Investigate and report on research at the Australian Stem Cell Centre.

5.10 Form and function: Comparing reproductive strategies

Reproduction can be a risky business — but when the stakes are high it can be worth it! Some animals have some pretty tricky ways of reproducing …

5.10.1 Big families

Many organisms produce more eggs than can survive. Imagine what would happen if the 2000 eggs laid by a female house fly all survived! Environmental factors and predators kill many offspring before they get a chance to develop to the stage at which they themselves can reproduce. Sea urchins, for example, discharge millions of gametes into the sea at one time. The coordinated timing of this release increases the chances of fertilisation occurring. However, most of the young sea urchins die. These deaths are caused by many factors, such as competition for food and resources, and predation by other animals. If this reduction in the numbers of sea urchins did not occur, they would soon over-populate the oceans. A high juvenile death rate is also quite common in many other organisms.

5.10.2 Dad’s having a baby

Seahorses are very unusual fish, especially when it comes to making babies! It is the female that inserts part of her body (an ovipositor) into the male. She pumps eggs into a pouch at the front of his body and he then fertilises them with his sperm. Labour can sometimes take two days. Dad gives birth to 50–100 little seahorses, squeezing them out one at a time. No wonder he’s called a big-bellied seahorse.

There are some amazing stories to tell about other types of seahorses. The male *Photocorynus* seahorse never grows larger than 10 cm and leads a parasitic life in which he is permanently attached to the female, hanging on by his mouth! This is useful to the female because it means that she doesn’t have to search dark ocean depths to find a mate when her eggs are ready for fertilisation.

5.10.3 Guess who’s coming to dinner?

In some fish species in which the male is in charge of protecting a clutch of eggs, it is not unusual for him to indulge in eating some of his own offspring. Honey, I ate the kids!

This trend also appears in some spider groups. The male Australian red-back spider, for example, is usually eaten by his sexual partner while mating with her. He is even considerate enough to position his

Male *Hippocampus abdominalis* seahorses try to get females to select them to carry eggs by inflating their pouches into a white balloon.
body directly in front of her jaws after he has inserted his coil-shaped sexual organ into her. Male red-backs have a short lifespan; locating a female is extremely competitive and often the tip of their sexual organ breaks off during sex!

Recent studies have found that males that are consumed increase their chances of fertilising the female’s eggs. By being eaten, they distract the female so that they may mate for longer. It was found that males that were eaten were able to mate for 25 minutes compared with 11 minutes for those that escaped. Hence, the eaten males had twice the chance of fertilising the eggs with their sperm. So, although being eaten for dinner seems like a high price to pay for sex, it does have some long-term rewards.

5.10.4 Did you know that …

• Some reptiles and rodents actually ‘cement’ up the female’s genitalia by using some of the semen, which sets into a hard plug, not allowing other sperm to get in.
• Male starworms are ‘live-in lovers’, spending their entire lives within the female’s vagina. Her eggs are fertilised by these parasitic males (which live off her vaginal fluids) as soon as they are released.
• Some butterflies have eyes on their genitals to help guide the hooks and claspers of the male to the appropriate nooks and crannies in the female during copulation.
• The Australian gastric brooding frog (now thought to be extinct) swallowed its externally fertilised eggs and then developed them in its stomach. A special chemical produced by the eggs stopped them from being digested. More than 25 baby frogs would crawl out of the female’s stomach and into her mouth.

5.10.5 Sending out signals

Using smell

Chemicals called *pheromones* can play an important role in communications between members of the same species. This type of communication makes it very easy for animals to locate a mate, even in sparsely populated areas.

When a female dog is about to ovulate, she comes ‘on heat’. During this time she releases a pheromone into her urine to notify male dogs that she is ready for mating. Likewise, female moths use scented chemicals that sexually attract male moths from as far away as 8 kilometres.
Using light

Fireflies can make part of their body glow different colours. A chemical reaction produces a bright yellow, green or blue colour, which is used to help males and females find each other so that they can mate. Not all females, however, have reproduction on their minds. Females of a particular type of firefly have a different activity in mind. They flash their glowing abdomens on and off in a particular pattern, usually suggestive of a mating invitation. Sadly, instead of a romantic rendezvous, the males become a tasty meal.

Using sound

Whales may become separated by long distances, so in order to reproduce it is important that they can communicate. The male humpback whale sings a song during the mating season to advertise his sexual availability to females.

Birds also use their songs to attract potential mates. Frogs and crickets may not sound so melodic, but they have their own way of making it known that they are available for sex. Male crickets make their chirping song by rubbing their forewings together. Often they build their own version of a stereo amplifier by digging an underground nest with a twin-horned tunnel entrance. By sitting at the junction of the horns they can beam out their message loud and clear for all to hear.

5.10.6 Tammar trends

Researchers are studying the reproductive biology of the Tammar wallaby, which may help us to understand more about ourselves.

A baby Tammar wallaby is born about 26 days after conception. At birth, it weighs only 400 mg, is about the size of the end of your little finger, and is blind and hairless. After leaving the birth canal, it crawls up into its mother’s pouch and attaches itself to one of her teats. At this stage, its external sex organs have not yet developed; researchers already know that these develop in stages quite different from those in many other mammals.

After suckling for about five months, it emerges from the pouch as a young joey. Although a joey can continue to suckle for up to a year, the mother can suckle another wallaby at a different stage of development at the same time. She does this by simultaneously producing two different types of milk. Research on how she does this could help us to improve milk production in farmed animals and our own human nutrition.

The mother Tammar wallaby can suspend the development of a fertilised egg until its older brother or sister has left the pouch, or until environmental conditions are more suitable. Finding out how she achieves this may help us develop new fertility and development technologies for other mammals, including humans.
5.10.7 Get a look at that!

Did you know that ancestral reptiles were the first vertebrates to have a penis, and that snails contain both male and female reproductive organs? While there is considerable diversity in the organisation of reproductive systems in organisms, there are also patterns and similarities. Although reproductive organs may appear structurally different, they often perform similar specialised functions that enable their species to survive and reproduce. In the figure of the snail below, can you identify similarities to our human reproductive systems? If so, what are they?

Snails are hermaphrodites because they have both egg-producing and sperm-producing organs.

5.10 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Explain why a male red-back spider has a difficult life.
2. Describe why male seahorses are unusual fish.
3. Why didn’t the babies in the Australian gastric brooding frog get digested in their mother’s stomach?
4. Describe one way in which the following males may increase the chances of their sperm fertilising a female gamete:
   (a) some butterflies
   (b) starworms
   (c) damselflies
   (d) some reptiles and rodents
5. What is the name of the group of chemicals that can play an important role in communications between members of the same species?
6. Suggest three ways in which smell is important to reproduction.
7. Describe what it means when a dog is ‘on heat’.
8. How do fireflies advertise their ‘sexual availability’?
9. Identify which animals use sounds as a key invitation for a sexual interlude.
10. Describe what the Tammar wallaby looks like when it is born.
11. Outline some ways that Tammar wallaby research may assist studies in reproductive biology.

Think and discuss
12. Suggest why reproduction is worth the ‘risks’ that may be involved.
13. Explain why internal fertilisation is generally more efficient than external fertilisation.
14. Describe three ways in which animals may increase their chance of successful reproduction by having specialised reproductive structures or techniques.

Investigate
15. Find out more about the reproductive systems and mating behaviour of two different animals. Draw up a summary table to describe how they are similar and how they are different.
16. Research the reproductive system of an animal of your choice. Describe how it reproduces and draw a diagram of its reproductive parts. Present your information in a poster.
17. Research some other methods that plants and animals use to increase their chances of producing offspring. Report your findings to the class.
18. Find out more about Tammar wallaby research and present your findings in a PowerPoint presentation, mind map, newspaper article or poster.

19. What is a hermaphrodite? Suggest possible advantages and disadvantages of this condition.

20. Find out more about the evolution of reproductive structures in vertebrates, and report to others on current scientific research in this field.

21. Research the reproductive systems of at least three different animals and then suggest modifications to the design of reproductive systems that could improve their efficiency.

22. (a) Investigate the reproductive systems of the following animals so that you can complete the table.

<table>
<thead>
<tr>
<th>Features of</th>
<th>Mammal</th>
<th>Fish</th>
<th>Turtle</th>
<th>Snail</th>
<th>Insect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gametes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male reproductive structures</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female reproductive structures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilisation</td>
<td></td>
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</tr>
</tbody>
</table>

(b) Comment on the (i) similarities and (ii) differences between animals recorded in your table.
(c) Which animals are most similar? Which animals are most different? Suggest possible reasons for this pattern.
(d) Identify a reproductive research question that could be investigated for each animal.
(e) Select one of the animals and build a model of its reproductive system.
(f) Suggest criteria that could be used to distinguish between the reproductive systems of the animals in the table.
(g) Explain, using examples, how the structure of a reproductive cell, organ or structure is well suited to its function.

Create

23. Write a story, play or poem about the life cycle (from gamete production to death) of an animal of your choice.

24. Make up a crossword with some amazing reproductive stories discovered from your own research.

25. Design a new breed of organisms. Make your ‘organisms’ out of plasticine or bread dough. Create a booklet that describes their lifestyle, how they find their mates and how they reproduce.

5.11 The sex life of plants

Like animals, many plants can reproduce sexually. Flowering plants (angiosperms) have their reproductive structures located in their flowers.

5.11.1 Flowers

Flowers make up the sexy bits of plants. The petals and nectaries are often used to lure insects and other animals to assist in the delivery of ‘sperm’ or pollen. Flowers are designed to increase the chances of pollen grains making contact with the sticky stigma.

5.11.2 Pollination

Pollination describes the way in which pollen grains reach the stigma. Plants may pollinate themselves (self-pollination). More often, however, they obtain the pollen from the flower of a different plant of the same species (cross-pollination). Cross-pollination increases the variation among the offspring and gives them a better chance of survival. The pollen grains may be transferred to other flowers by wind, insects or other animals.
Insect-pollinated flowers usually have attractive, brightly coloured petals and nectaries. The pollen grains themselves may be in a shape that makes them become easily attached to the insect.

Wind-pollinated flowers are usually less conspicuous and have no large scented petals or nectar. Their shape enables small, light pollen grains to be shaken from the plant and carried away with even the slightest gust of wind. The anthers hang outside the flower and the feathery stigmas spread out to catch airborne pollen grains.

The difference between self-pollination and cross-pollination

Self-pollination

Cross-pollination
5.11.3 Fertilisation

As in animals, only a few of the pollen grains produced actually fertilise an egg cell. After pollen grains are on the stigma of a flower, a long hollow tube called a pollen tube is formed. This pollen tube grows down the style. Male gametes (sex cells) travel down these tubes to the ovules inside the ovary, where they fuse with the ovum (female gamete or egg). This joining of male and female gametes is called fertilisation. The fertilised egg is called a zygote.

5.11.4 Plant babies

Once the flower has done its job and the egg cell has been fertilised by the pollen nucleus, another sequence of events takes place. Inside the ovule, the fertilised egg, or zygote, divides into a little ball of cells that becomes an embryo. Special tissue called endosperm surrounds the embryo and supplies it with food. The ovule becomes the seed, and tissue forms around it to provide a protective seed coat.

5.11.5 Seeds and fruit

Are you aware that when you bite into an apple, cherry or orange you are actually eating the enlarged ovary of the plant? Did you know that these swollen ovaries contain the plant’s ‘babies’ in their embryonic form? The plants are using you as a way of distributing their ‘young’ out into the world.

During the formation of the seed, the ovary expands and turns into a fruit.

The fruit of some plants can be sweet, which makes them attractive to animals, including humans, as a source of food. The animals that eat the fruit aid the plant by dispersing the seeds over a much wider area than the plant could achieve by itself.

5.11.6 Seed dispersal

One of the main jobs that fruits do is to help disperse or spread the seeds. Plants disperse their seeds in a variety of ways: dispersal may involve animals, including birds (such as in tomatoes, grapes and apples); water (such as in coconuts); or wind (such as in grasses and dandelions). Some plants can disperse their seeds by themselves. For example, the fruits of some plants in the pea family (legumes) split open suddenly when they are ripe and dry, throwing the seeds long distances.
5.11.7 Seeds and germination

The embryo, inside the seed, is made up of three different parts: the baby shoot (plumule), the baby root (radicle) and one or two thick, wing-like cotyledons.

When the conditions are right, the seed bursts open and a new plant grows out. This process is called germination. When germination is complete, the embryo has become a young plant or seedling.
INVESTIGATION 5.3

What’s in a flower?
AIM: To identify the parts of a flower and relate their structure to their function

Materials:
flowers
sharp knife or razor blade
cutting board
hand lens
tweezers

Method and results
1. Draw a diagram of your flower. Locate, count and label the petals and sepals.
2. Identify and label the male and female parts you can see.
   • Place the flower on the cutting board and hold it with the tweezers.
   • Carefully cut the flower in half down the middle (a vertical cross-section).
   • Use the hand lens to look at the ovary and eggs.
3. Draw the cross-section and label the female parts inside the flower.

Discuss and explain
4. Identify ways in which the flowers you observed were (a) similar and (b) different.
5. Suggest reasons for (a) similarities between the flowers and (b) differences between the flowers.
6. (a) Predict which parts of the flower (i) become seeds and (ii) may grow into fruit.
(b) Justify your predictions.
(c) Check references to see if your predictions were accurate and comment on your findings.
7. Describe possible relationships between the parts of the flower in your diagram.
8. Describe how the various structures of the flower that you have observed assist the plant in reproduction.
9. Suggest how the investigation could be improved.

INVESTIGATION 5.4

Investigating features of flowers
AIM: To identify a feature of a flowering plant and investigate its relationship to reproduction

CAUTION
Be responsible in your fieldwork and handle the plant parts very gently and carefully. Do not pick, break, tread, trample or climb the plants. Remember that you are dealing with living things.
**Materials:**
- 5 pieces of blank A4 paper
- pencil
- flowering plants growing in local environment

**Method and results**
1. Identify a research question that relates to either the structure or a feature of a flower that may increase its chances or effectiveness of pollination.
   - Find five plants, each with different types of flower.
2. Using a separate page for each plant: at the top of the page:
   - record your name and the date
   - record the plant's name, or, if unknown, record it as ‘specimen A, B, C’ etc.
   - give a general description of the location in which the plant is found
3. Divide the rest of your A4 sheet into three sections:
   (i) half-page sketch of a flower
      - Try to show the parts listed in the table on page 243 and label them.
      - Count or estimate how many stamens, stigma, petals and sepals are present.
   (ii) quarter-page sketch of a leaf — include any veins that you see.
   (iii) quarter-page sketch of the plant’s overall appearance.
4. Record the structure or feature of your flower identified in your research question from part 1.

**Discuss and explain**
5. In regards to your chosen floral structure or feature, identify ways in which the flowers you observed were (a) similar and (b) different.
6. Suggest reasons for (a) similarities between the flowers and (b) differences between the flowers.
7. Research your observed plants using databases and the internet. Construct a table, field guide, cluster map or multimedia format to summarise your findings on the following:
   (a) possible identification
   (b) labelled sketch or image of flower and fruit
   (c) type of pollination and type of seed dispersal
   (d) an interesting fact.
8. Based on your observations and your research:
   (a) suggest how your chosen floral structure or feature may influence the effectiveness of the pollination of the plant to which it belongs
   (b) construct a relevant hypothesis that may be investigated.

**Evaluation**
9. Identify strengths and limitations of this investigation and suggest possible improvements.

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### 5.11 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

**Remember**
1. Match the words in the left-hand column (below) with those in the right-hand column.

```
sepal    sperm
petal    sugar
pollen   leaflet
nectary  colour
ovule    egg cell
```

2. Copy and complete the table on next page for the flower parts shown in the flower figure on page 238.
Name of flower part | Function | Male, female or neither
---|---|---
3. Describe the relationship between:
   (a) stigma and stamen
   (b) ovule and seed
   (c) ovary and fruit
   (d) pollen and anthers.
4. Distinguish between the following terms.
   (a) Self-pollination and cross-pollination
   (b) Pollination and fertilisation
   (c) Plumule and radicle
   (d) Germination and fertilisation
5. Rearrange the following terms to construct a flowchart that shows the correct sequence for flowering plant reproduction: fertilisation, seed dispersal, germination, pollination.
6. Construct a mind or concept map to summarise the functions of different parts of a flower.

Think
7. Suggest why some orchid flowers closely resemble female wasps.
8. Use storyboards, cartoons or timelines to summarise how plants reproduce.
9. Use a bubble or mind map to show some foods that are seeds or products of seeds.

Investigate and create
10. Find and research examples of wind-pollinated and insect-pollinated plants. Construct models that show what you have found out about their structures.
11. What does pollen have to do with hay fever? Make a model to show the relationship.
12. What are the conditions needed by most plants for germination?
13. Find four examples of different ways that the seeds of plants can be dispersed. Construct a story or play that includes these examples.
14. Find out more about the life cycle of a plant of your choice. Report your findings as models, puppets or a poster.
15. Construct a Gantt chart or storyboard that includes seed dispersal, pollination, fertilisation, germination and development into a seedling.
16. Write a poem about the sex life of plants. Include as many of the bold-typed words in this section as possible.

Investigate
17. Is there a relationship between the colour of a flower and the strength of its scent? Design and then carry out an investigation to determine whether the colour of the flower influences how strong the scent is.
18. Do some insects prefer some types of flower colour? Research or devise your own investigation. Share your conclusions with others in your class.
19. Find out more about the seed dispersal of five different types of plants and report your findings in a visual map.
20. Use information in this section and other resources to relate structural features of the following parts of the reproductive system of a flowering plant to their functions.

<table>
<thead>
<tr>
<th>Part of system</th>
<th>Structural features</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stigma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Style</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ovary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollen tube</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nectary</td>
<td></td>
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</tr>
</tbody>
</table>
21. The figure below shows stages in the formation of a pear (fruit) from the flower. Use the internet to find details of this process for three other fruits. Present your findings in labelled diagrams.

A pear: from flower to fruit

learn on RESOURCES — ONLINE ONLY

Watch this eLesson: Growing plants in Australia: This video lesson is presented by a top Australian horticulturalist and provides you with tips for successfully growing plants in Australia. Watch this video as an introduction to your experiments with plants.
Searchlight ID: eles-0055

Try out this interactivity: Sex life of plants
Searchlight ID: int-2011

Complete this digital doc: Worksheet 5.7: Science battles weeds
Searchlight ID: doc-18728

Complete this digital doc: Worksheet 5.8: The sex life of plants
Searchlight ID: doc-18729

Complete this digital doc: Worksheet 5.9: Those fabulous plants!
Searchlight ID: doc-18730

Complete this digital doc: Worksheet 5.10: Plant reproduction
Searchlight ID: doc-18736

5.12 Multiplying by dividing

Imagine looking exactly like your parent — and all of the rest of your family!

5.12.1 Asexual reproduction

Not all organisms reproduce by sexual methods. In some types of organisms, a single parent produces one or more genetically identical offspring. This is called asexual reproduction. Binary fission, spore formation, budding and vegetative propagation are examples of this type of reproduction.

Unlike sexual reproduction, asexual reproduction does not require the fusion of sex cells. It also does not require sex cells from another organism. Because all the genetic information comes from a single individual, all offspring of asexual reproduction are identical to each other — and to their parent.

Individuals that have identical genetic information to each other are called clones. As well as occurring in nature, technology has also used cloning to produce genetically identical organisms.
5.12.2 Binary fission — let’s split

Some unicellular organisms reproduce by binary fission. In this type of asexual reproduction, when an organism has grown to a certain size, it divides into two. Prior to this division, the genetic material in the cell is replicated. The cytoplasm then divides, producing two cells with identical genetic information.

Binary fission can occur in both prokaryotes (such as bacteria) and eukaryotes (such as Amoeba, Euglena and Paramecium). While the same term is used, the actual processes involved for these different types of organisms are different. In eukaryotes, a type of cell division called mitosis is involved, whereas in prokaryotes it is not. The process in prokaryotes is less complex and faster. For example, one bacterial cell could produce about 16 million offspring in eight hours. Some types of bacteria can also produce more than two cells per division. This is called multiple fission. Multiple fission is very efficient and allows for an even greater increase in numbers within a short time frame.

5.12.3 Budding offspring!

Imagine your offspring beginning as a simple swelling on your side and then developing its own mouth and features. When its development is complete, it merely detaches itself and independently continues its own life. This is the sequence of events that happens in yeasts and also in freshwater hydra. The initial swelling is called a bud and hence this process is often called budding.
5.12.4 Spores on the wind

Some fungi (such as mushrooms, and bread and fruit mould) have spores that, when released, may develop into offspring identical to the parent fungi. These spores are merely a group of unspecialised body cells, combined with a source of nutrients and packaged in a resistant coat. They can provide an effective means of dispersing future generations, and may also overcome adverse conditions by waiting until conditions are favourable before they begin to grow.

5.12.5 Taking a short cut

In vegetative propagation, the non-sexual parts of the plant are used to develop new individuals of the same type. Examples include bulbs (e.g. daffodils), stem tubers (e.g. potatoes), runners (e.g. native violets) and cuttings (e.g. roses).
5.12.6 Fragmentation and regeneration

Flatworms and starfish are animals with some strange reproductive abilities. Fragmentation is commonly observed in flatworms. During this type of reproduction, the parent flatworm breaks into several pieces and, over time, each piece develops into a new adult flatworm. Regeneration is a similar type of reproduction that can be seen in starfish. While some starfish can regenerate replacement new limbs, others, such as the *Linckia* starfish, can regenerate completely new organisms from a severed arm.

5.12.7 Parthenogenesis — girls only?

In some animals, the females produce eggs, but these develop into embryos without fertilisation taking place. The scientific name for the development of new individuals from an unfertilised egg is parthenogenesis. Worker bees, for example, develop from unfertilised eggs laid by the queen bee.

Some gecko lizard groups are parthenogenetic and form all-female families. An example is Bynoe’s gecko (*Heteronotia binoei*), which is found only in Australia. A population of these geckos would contain only females. Births that result without any meeting between eggs and sperm are often referred to as virgin births.
5.12 Exercises: Understanding and inquiring

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. State what is meant by the term ‘asexual reproduction’.
2. List four examples of asexual reproduction.
3. Describe what is meant by the term ‘clone’.
4. Identify one way in which asexual reproduction differs from sexual reproduction.
5. Explain why the offspring produced by asexual reproduction are all identical.
6. Match (a) binary fission, (b) fragmentation and (c) budding with the correct description of the reproductive process.
   (i) Offspring starts out as a growth on the parent.
   (ii) Single-celled parent grows to a certain size, genetic material replicates, then cytoplasm divides the cell in two.
   (iii) Parts of the parent break into pieces and each piece develops into a separate organism.
7. List three types of vegetative propagation and examples of plants associated with them.
8. Describe what is meant by the term ‘parthenogenesis’, including two examples in your response.

Think and discuss
10. Sexual reproduction results in variation among the offspring, whereas asexual reproduction does not. Discuss and record advantages and disadvantages for each type of reproduction.
11. Suggest why many insects, which would usually reproduce sexually, use parthenogenesis to produce offspring in favourable conditions.

Investigate
12. (a) Place a carrot top on moist cottonwool until leaves appear, then transfer the plant to a plastic pot containing moist potting mix. Record what happens.
   (b) Try this with a variety of other vegetables. Summarise your findings.
12. Find out more about parthenogenesis and virgin births.
13. Investigate and report on the impact of plant cloning techniques in agriculture in one of the following areas: horticulture, fruit production, vineyards.

Results
1. Copy and complete the table below. You may need to dig the leaf–stem cutting and the runner from the rooting medium and wash them to see what has happened to them.

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Description after two weeks</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato</td>
<td></td>
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<tr>
<td>Leaf–stem cutting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discuss and explain
2. In your own words, summarise your observations for each of the plant parts.
3. Based on your observations, what conclusions can you make?
4. Explain why each of the examples in the table above are forms of asexual reproduction.
5. What are the advantages of growing plants using one of the techniques described above rather than growing them from seeds?
6. Suggest improvements to the design of the investigation.

5.12 Exercises: Understanding and inquiring

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<td></td>
</tr>
<tr>
<td>Leaf–stem cutting</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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5. What are the advantages of growing plants using one of the techniques described above rather than growing them from seeds?
6. Suggest improvements to the design of the investigation.
5.13 Storyboards and Gantt charts

1. Decide how many scenes you need in your story. Often, 6–8 is a good number. Divide your page into this number of equal sections.
2. Consider which will be the three main events in your story and draw them roughly in the first, middle and last sections of your page.
3. Brainstorm the scenes that fit between these. Select the most appropriate and add them as intermediate scenes.
4. Mentally stand back and examine your story outline; make any desired changes to enhance its dramatic impact.

Helps you to use both your imagination and organisational skills to capture and share thoughts and ideas

Why use?

Also called

Comic strip

Outline of scene 1

Outline of scene 2

Outline of scene 3

Outline of scene 4

Outline of scene 5

Outline of scene 6

Similarity

Both show the sequence of events.

Difference

Storyboards use sketches or diagrams while Gantt charts use tables.

Gantt chart

Example

Action Sunday Monday Tuesday Wednesday Thursday Friday Saturday

1

2

3

4

5

6

7

8

What are the main scenes in a story or event?

How to ...?
5.14 Review

5.14.1 Asexual reproduction
- contrast sexual and asexual reproduction
- outline the role of cell division in asexual reproduction
- describe some types of asexual reproduction

5.14.2 Sexual reproduction
- describe fertilisation
- contrast internal and external fertilisation
- outline the life cycle of flowering plants
- compare the reproductive systems of three different animals
- contrast mammalian and plant sexual reproduction

5.14.3 Human reproduction
- recall the name and function of the organs of the male and female human reproductive system
- relate the structure of the organs of the male and female reproductive system to their function
- explain the role of the placenta
- outline the role of hormones in reproduction
- describe the process of fertilisation
- outline some changes that occur to the zygote between the time of fertilisation and implantation
- outline some changes that occur to a fetus as it develops inside the womb
- describe the birth process in humans
- describe some birth control techniques

5.14.4 Life cycle of flowering plants
- recall the names and functions of the parts of flowering plants
- distinguish between pollination and fertilisation in flowering plants
- describe how fruit and seeds are formed from flowers
- outline ways in which seeds can be dispersed

5.14.5 Reproductive technologies
- evaluate the benefits and disadvantages of a number of reproductive technologies
- identify some causes of infertility
- assess the impact of reproductive technologies
- describe fertility treatments including artificial insemination and in-vitro fertilisation

Individual pathways

<table>
<thead>
<tr>
<th>ACTIVITY 5.1</th>
<th>ACTIVITY 5.2</th>
<th>ACTIVITY 5.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth and reproduction</td>
<td>Investigating growth and reproduction</td>
<td>Analysing growth and reproduction</td>
</tr>
<tr>
<td>doc-6087</td>
<td>doc-6088</td>
<td>doc-6089</td>
</tr>
</tbody>
</table>
5.14 Review 1: Looking back

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

1. Identify the parts labelled A–T in the diagrams below. Write one function of at least two parts in each diagram.

The male reproductive system

A
B
C
D
E
F
G
H

The female reproductive system

J
K
L
M
N
O
P
Q
R
S
T
2. Design a calendar of the menstrual cycle and then outline the events that occur at each stage on your calendar.

3. Unscramble the following types of asexual reproduction.
   
   taevvegeti gatponproai  
   narybi sfi  
   sheneipartognes  

4. Summarise the disadvantages and advantages of sexual and asexual reproduction.

5. Invent, design and make your own creature. Describe its courting and mating behaviour, and give details about the way it reproduces.

6. A paramecium is a single-celled organism that reproduces asexually.
   (a) Make a list of the advantages and disadvantages of reproducing this way.
   (b) Compare your list with that of your team. Discuss any differences.
   (c) Find out more about paramecia and, as a team, write and perform a paramecium puppet play about their lives.

7. Match the contraceptives below with the way they prevent conception and their effectiveness.

<table>
<thead>
<tr>
<th>Contraceptive</th>
<th>How it prevents conception</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condom with spermicide</td>
<td>Prevents ova from developing</td>
<td>Extremely effective</td>
</tr>
<tr>
<td>Diaphragm without spermicide</td>
<td>The fallopian tubes or vas deferens are cut and sealed</td>
<td>Unreliable</td>
</tr>
<tr>
<td>Daily contraceptive pill</td>
<td>Keeps sperm and semen from entering the woman’s vagina after ejaculation</td>
<td>Highly effective</td>
</tr>
<tr>
<td>Surgical: vasectomy and tubal ligation</td>
<td>Removal of male’s penis from the vagina before ejaculation</td>
<td>Highly effective</td>
</tr>
<tr>
<td>Coitus interruptus</td>
<td>Prevents sperm cells from reaching the cervix</td>
<td>Moderately effective</td>
</tr>
</tbody>
</table>

8. Label the parts A–G in the diagram below.
9. (a) Using information from this chapter, make at least 20 ‘reproduction game cards’ with a question on one side and the answer on the other side.
   (b) Write a list of any questions that you still have about reproduction.
   (c) Research at least three of these questions and summarise your findings on ‘reproduction game cards’ with the question on one side and the answer on the other.
   (d) Design and construct a game board with at least one diagram idea from this chapter.
   (e) Design a game that uses the cards and the board that you have made. Create a game rules book so that others will know how to play. Create any other materials that you need for your game.
   (f) Play each other’s games.
10. Construct a working model that simulates some aspect of this chapter.
11. It has been said that we are currently in the midst of a biotechnological revolution with new technologies offering us many more reproductive options. Is this true for all parts of the world? Hold a discussion about the global impact of reproductive technologies.
12. Construct a table naming the organs of the human male and female reproductive systems. For each organ, describe its structure and function.
13. Suggest how scientific knowledge about the life cycles of plants and animals can be used to develop regulations about importation of foodstuffs into Australia. Suggest reasons for these regulations.
14. Suggest how knowledge of the life cycle of a particular plant or animal may influence the practices of an agriculturalist.
15. On the basis of what you have learned in this section of your studies, suggest responses to the following questions.
   (a) How can there be weeds in the garden if I didn’t plant them there?
   (b) Why don’t twins always look the same?
   (c) Why doesn’t a caged bird lay eggs that can hatch into baby birds?
16. Write down in your workbook which letter in the following diagram corresponds to each of these terms: ovules, sepals, filament, style, stigma, ovary, anther, petals, stamen, carpel.

**Heights (cm) of seedlings**

<table>
<thead>
<tr>
<th>Position</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
<th>Day 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fridge</td>
<td>5.0</td>
<td>5.5</td>
<td>6.0</td>
<td>6.2</td>
<td>6.6</td>
<td>7.0</td>
<td>7.3</td>
<td>7.5</td>
<td>7.7</td>
<td>8.0</td>
</tr>
<tr>
<td>Garage</td>
<td>5.0</td>
<td>5.6</td>
<td>6.2</td>
<td>6.6</td>
<td>7.0</td>
<td>7.3</td>
<td>7.6</td>
<td>7.9</td>
<td>8.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Windowsill</td>
<td>5.0</td>
<td>6.0</td>
<td>6.7</td>
<td>7.5</td>
<td>8.0</td>
<td>8.5</td>
<td>9.0</td>
<td>9.6</td>
<td>10.2</td>
<td>10.6</td>
</tr>
<tr>
<td>Desk</td>
<td>5.0</td>
<td>5.8</td>
<td>6.3</td>
<td>7.0</td>
<td>7.5</td>
<td>8.0</td>
<td>8.5</td>
<td>9.1</td>
<td>9.6</td>
<td>10.0</td>
</tr>
</tbody>
</table>
17. Charlotte wanted to find out if temperature affects the growth of plants. She bought four seedlings. She put one seedling in the fridge and one in her garage (which has no windows so is dark and cooler than her house). She put the third seedling on the windowsill (in full sun) and the fourth seedling on her desk (out of the sun but in daylight). Charlotte measured the height of each seedling every day for 10 days. Her results are shown in the table on previous page.
(a) Write an aim for Charlotte’s experiment.
(b) Suggest three improvements to Charlotte’s experiment.
(c) Graph Charlotte’s results.
(d) Write a conclusion for this experiment.

Complete the following activities to produce a learning and thinking journal for this chapter.
18. Draw a diagram of an insect-pollinated flower and use descriptive labels to show what each part does.
19. (a) Use a table to show differences between the sizes, shapes and structures of a fly during each stage of its life cycle.
(b) Construct a graph to show the differences in length during the adult, egg, larval and pupal stages of the life cycle.
(c) Suggest possible survival advantages for the differences throughout the life cycle.

![Life cycle of a fly](image)

20. Use a matrix to compare flowers that are wind pollinated with those that are insect pollinated.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Feature A</th>
<th>Feature B</th>
<th>Feature C</th>
<th>Feature D</th>
<th>Feature E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>√</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>√</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

21. Construct a Venn diagram or double bubble map to show the similarities and differences between:
(a) structures involved in plant and animal reproduction
(b) fertilisation in plant and animal reproduction
(c) fusion of gametes in plants and animal reproduction
(d) embryo development in plants and animals
(e) ‘birth’ in plants and animals.

22. Construct a concept map to summarise what you know about reproduction.

23. Increased knowledge and understanding of reproductive processes have led to the development of new reproductive technologies. Construct a PMI for issues associated with one of these technologies.

24. Use a flowchart to show an example of a life cycle of a flowering plant. Include pollination, fertilisation, development, seed dispersal and germination.
25. Use the figure below to help you construct a summary of the differences between sexual and asexual reproduction. What other features can you add?

Fusion of gametes  Binary fission

Sexual  Reproduction  Asexual

Type of reproduction: Sexual involves Fusion of gametes results in Variation in offspring

Type of reproduction: Asexual involves Binary fission results in Identical offspring

26. Use a tree map to show two sides of a discussion about plant reproduction and animal reproduction.

Topic

Concept

Element

Feature

Feature

Feature

Feature

Feature

Feature

27. Make up (and perform) a song or poem to summarise something that you have learned in this chapter.

28. Label the parts of the plant in the diagram using the following terms: stigma, male gamete, pollen grain, pollen tube, stamen, ovary, ovule.
Complete this digital doc: Worksheet 5.12: Science literacy 1
Searchlight ID: doc-18731
Complete this digital doc: Worksheet 5.13: Science literacy 2
Searchlight ID: doc-18732
Complete this digital doc: Worksheet 5.14: Reproduction: Crossword
Searchlight ID: doc-18733

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