

Lesson Fourteen

Human Reproduction

Aims

By the end of this lesson you should be able to:

- understand the differences between sexual and asexual reproduction
- understand that fertilisation involves fusion of a male and a female gamete to produce a zygote, and that this undergoes cell division to develop into an embryo
- understand how the structures of the human male and female reproductive systems are adapted for their functions
- understand the roles of oestrogen, progesterone, **FSH and LH** in the menstrual cycle and the development of secondary sexual characteristics
- describe the role of the placenta in the nutrition of the developing embryo, and understand how the embryo is protected by the amniotic fluid

Context

This lesson covers elements 3.1–3.2 and 3.8–3.13 of Section 3 ‘Reproduction and inheritance’ of the Edexcel specification.



Edexcel International GCSE (9-1) Biology Student Book, pages 118-126.



Oxford Open Learning

Introduction

Reproduction occurs when an organism makes **offspring** (babies). But this can happen in two fundamentally different ways:

- The first way, called **sexual reproduction**, involves the production of special male and female sex cells called **gametes**, two of which **fuse** (join together) to form a single cell called a **zygote**. This fusion is called **fertilisation**. The zygote then divides repeatedly to form a many-celled **embryo** which eventually grows and develops into a new **adult**.
- The second way, called **asexual reproduction**, does not involve gametes.

Flowering plants, as we will see in the next lesson, can reproduce in both ways, but humans can only do sexual reproduction.

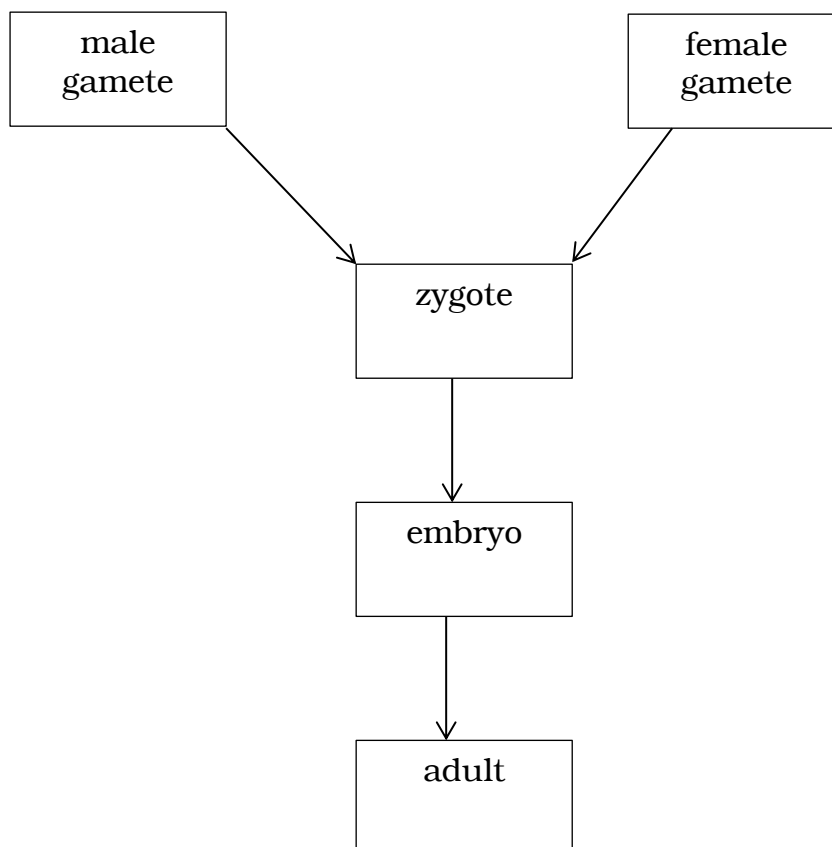


Diagram 1: Sexual Reproduction

We will first look at some more fundamental differences between the two systems, and then examine the details of sexual reproduction in humans.



Get it right!

A sperm, an ovum and a zygote are each only one cell. This is one of the rare cases where $1 + 1 = 1$!

Sexual and Asexual Reproduction

Variation

Sexual reproduction produces **variation** in a species – it makes the organisms in the species less alike.

This is because it involves the fusion of two gametes. Gametes all contain slightly different versions of the **genes** – the information which decides what the organism will be like. So the offspring produced by sexual reproduction will *differ from each other and from the parents*. You will notice that you differ from both of your parents and, if you have siblings, you differ from them as well.



Get it right! Identical twins are a special case. They are formed by two gametes fusing as normal to form a zygote then an embryo, but the embryo accidentally falling in half before it implants in the uterus lining.

Asexual reproduction, by contrast, does not produce variation. All the offspring are **clones** – genetic copies – of the parent, and are genetically identical to each other.

Gametes

Male and female gametes differ from each other in three important ways:

characteristic	male gametes	female gametes
size	small	bigger, because they contain a food store to nourish the embryo later on
movement	motile – i.e. move to find the female gametes	non-motile – i.e. stay put and wait for the male gametes to reach them
number	lots of them, to increase the chance of the female gametes being fertilised	few in number

In humans:

- the male and female gametes are made by different male and female organisms
- the male gamete (**sperm**) has a tail for swimming to the female gamete (egg or **ovum**)

This seems normal to us but, as we shall see in the next lesson, neither of these points is true for sexual reproduction in flowering plants.



Log on to Twig and look at the film titled: **Fertilisation**

www.ool.co.uk/931ny

An introduction to human fertilisation and the challenges facing the sperm and egg. How do they find each other and how do they combine to form a new life?



Get it right! The naming of gametes is a minefield.

The proper biological name for sperm is "spermatozoa" (plural) and "spermatozoan" (singular). This is usually shortened to "sperm" for obvious reasons. Technically, "sperm" is used as both the singular and the plural form of the word, but you will often hear people talking about "sperms".

The proper biological name for a woman's eggs is "ova" (plural) and "ovum" (singular). This is where words like "ovulation" and "ovary" come from. "Ovum" is simply the Latin word for "egg".

Activity 1

Female frogs lay their eggs in water, where the male squirts his sperm onto them. Neither parent then cares for the fertilized eggs. Comment on the number of eggs that a female frog lays each year compared to the number produced by a woman.



Human Reproduction

Male Reproductive System

The male reproductive system is shown in figure 9.7 on page 122 of the textbook.

Sperm are produced in the **testes** which hang in a bag called the **scrotum** outside the main body cavity. This keeps the testes cool, because sperm need temperatures lower than 37°C to develop properly.

The sperm are carried away in the **sperm duct** (medical name “vas deferens”), and mixed with a fluid called **semen** made in the **seminal vesicle**. This fluid contains nutrients for the sperm to enable them to swim. They exit to the outside through a tube called the **urethra** which runs down the **penis**. The urethra also carries urine from the bladder (but not at the same time!)



Log on to Twig and look at the film titled: **Sperm**

www.ool.co.uk/929ku

99% of sperm die before they reach the egg. What challenges face the sperm as they journey from the testes to fertilise the egg?

Sexual Intercourse

During sexual intercourse, the **erectile tissue** in the penis fills with blood so that it enlarges. It fits inside the **vagina** of the female, and semen containing sperm is **ejaculated** into the top of the vagina. From here the sperm swim to the ovum, meeting it in one of the fallopian tubes.



Get it right!

1. "Sexual intercourse" is the biological term to use for this activity in human beings. The terms "mating" and "copulation" are generally used for the same activity in other animals. More polite and ruder terms should be avoided in Biology answers!
2. Fertilisation occurs in one of the fallopian tubes, *not* in the uterus.

Female Reproductive System

The female reproductive system is shown from the front and from the side in figure 9.6 on page 122 of the textbook.

Ova are produced in the **ovaries**. Once a month a single ovum is released from one of the ovaries, a process called **ovulation**. For the next 48 hours it is wafted down the fluid in one of the **fallopian tubes** (also called the **oviducts**), and it is here that fertilisation must take place. The zygote divides continuously once formed, and has turned into a ball-like **embryo** by the time it reaches the **uterus** (womb).



Log on to Twig and look at the film titled: **Egg**

www.ool.co.uk/930rf

A woman is born with all the eggs she will ever need and will ovulate 400 times in her lifetime. But what are human eggs and how are they released?

Activity 2

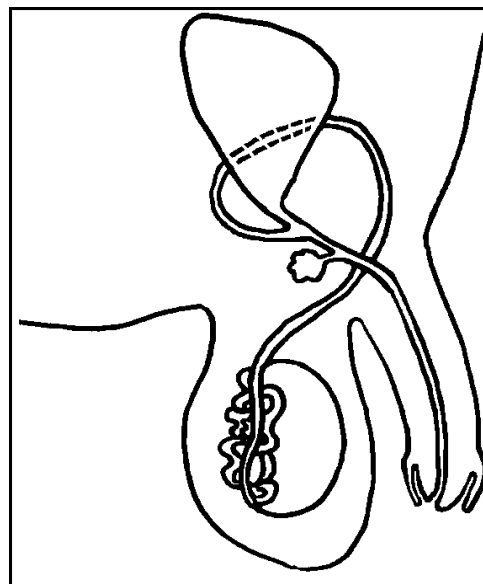
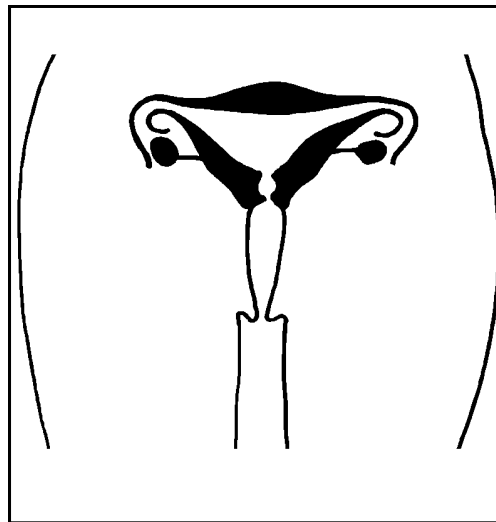
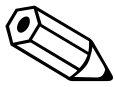
Add the following labels to the diagrams of the reproductive systems given below, and then check your answers from page 122 of the textbook.

Male:

Scrotum, testis, sperm duct, seminal vesicle, urethra, penis, bladder

Female:

Ovary, oviduct (fallopian tube), uterus, cervix, vagina.



Implantation and Development

The embryo **implants** in the soft *lining* of the uterus, whose *wall* is made of muscle. It **grows** (gets bigger) and **develops** (changes its form). Once it looks recognizably like a baby, it is called a **fetus** (also spelled “foetus”) rather than an embryo.



Log on to Twig and look at the three films titled: **Being Pregnant**

www.ool.co.uk/201qx

The Placenta and the Amniotic Fluid

While it is growing, the fetus develops a **placenta**, through which it will be provided with nutrients and oxygen from the mother's blood, and a surrounding skin called the **amnion** which secretes **amniotic fluid**. The embryo develops bathed in this fluid, which protects it against bumps as the mother moves about.

The structure of the placenta is shown in figure 9.8 on page 122 of the textbook. The **umbilical cord** attaches the fetus to the placenta in the uterus lining. Its blood passes down the cord in the **umbilical artery**, and runs close to the mother's blood in the placenta, separated from it by a thin membrane. Materials *diffuse* between the two bloodstreams:

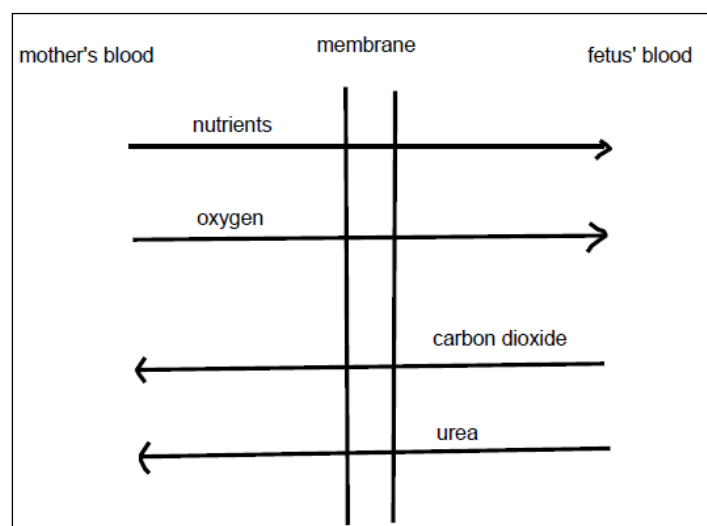


Diagram 2: Transfer of materials by diffusion in the placenta

The blood then returns to the fetus down the umbilical cord in the **umbilical vein**.



Get it right!

The umbilical cord carries the *fetus*' blood, not the mother's blood.

Activity 3

One of the main causes of miscarriage is damage to the placenta, where the membrane between the two blood supplies is torn. (a) Why might this cause a miscarriage? (b) Why isn't the membrane thicker to stop this happening?



Birth

At the end of about nine months, the **gestation period**, the fetus turns head downwards in the uterus ready for birth. The birth process is called **labour**, and it is illustrated in figure 9.9 on page 123 of the textbook:

- The fetus is pushed out by strong, rhythmic contractions of the muscular wall of the uterus. This breaks the amnion and the amniotic fluid escapes through the vagina.
- The **cervix** (the narrow entrance between the vagina and the uterus) **dilates** (widens) to allow the head of the baby through, and the baby is born through the vagina.
- The umbilical cord is cut, and the baby starts to breathe for itself.

- The contractions of the uterus wall continue, and the placenta plus umbilical cord are expelled through the vagina as the **afterbirth**.



Log on to Twig and look at the film titled: **Birth**

www.ool.co.uk/936ty

A guide to how the mother and baby's bodies change and cope with labour - the most challenging and potentially dangerous phase of pregnancy.

Hormonal Control of the Reproductive System

The development and functioning of the reproductive system is under the control of hormones. Puberty is the name given to the stage at which the systems become active, and the production of gametes (eggs or sperm) begins.

Male System

At the onset of puberty, the pituitary gland in the brain releases:

- **follicle stimulating hormone (FSH)**, which stimulates sperm production
- **luteinising hormone (LH)**, which makes the testes secrete **testosterone**

Testosterone then stimulates development of the **secondary sexual characteristics**, such as the deepening of the voice and the growth of facial hair. A list of the changes at puberty in boys and girls is given in table 9.1 on page 124 of the textbook.

Female System

This is more complicated, and hormones are involved in both sexual development and the control of the menstrual cycle.

(a) **Sexual development**

FSH and LH from the pituitary gland are produced, as in the male. In the female they stimulate the release of **oestrogen**

from the ovaries, which controls the development of the secondary sexual characteristics such as widening of the hips and growth of hair in the armpits.

(b) **The menstrual cycle**

The monthly menstrual cycle is illustrated in figures 9.10 and 9.11 on pages 124-125 of the textbook. It involves changes to both the ovaries and the uterus lining. Day 1 is, by convention, the onset of **menstruation**, when the old uterus lining starts to break down and is lost with blood through the vagina over the course of a few days. The subsequent changes are as follows:

- Rise in the blood concentration of **FSH** from the pituitary stimulates a **follicle** in the ovary to bring an ovum to maturity (hence the name “follicle stimulating hormone”).
- FSH also stimulates the ovaries to release **oestrogen**, which stimulates the growth of a new uterus lining once menstruation stops.
- The oestrogen also suppresses the release of FSH, and stimulates the release of **LH** by the pituitary. This acts on the ovary, causing **ovulation** at about day 14.
- The remains of the follicle develops into the **corpus luteum**, which releases **progesterone** into the blood. This completes the development of the uterus lining, and also suppresses the release of FSH and LH by the pituitary.
- If the ovum is not fertilised, the corpus luteum breaks down and stops releasing progesterone. As progesterone levels fall, FSH is again released by the pituitary, and the next cycle starts.



Get it right!

An ovum is not *made* once a month in the ovary, it *matures*. A new-born baby girl already has all the ova she will release in her lifetime, but held in an immature form in her ovaries. One of these is selected each month to be matured and released.

Activity 4

Use figures 9.10 and 9.11 on pages 124-125 of the textbook to help you answer the following questions.

- (a) For how many days would you expect a period to last?
- (b) On what day of the cycle does ovulation occur?
- (c) On what day does the progesterone level begin to rise?
- (d) Describe the changes to the progesterone and oestrogen levels during the breakdown of the corpus luteum.
- (e) During which days of the cycle can an ovum be fertilised?



Now is the time to read through Edexcel International GCSE (9-1) Biology Student Book, pages 118-126.

This covers the same topics as this lesson, so will add to your understanding of the material.

Keywords

- | | |
|------------------------|----------------------|
| Gamete | Ovum |
| Testis | Ovulation |
| Embryo | Implantation |
| Placenta | Afterbirth |
| LH | Progesterone |
| Sperm | Zygote |
| Ovary | Fertilisation |
| Fallopian Tube | Fetus |
| *Amniotic Fluid | FSH |
| Oestrogen | Genes |

Summary

Lesson Fourteen: Human Reproduction

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|--------------------|-------|------------------------------|
| SEXUAL and ASEXUAL | ----- | gametes |
| | ----- | variation |
| HUMAN REPRODUCTION | ----- | male system |
| | ----- | sexual intercourse |
| | ----- | female system |
| | ----- | implantation and development |
| | ----- | placenta and amniotic fluid |
| | ----- | birth |
| HORMONAL CONTROL | ----- | puberty |
| | ----- | the menstrual cycle |

What you need to know

- The meanings of the terms printed in **bold** in the lesson
- The differences between male and female gametes
- The parts of the male and female reproductive systems, and the function of each
- The processes of sexual intercourse, fertilisation, implantation, growth and development, and birth
- The secondary sexual characteristics in men and women, and the hormones that control them
- The function of the amniotic fluid

What you might be asked to do

- Label a diagram of the male or female reproductive system
- Explain the differences between sexual and asexual reproduction
- Explain how the placenta effects the transfer of materials to and from the foetus
- Explain the hormonal control of the menstrual cycle

Suggested Answers to Activities

Activity 1

Many of the frog's eggs will not be fertilized, and most of the embryos will be eaten by predators before reaching adulthood. A female frog had to produce hundreds of eggs each year, just so that one may become an adult and lay its own eggs. Human females are much more successful!

Activity 3

- (a) The fetus and mother are genetically different, and will have different antigens on their blood cells. If the two blood supplies

mix, the mother's white blood cells will make antibodies against the cells of the fetus and kill it (see lesson 9).

- (b) If the membrane was thicker, the concentration gradient across it for oxygen and other materials would be too shallow, and materials would not pass across between the two blood supplies fast enough by diffusion (see lesson 2).

Activity 4

- (a) About 5 days. "A period" is the common name for "menstruation".
- (b) Day 14.
- (c) About day 15.
- (d) They fall (especially the progesterone).
- (e) Days 14 to 16 or 17.

Tutor-Marked Assignment G

Question 1

- (a) The following account was written by a confused student. Rewrite the paragraphs with the mistakes corrected:

“Shortly after a heavy meal, glucose is absorbed from the large intestine, and its concentration in the blood cells goes up. This rise is detected by the liver, which releases the hormone insulin into the blood. Insulin makes the pancreas remove the extra glucose from the blood and store it as starch.

Later on, the concentration of glucose in the blood drops. The liver breaks down fat so that it goes up again. (6 marks)

- (b) Explain why, some time after the meal, the blood glucose concentration falls below its correct level. (2 marks)

(total marks: 8)

Question 2

Sperm must travel through the female reproductive system in order to reach the ovum.

- (a) Which organ produces ova? (1 mark)
- (b) List in the correct order these structures through which the sperm travels to reach the ovum:
vagina, uterus, cervix, fallopian tube (2 marks)
- (c) In which part of a female’s body does fertilisation take place? (1 mark)
- (d) In which part of the female’s body does the fetus develop? (1 mark)
- (e) Explain how the placenta works. (5 marks)

(total marks: 10)

Question 3

- (a) Explain the term positive geotropism of roots. (3 marks)

- (b) In an investigation into the effect of light intensity on the growth of young shoots, some seedlings were grown in bright light and some in the dark.
- (i) Predict the results of the experiment. (1 mark)
- (ii) What steps should be taken to make the investigation (a) valid and (b) reliable? (4 marks)
- (iii) Explain the results in terms of the auxin content of the seedlings. (3 marks)
- (c) Suggest the survival value to the seedlings of the behaviour investigated in (b). (3 marks)
- (total marks: 14)

Question 4

An experiment was carried out to investigate the effect of auxin on the growth of oat coleoptiles (shoots). The auxin was dissolved in lanolin, a lipid made from wool.

A number of oat seeds were soaked overnight in water, and then allowed to germinate on wet cotton wool in three petri dishes. When the coleoptiles were about 15mm long, they were treated as follows:

- Dish A: auxin in lanolin was applied along ONE side, just behind the tip, for a distance of 5mm downwards.
- Dish B: lanolin without auxin was applied in the same way.
- Dish C: no treatment.

The dishes were then left in a dark cupboard overnight. The next day they were examined to see if any bending had taken place, and the degree of bending (if any) was measured.

The results were as follows:

Dish	0 – 45°	45 – 90°	Over 90°
A	7	37	6
B	45	3	2
C	42	7	1

- (a) What are (i) the dependent variable and (ii) the independent variable in the experiment? (2 marks)
- (b) Explain the need for Dish B. (2 marks)
- (c) Explain why several seedlings were used in each dish, rather than just one. (2 marks)
- (d) Why were the dishes kept in a dark cupboard, rather than on a brightly-lit windowsill? (3 marks)
- (e) Explain why, if different sides of the shoot grow at different rates, the shoot will bend over. (1 mark)
- (f) Draw a conclusion on the basis of the recorded data. (2 marks)
- (total marks: 12)

Question 5

Explain the role of hormones in the control of the female menstrual cycle in humans. Write your answer in full sentences. (6 marks)

Total marks for TMA: 50