

CHAPTER 15.1 – REPRODUCTIVE SYSTEM OF HUMANS

The male and female reproductive system

- Δ The continuity of a species is dependent on the increase in population through the process of sexual or asexual reproduction
- Δ Sexual reproduction involves the production of male and female gametes by individuals who have reached sexual maturity
- Δ This process is completed with the fertilization of both gametes to create new life

MALE REPRODUCTIVE SYSTEM

SPERM DUCT

- » Sperm is transported through the sperm duct (vas deferens)

SCROTUM

- ⊕ A sac-like structure that holds and protects the testis

PENIS

- ↳ The male sexual organ that is rich in soft tissues and blood vessels
- ↳ Releases sperm into a female's vagina during copulation

SEMINAL VESICLE

- ❖ Secretes fluid filled with nutrients for the sperms

PROSTATE GLAND

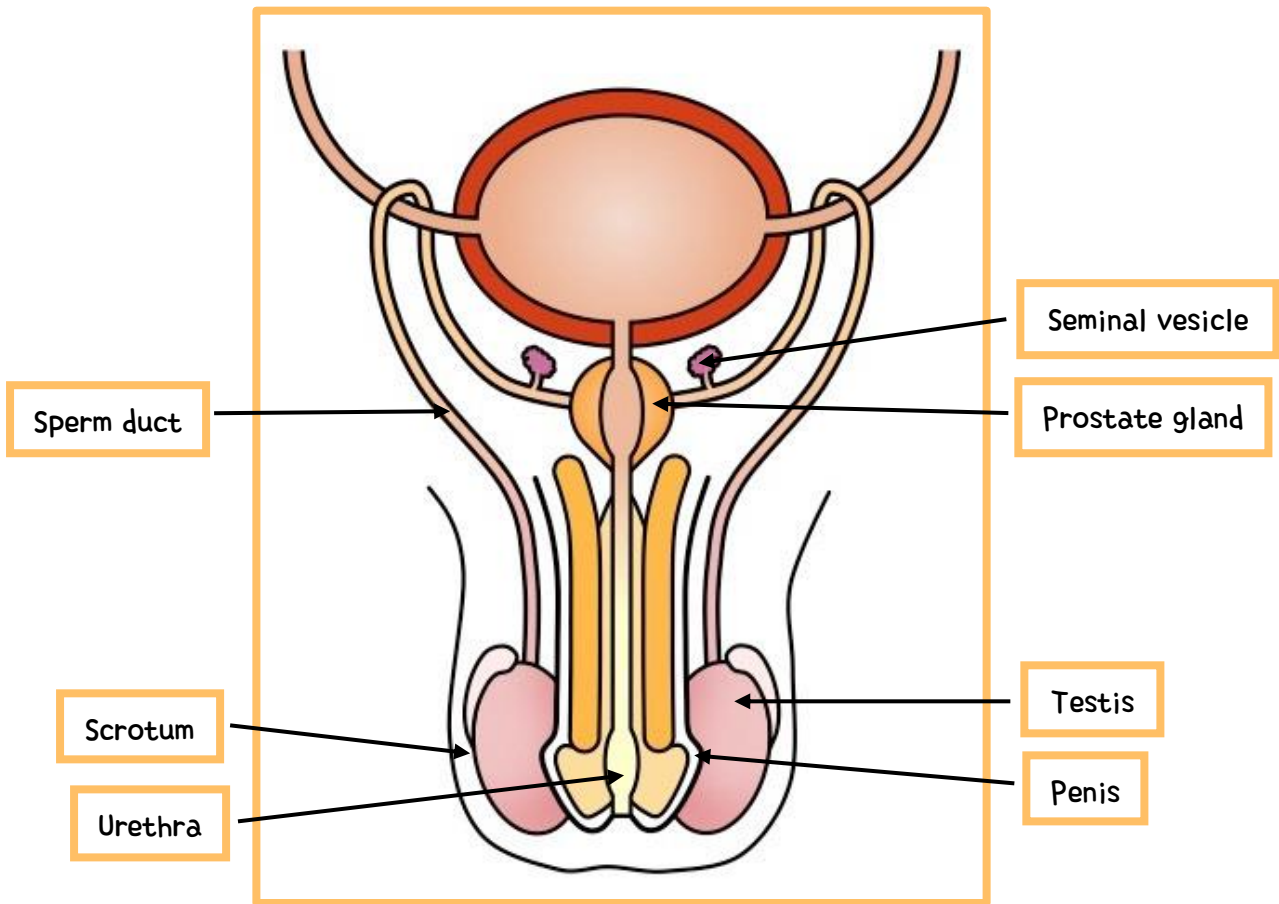
- ◇ Secretes a fluid that helps in sperm movement

TESTIS

- ☐ Located within the scrotum
- ☐ Produces sperm (male gametes) and the male sex hormone, testosterone

URETHRA

- ⊞ A tube for the discharge of sperm and urine from the body



FEMALE REPRODUCTION SYSTEM

secondary oocyte or embryo to the uterus

UTERUS

- The uterus is an organ with thick muscular walls
- The inner wall of the uterus is lined with endometrium tissue, which secretes mucus and is rich in blood vessels
- Embryo implants in the endometrium
- The endometrial tissue which is thick and rich in blood vessels supplies the embryo with nutrients and oxygen

OVARY

- ↳ The female reproductive organ that produces ovum (female gamete, plural: oval) and the female sex hormones, which are oestrogen and progesterone

FALLOPIAN TUBE

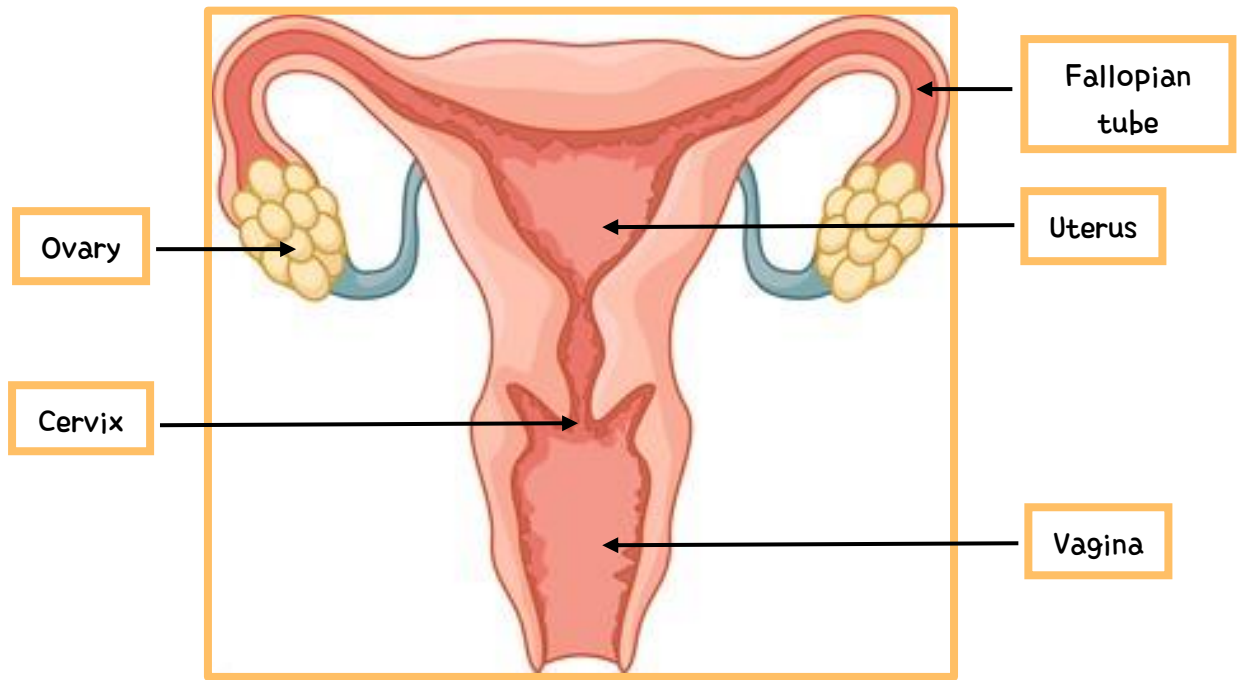
- ✚ A thin, muscular tube
- ✚ The inner wall is lined with cilia
- ✚ The action of the cilium, combined with the peristalsis of the Fallopian tube, helps in delivering the

VAGINA

- A canal where sperms enter, and also serves as a passage for birth and menstruation

CERVIX

- ↳ Narrow opening to the uterus which secretes mucus to help sperm swim up to the Fallopian tubes



CHAPTER 15.2 – GAMETOGENESIS IN HUMANS

Gametogenesis

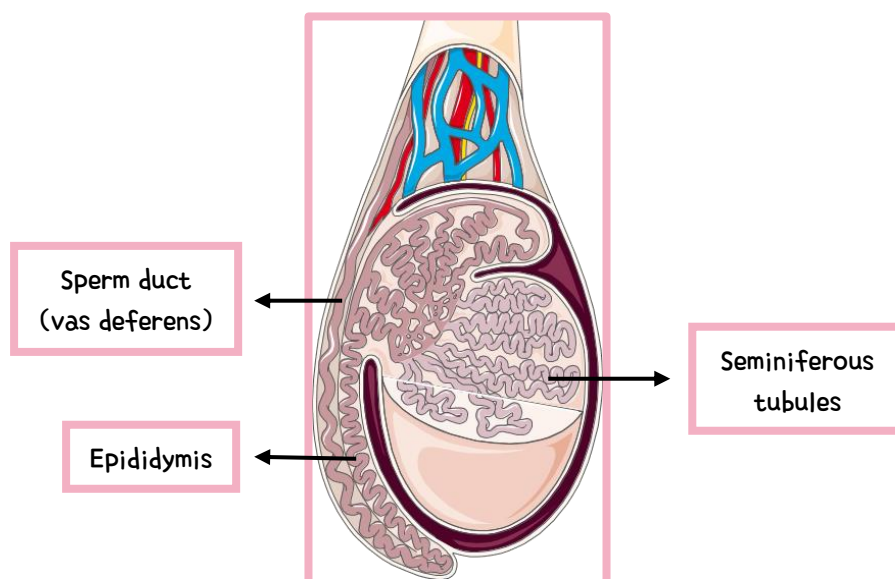
- ✎ The production process of reproductive cells (gametes) is called **gametogenesis**
- ✎ This process takes place in the gonads, which are the **testes** in males, and the **ovaries** in females
- ✎ This process is divided into two
 - 1) Spermatogenesis (in male)
 - 2) Oogenesis (in female)

The necessity of gametogenesis

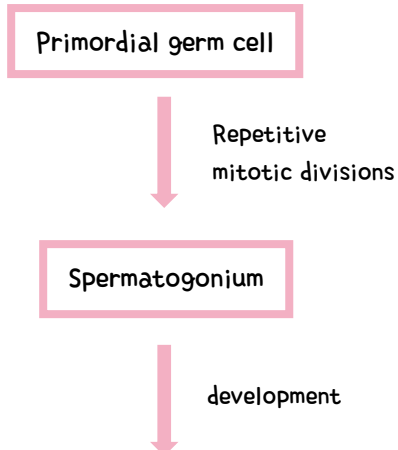
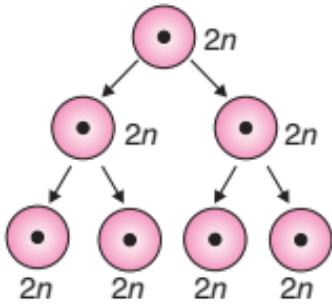
- △ Gametogenesis **produces gametes** that are **haploid (n)**
- △ When fertilisation takes place, the **nucleus of the sperm** will **fuse** with the **nucleus of the ovum** in the Fallopian tube to **form a diploid zygote (2n)**

Spermatogenesis

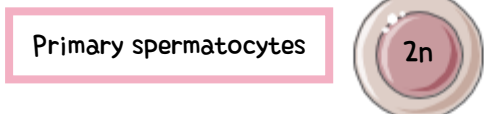
- **Spermatogenesis** is a process of **sperm production** that takes place in the **seminiferous tubules**
- Each seminiferous tubule **consists of primordial germ cells**
- Primordial germ cells will **undergo cell division to produce sperm**
- **Sertoli cells** within the walls of the seminiferous tubules to the epididymis and **flows out** through the **sperm duct (vas deferens)**
- Spermatogenesis is **stimulated** by the **follicle-stimulating hormone (FSH)** and **testosterone**
- This process is also **aided** by the **luteinizing hormone (LH)** which **stimulates testosterone secretion** in the testes



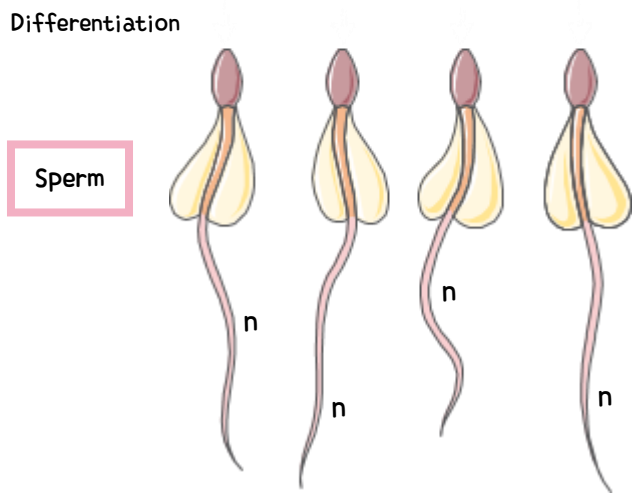
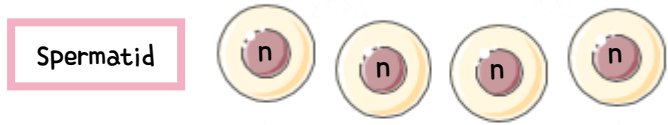
MULTIPLICATION PHASE



GROWTH PHASE

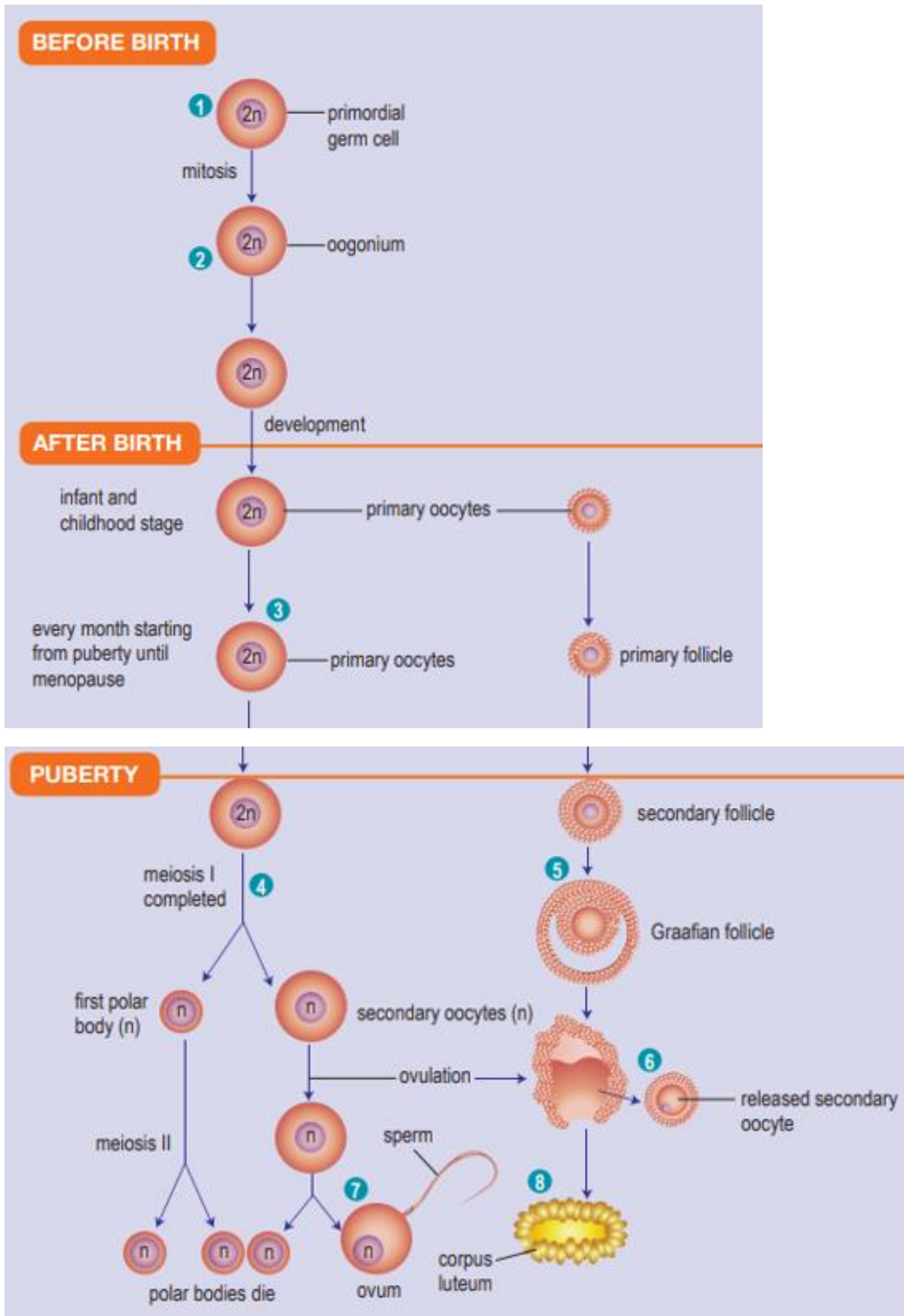


MATURATION PHASE



- » Primordial germ cells divide mitotically to form diploid spermatogonium
- » Spermatogonium expands to form primary spermatocytes (diploid)
- » Each primary spermatocyte undergoes meiosis I to form two secondary spermatocytes (haploid)
- » Each secondary spermatocyte undergoes meiosis II to produce two haploid spermatids
- » Spermatids then undergo differentiation to form sperms

Oogenesis



- 1
- ⇒ Primordial germ cells undergo mitotic division multiple times to form oogonium (diploid)
- 2
- ⇒ Oogonium develops into primary oocyte which is encapsulated with one or more layers of follicular cells, forming primary follicles
 - ⇒ The growth of the follicle is stimulated by the follicle-stimulating hormone (FSH)
 - ⇒ Primary oocyte then undergoes meiosis but the process stops at prophase I during fetal development
- 3
- ✓ At birth, a baby girl already has millions of primary oocytes that remain dormant in prophase I meiosis I
 - ✓ The number of oocytes will decrease at puberty
- 4
- ✚ Upon reaching puberty, the primary oocytes will continue meiosis I to form secondary oocyte and a first polar body
 - ✚ Secondary oocyte will begin meiosis II which is then halted at metaphase II
 - ✚ The first polar body will complete meiosis II and form two second polar bodies
- 5
- ⊕ A layer of follicular cells envelops the secondary oocyte and is called secondary follicle
 - ⊕ The secondary follicle will then develop into the Graafian follicle, which releases oestrogen
- 6
- ❖ A mature Graafian follicle will approach the surface of the ovary and release a secondary oocyte into the Fallopian tube
 - ❖ This process is called ovulation
- 7
- ⊡ The secondary oocyte (immature ovum) will complete meiosis II once a sperm penetrates it
 - ⊡ Meiosis II produces ovum (n) and a polar body (n)
 - ⊡ Fertilisation takes place when the sperm nucleus fuses with ovum nucleus and produces a diploid zygote (2n)
 - ⊡ The rest of the polar bodies will die and will be distinguished by the ovary
- 9
- Upon fertilisation, corpus luteum continues to grow and secretes oestrogen and progesterone
- 10
- ⊕ Without fertilisation, corpus luteum and secondary oocyte denigrate and dies, and then is removed through menstruation

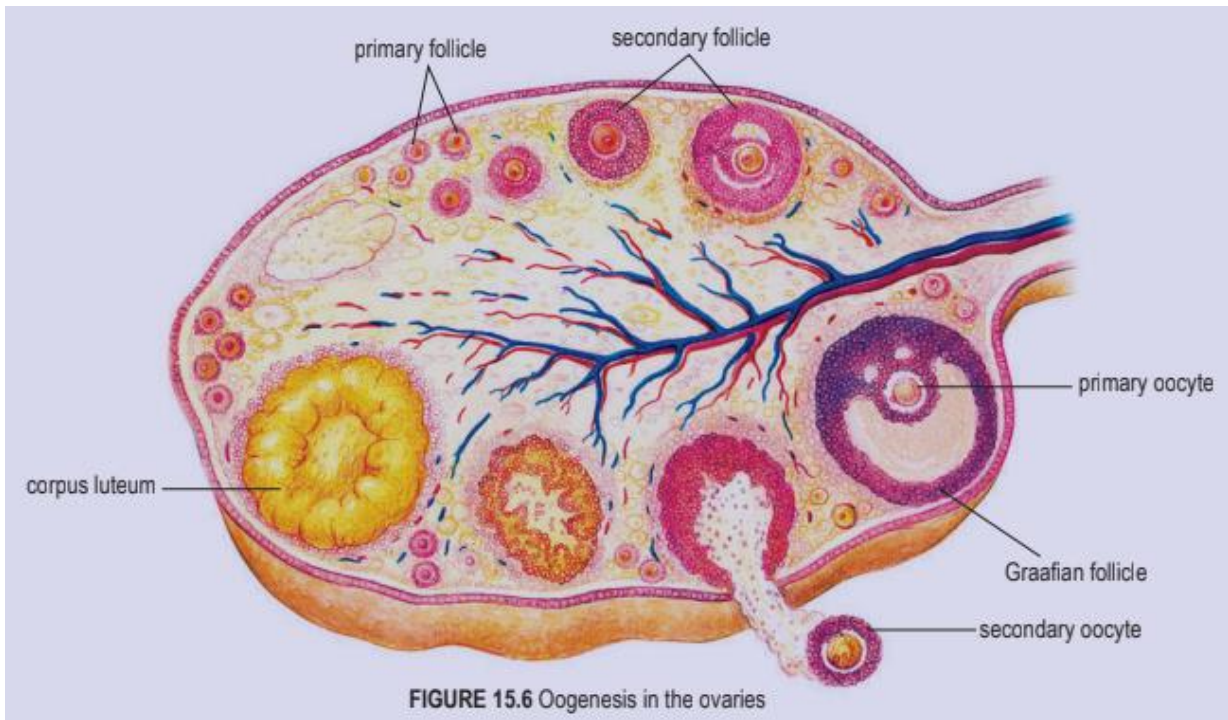
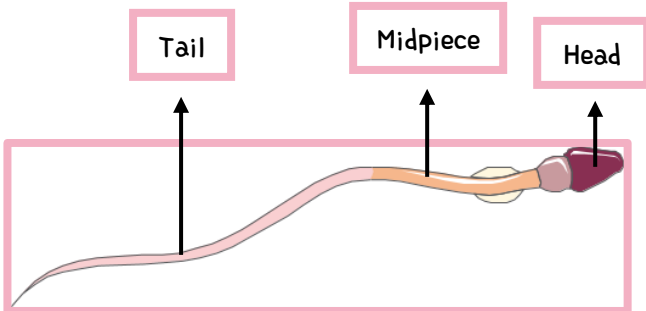


FIGURE 15.6 Oogenesis in the ovaries

Structure of sperm and Graafian follicle

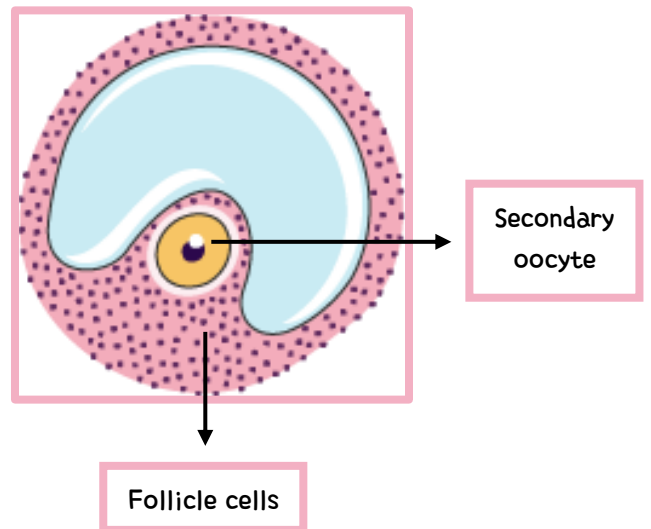
SPERM

- ♥ A sperm has three main parts
 - I. Head
 - II. Midpiece
 - III. Tail
- ♥ The head contains a nucleus whereas the midpiece is packed with mitochondria which generates energy for the sperm to swim to the Fallopian tube for fertilisation



GRAAFIAN FOLLICLE

- A secondary oocyte is a large cell that is surrounded by a gel-like substance and follicular cells
- The secondary oocyte and follicular cells will form the Graafian follicle



The comparison between spermatogenesis and oogenesis

SIMILARITIES

| SIMILARITIES |
|---|
| a) Both are the processes of gametogenesis that take place in the reproductive organs |
| b) Produces gametes that are haploid which are involved in fertilisation |

DIFFERENCES

| SPERMATOGENESIS | OOGENESIS |
|---|--|
| It takes place in the testis | It takes place in the ovaries |
| Spermatogonium (diploid) produces four sperms (haploid) after meiosis | Oogonium (diploid) only produces one functional secondary oocyte (haploid) and three non-functioning polar bodies after meiosis |
| Sperms are smaller and made up of the midpiece, head and tail | Secondary oocytes are large and spherical in shape |
| After meiosis I, two secondary spermatocytes are produced | After meiosis I, one secondary oocyte and one polar body is produced |
| Meiosis is completed | Meiosis II is only completed when a sperm fertilises the secondary oocyte |
| Spermatids undergo differentiation to become sperms | Secondary oocyte does not undergo differentiation |
| The production of sperm is continuous from puberty until old age | <ul style="list-style-type: none"> » The production of the secondary oocyte is not continuous » It starts in the female foetus and remains dormant when the baby is born » The process continues once the female reaches puberty and stops during menopause |
| Millions of sperms are formed every day | Only one secondary oocyte is released from the ovaries at every menstrual cycle |

CHAPTER 15.3 – MENSTRUAL CYCLE

Role of hormone in menstrual cycle

MENSTRUAL CYCLE

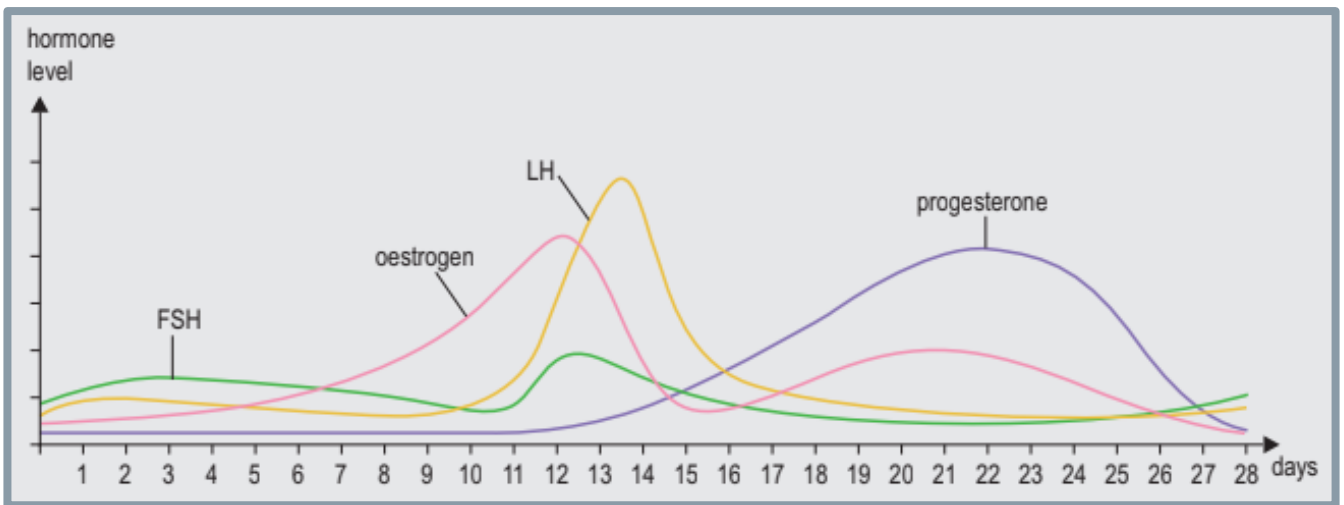
- ❑ The menstrual cycle involves the production of a secondary oocyte and thickening of the endometrial wall throughout one cycle

- ❑ In this cycle, the endometrium will become soft, thick and rich with blood vessels
- ❑ This is to prepare the endometrium for embryo implantation
- ❑ If the fertilisation does not take place, the secondary oocyte will die and the endometrium wall will shed
- ❑ This will lead to bleeding known as menstruation

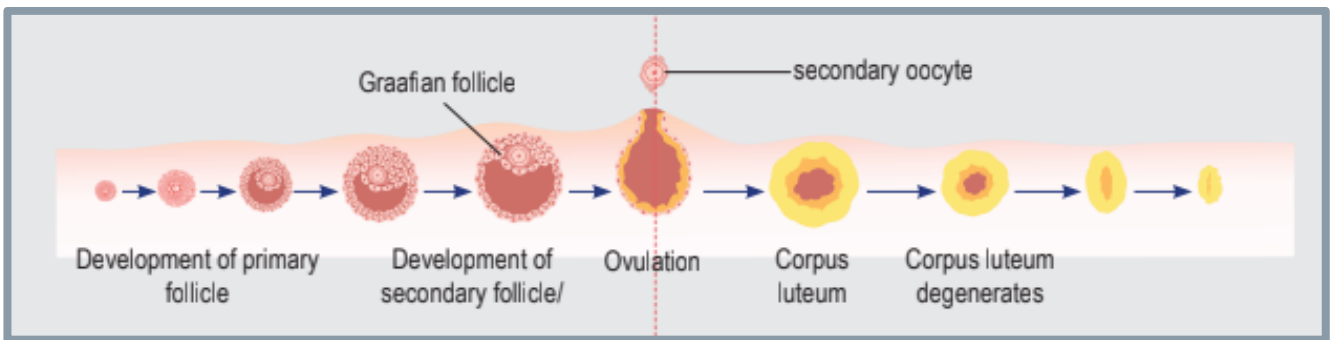
The functions of hormones in a menstrual cycle

| GLAND | HORMONE | FUNCTION |
|-----------|------------------------------------|---|
| Pituitary | Follicle-stimulating hormone (FSH) | » Stimulates follicle growth in the ovary » Stimulates the release of oestrogen |
| | Luteinizing hormone (LH) | Δ Stimulates ovulation Δ Causes the formation of the corpus luteum Δ Stimulates the release of progesterone |
| Ovary | Oestrogen | ⊕ Repairs and stimulates the thickening of the endometrium ⊕ Stimulates follicle growth until it matures ⊕ Stimulates FSH and LH release prior to ovulation |
| | Progesterone | ∨ Stimulates the thickening of the endometrium, making it thick, folded and rich in blood vessels to prepare for the implantation of embryo ∨ Stops the release of FSH and LH to prevent follicle growth and ovulation |

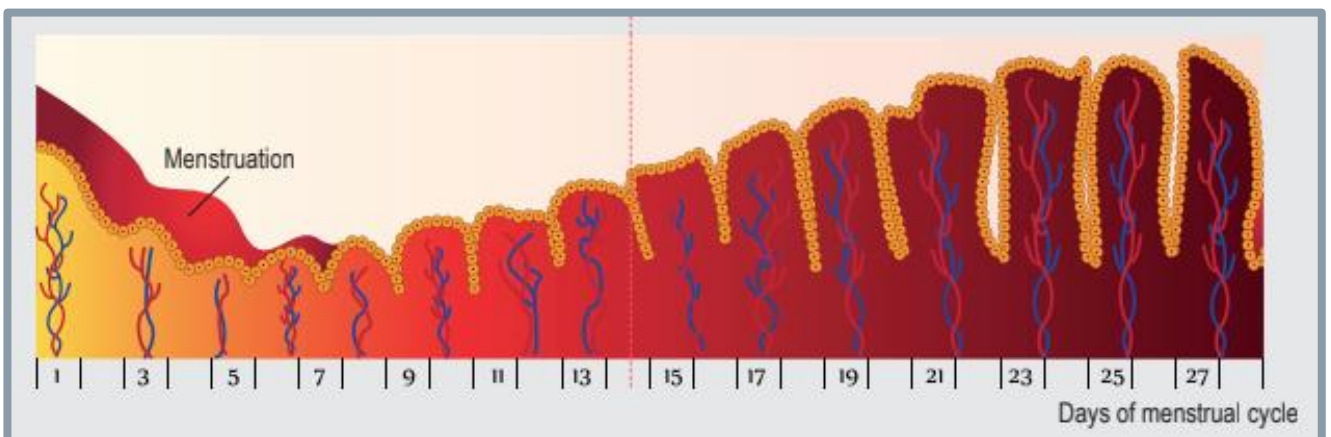
Hormone level



Follicle development



Changes in endometrial thickening



Menstrual cycle

DAY 0-5

- ⊞ Before a menstrual cycle begins, the level of hormones is low. With the absence of stimulation from the progesterone and oestrogen, the thickened endometrium will shed and menstruation will begin (first day).
- ⊞ A menstrual cycle begins a day before menstruation when the hypothalamus releases the gonadotrophin-releasing hormone (GnRH).
- ⊞ GnRH stimulates the pituitary gland to release the follicle-stimulating hormone (FSH) and luteinizing hormone (LH) into the blood.
- ⊞ FSH stimulates follicle growth in the ovary. Within the primary follicle, the oocyte grows into the secondary oocyte, which is contained within the Graafian follicle.
- ⊞ Growing follicles release oestrogen.
- ⊞ Oestrogen encourages follicle maturation and also encourages endometrial wall repair.
- ⊞ Low levels of oestrogen inhibit the release of FSH and LH via a negative feedback mechanism, which in turn prevents the growth of new follicles

DAY 6-14

- ❖ Oestrogen level rises and peaks on day 12, stimulating the hypothalamus to secrete GnRH via a positive feedback mechanism.
- ❖ A high level of GnRH then stimulates the pituitary gland to secrete more FSH and LH.

- ❖ The LH level rises until it peaks on day 13, leading to ovulation and release of a secondary oocyte from Graafian follicle on day 14.
- ❖ LH also stimulates the follicular tissue left behind to transform into the corpus luteum.

DAY 15-21

- ↗ LH stimulates the corpus luteum to secrete oestrogen and progesterone.
- ↗ The combination of oestrogen and progesterone inhibits the release of FSH and LH from the hypothalamus via negative-feedback mechanism so as to stop the growth of new follicles.
- ↗ Progesterone stimulates endometrial wall thickening, enriching it with blood vessels in preparation for embryo implantation, in the event that fertilisation takes place.

DAY 22-28

- ✚ If fertilisation does not take place, decreasing LH levels will cause the corpus luteum to degenerate, which in turn stops the secretion of oestrogen and progesterone
- ✚ Without stimulation from oestrogen and progesterone, the endometrium will shed and menstruation will begin.
- ✚ Low levels of progesterone and oestrogen will no longer inhibit the hypothalamus and pituitary gland, making way for GnRH to be secreted again, which stimulates secretion of FSH and LH. A new menstrual cycle will begin with new follicle growth.

- + If fertilisation occurs, the corpus luteum will continue to grow and secrete progesterone and oestrogen.
- + This will cause the endometrial wall to continually thicken in order to support foetal growth.

Role of hormone in pregnancy and miscarriage

- The corpus luteum will continue to produce oestrogen and progesterone up to three to four months after pregnancy
- Thereafter, the corpus luteum will degenerate, and the production of oestrogen and progesterone will be taken over by the placenta until birth
- Progesterone inhibits the secretion of FSH and LH
- Therefore, the menstrual cycle and ovulation do not occur throughout a pregnancy
- The imbalance of progesterone and oestrogen levels may lead to a miscarriage, due to the decrease of progesterone level which causes the uterus to shrink

Premenstrual syndrome

- Premenstrual syndrome or symptoms that appear prior to a menstrual cycle usually manifests between 7 to 14 days before the first day of the menstrual cycle
- This syndrome occurs due to the imbalance of oestrogen and progesterone hormones within the menstrual cycle
- Premenstrual syndrome symptoms
 1. Fatigue
 2. Headache
 3. Emotional instability
 4. Bad temper

Menopausal syndrome

- ☐ Menopausal syndrome or menopause occurs within the ages of 46 to 50 years old, when ovulation and menstruation stop naturally
- ☐ The increase in age leads to reduced secretion of progesterone and oestrogen, which then causes reduced stimulation of FSH and LH on the ovaries
- ☐ At this stage, the ovaries stop producing ovum
- ☐ After menopause, a woman is not able to conceive a child anymore
- ☐ Menopausal syndrome symptoms
 - a. Difficulty sleeping
 - b. Hot flushes
 - c. Low mood
 - d. Bad temper

CHAPTER 15.4 – DEVELOPMENT OF A HUMAN FOETUS

The process of fertilisation

- ◇ Fertilisation can occur when one out of the millions of sperm succeeds in penetrating the secondary oocyte in the Fallopian tube
- ◇ This is followed by changes to the secondary oocyte's membrane that prevents penetration from the other sperms
- ◇ Then, fertilisation occurs when the sperm nucleus fuses with the ovum nucleus to form a diploid zygote

Early development of an embryo until implantation

- While travelling down the Fallopian tube, the zygote undergoes multiple divisions through mitosis
- The first cell division produces a two-cell embryo
- The following cell divisions will finally produce a morula
- The morula then transforms into a blastocyst
- The blastocyst will then implant in the endometrium
- This process is called implantation
- The blastocyst continues to grow into an embryo

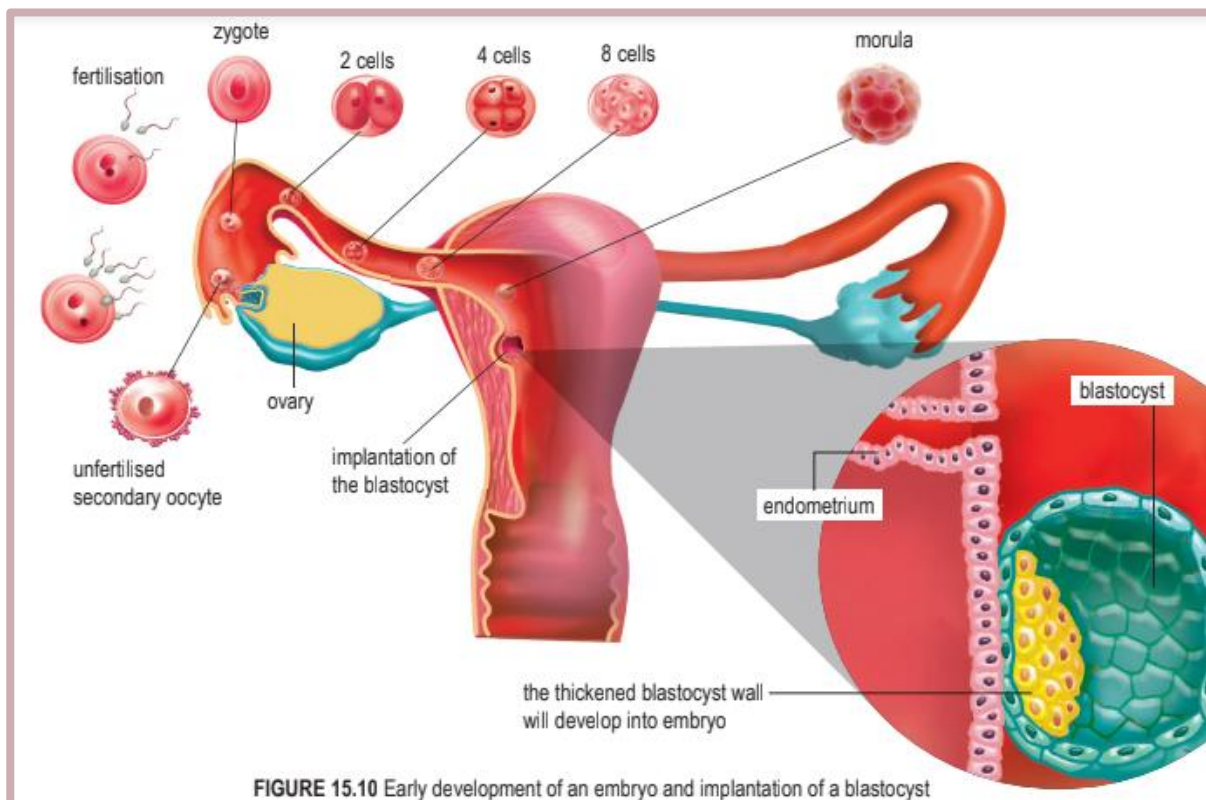


FIGURE 15.10 Early development of an embryo and implantation of a blastocyst

Role of human chorionic gonadotropin (HGG) hormone

- ↘ The placenta also produces the human chorionic gonadotropin (HGG) hormone during pregnancy
- ↘ The level of this hormone increases at the early stages of pregnancy and will double every two to three days for the first four weeks of pregnancy
- ↘ The main function of HGG is to ensure that the corpus luteum continues to secrete oestrogen and progesterone in the early stages of pregnancy
- ↘ This hormone can be detected in the urine of pregnant mothers

Role of placenta and umbilical cord in foetal development

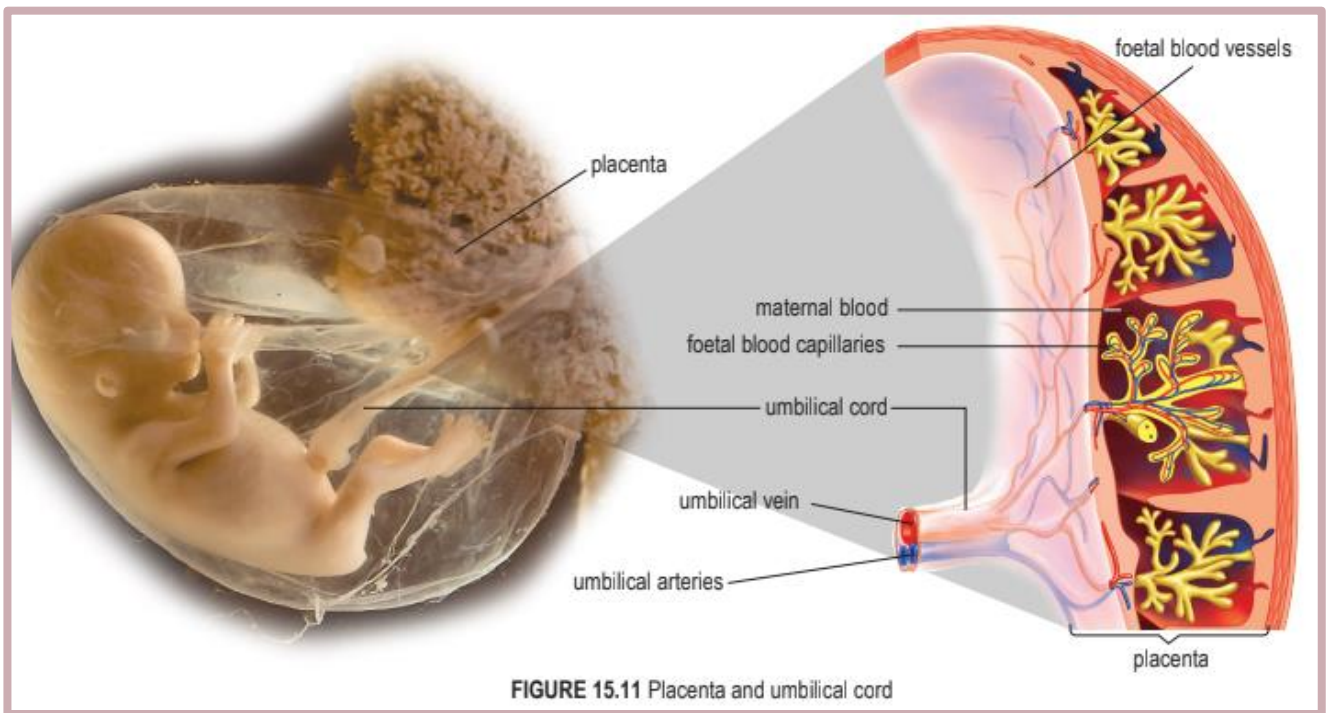
- ♥ The placenta is formed from the mother's endometrial tissue and embryonic tissue
- ♥ It is connected to the foetus through the umbilical cord which contains blood vessels that carries substance in and out of the foetus

UMBILICAL CORD

- The umbilical cord is a tube that contains the umbilical vein and umbilical arteries
- The umbilical vein carries blood rich in oxygen and nutrients from the placenta to the foetus
- Umbilical arteries carry deoxygenated blood (rich in carbon dioxide) and nitrogenous waste such as urea from foetus to the placenta

IMPORTANCE OF PLACENTA

- » The placenta is the exchange site of substances between mother and foetus
 - 1) Glucose, amino acids, hormones, antibodies and oxygen are absorbed from the mother's blood into the foetal blood capillaries
 - 2) Carbon dioxide and nitrogenous waste such as urea are absorbed from the foetal blood capillaries into the mother's blood circulation
- » The placenta also acts as an endocrine organ that secretes hormones during pregnancy
 - i) In the fourth month of pregnancy, the corpus luteum will degenerate and no longer secrete progesterone
 - ii) The placenta will replace corpus luteum in producing progesterone and oestrogen needed to maintain endometrial thickness



Foetal and maternal blood circulatory systems

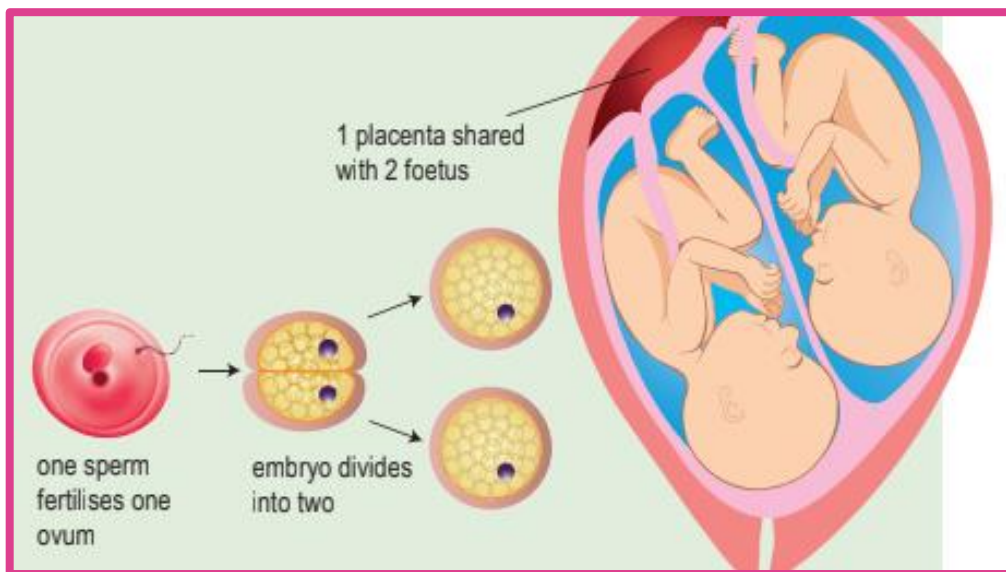
- ⊞ The blood of the mother and the foetus do **not mix** as they are **separated by a thin membrane**
- ⊞ This is important because:
 - a) It **protects** the foetus from the **certain dangerous chemical substances** such as toxins and bacteria that can be **absorbed** into the foetal blood circulation
 - b) It **prevents** the thin foetal blood vessels from **bursting** due to the mother's high blood pressure
 - c) It **prevents agglutination or blood clots** from happening in the foetus, as the foetus might not be of the same blood group as the mother
- ⊞ The thin membrane layer is **not able to prevent** certain substances from **being absorbed**, such as drugs and medication, cigarette smoke and alcohol ingested by the mother
- ⊞ **Viruses** such as HIV and rubella can also **cross the placenta** and be **absorbed** into the foetal blood circulation, which may **disrupt the foetal development**

CHAPTER 15.5 – FORMATION OF TWINS

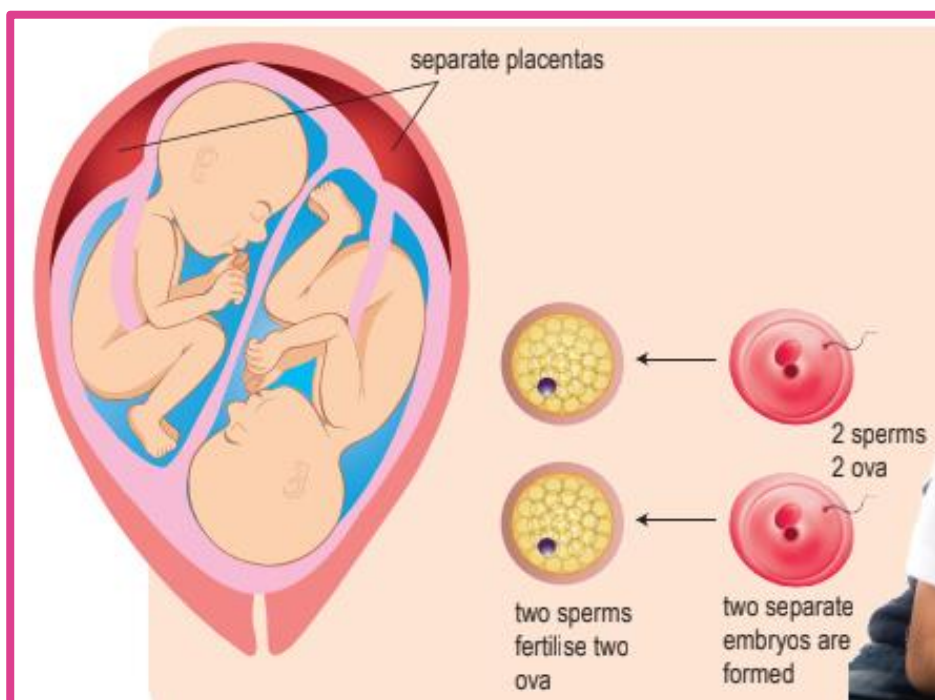
Process of twin formation

- + Twins refers to **two or more children** that are born from **one pregnancy**
- + **Two types** of twins
 - i. Identical twins
 - ii. Fraternal twins

IDENTICAL TWINS



FRATERNAL TWINS

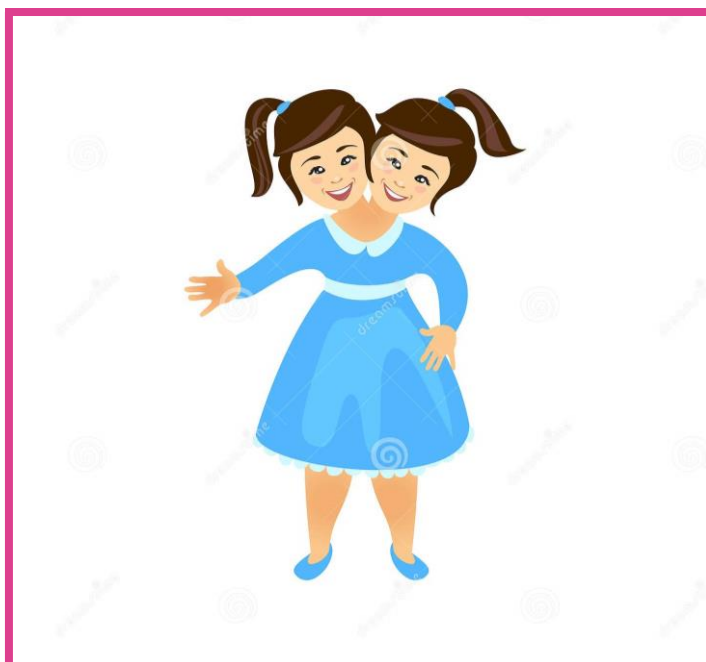


Differences between identical and fraternal twins

| IDENTICAL TWINS | FRATERNAL TWINS |
|---|---|
| Product of fertilisation of one ovum and one sperm forming one zygote | Product of fertilisation of two sperms and two ova forming two zygotes |
| Embryo divides into two | Embryo does not divide into two |
| One placenta is shared between two fetuses | Each foetus has its own placenta |
| The genetic makeup and physical appearances of these twins are similar as they are from the same zygote | the genetic makeup and physical appearances of these twins are different as they are from two different zygotes |
| The sex of both twins is the same | The sex of both twins may be the same or different |

Development of conjoined twins

- Conjoined twins develop when there is **incomplete division** of the embryo in **identical twins**
- Although two foetuses are formed from the embryo, **some** of their **physical parts are still fused together**, usually the chest, abdomen or buttocks
- Conjoined twins may also **share one or two internal organs**
- The life of conjoined twins may be difficult as they must always be together
- They also **do not have time alone**
- Their movements are **limited** due to their physical state
- Most conjoined twins **die before they are born or have short lifespans**
- They **may be able** to be **separated through surgery**
- However, the success of surgery **depends** on the joined part and what internal organs are shared between them



HEALTH ISSUES RELATED TO THE HUMAN REPRODUCTIVE SYSTEM

Impotency

- Δ Impotency **occurs** when a husband and wife are **unable to conceive**
- Δ The cause of this might be from the husband or wife, or both

CAUSES OF MALE IMPOTENCY

- Testes do not produce sperm
- Low quality sperm or abnormal sperm
- Hormonal imbalance
- Erectile dysfunction
- Low sperm count
- Blocked sperm ducts

CAUSES OF FEMALE IMPOTENCY

- ◇ Ovaries do not produce secondary oocyte
- ◇ Abnormal uterus
- ◇ Hormonal imbalance
- ◇ Blocked Fallopian tubes
- ◇ Growth in the uterus

TREATMENT FOR IPMOTENCY

- Hormonal imbalance can **be treated** with **hormonal therapy**
- Blocked Fallopian tubes or blocked sperm ducts can **be treated** via **surgery**
- **In vitro fertilisation (IVF)** for women who **have blocked Fallopian tubes**



CHAPTER 15.7 – GROWTH IN HUMANS AND ANIMALS

Growth in organisms

- ⊞ Growth in organisms is an irreversible, permanent process that involves the increase in the number of cells, size, volume and weight of the organism's body
- ⊞ Growth also involves differentiation and cell specialisation as well as specialising the shapes and functions of cells
- ⊞ Growth in organisms is important for the development and maturation of bodily systems

Measuring growth in humans and animals

The parameters that are used in measuring growth are:

- ∨ Increase in size or volume, for example, changes in height or length of an organism
- ∨ Changes in dry weight or fresh weight

DRY WEIGHT

- ❖ Dry weight refers to the weight of an organism after all the fluid is removed from its body
- ❖ This is done by weighing the organism after it has been dried in the oven at 100°C repeatedly until the weight remains the same
- ❖ The weakness of this parameter is that the organism has to be killed
- ❖ However, this method is suitable for plants

FRESH WEIGHT

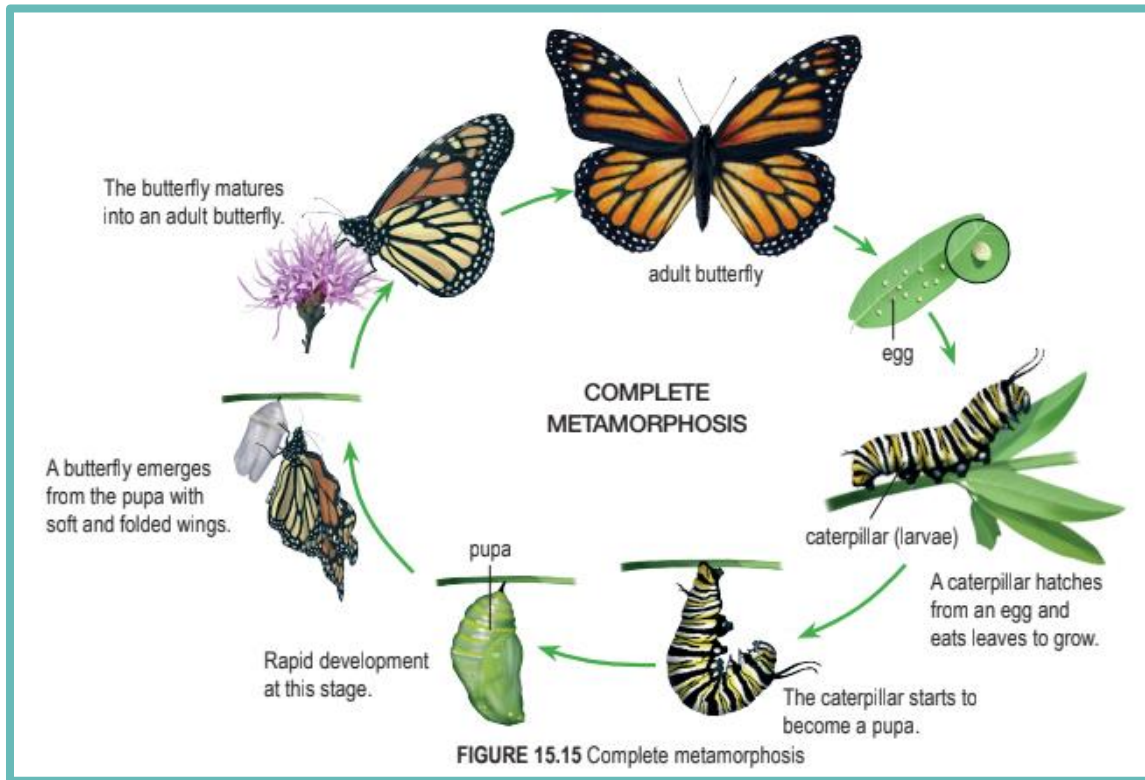
- ⊕ Fresh weight can be taken whenever and organisms do not need to be killed
- ⊕ However, this method is less accurate because the amount of fluid in the body is dependent on the organism's fluid intake
- ⊕ This parameter is measured for a certain amount of time

Growth of insects

- Organisms with exoskeletons like insects undergo growth differently
- Insects go through two different types of growth which are complete metamorphosis and incomplete metamorphosis

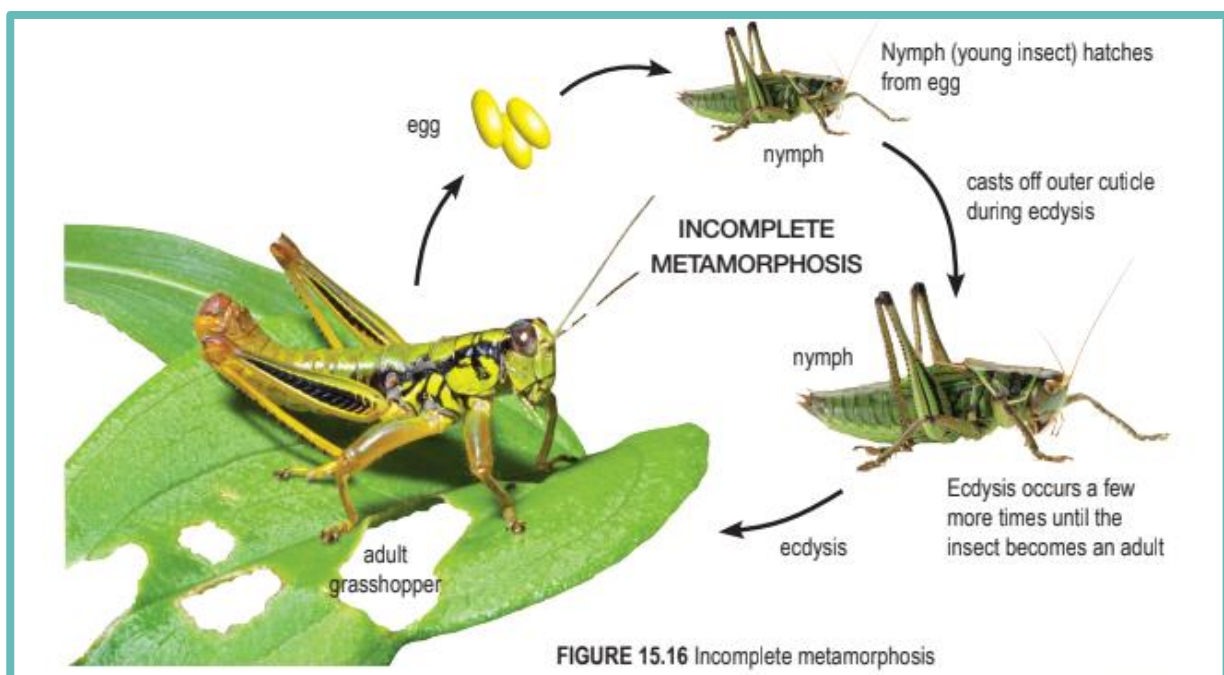
COMPLETE METAMORPHOSIS

- Insects like butterflies undergo complete metamorphosis
- In complete metamorphosis, there are four different stages of growth, which are egg, larvae, pupa and adult



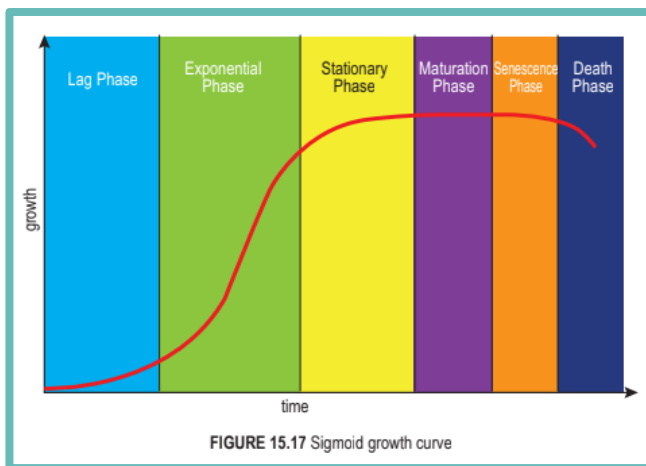
INCOMPLETE METAMORPHOSIS

- ✓ Grasshopper undergo incomplete metamorphosis, where the insect undergoes a few stages of ecdysis before becoming an adult



Growth phases in sigmoid growth curves of humans and animals

- » The growth curve is achieved by plotting growth parameters against time
- » Most organisms' growth curves show a similar pattern that is a sigmoid curve (s-shaped)
- » Growth occurs gradually and continuously
- » There are six phases in the sigmoid growth curve
 - i) Lag phase
 - ii) Exponential phase
 - iii) Stationary phase
 - iv) Maturity phase
 - v) Senescence phase
 - vi) Death phase



LAG PHASE

- ♥ The growth rate is low because it involves little cell division and cell elongation
- ♥ It is the phase of adjustment to new sources available in the environment

EXPONENTIAL PHASE

- ◇ Highest growth rate
- ◇ Cell division and elongation occurs actively
- ◇ Organism's size increases rapidly

STATIONARY PHASE

- ⊠ Growth rate slows down and occurs at a constant rate
- ⊠ Cells reach maximum size
- ⊠ Cells undergo differentiation to form specialised cells

MATURITY PHASE

- ↗ Organism reaches maturity
- ↗ Zero growth rate
- ↗ The rate of cell division is similar to the rate of cell death
- ↗ Cell division only happens to replace impaired or dead tissues

SENESCENCE PHASE

- Negative growth rate
- Organism goes through ageing

DEATH PHASE

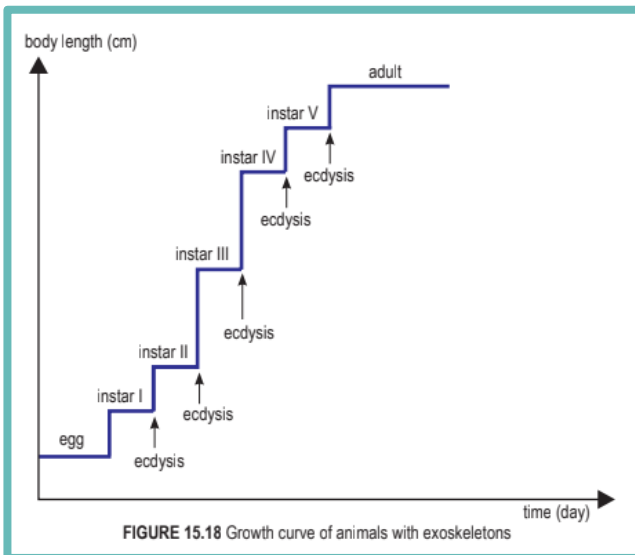
- △ Ageing, illness, lack of nutrients or space eventually leads to death of an organism

Intermittent growth curve of animals with exoskeletons

- ⇒ Insects such as grasshoppers have an exoskeleton made up of chitin
- ⇒ The exoskeleton does not grow proportionately with the growth of the insect

- ⇒ To allow growth and development, animals with exoskeletons must shed their hard exterior
- ⇒ The moulting process of the exoskeleton that allows growth and development of insects is called ecdysis
- ⇒ This process is controlled by hormones
- ⇒ The stages between ecdysis are called instar and at this stage, the insect is known as a nymph
- ⇒ During instar, the insect is actively building tissue and increasing body volume

- The process of ecdysis happens periodically
- Polar growth is not continuous and is intermittent
- The horizontal part of the graph indicates zero growth
- At this stage, known as instar, the insect is not increasing in length
- The vertical lines of the graph represent rapid growth
- At this stage, the nymph undergoes ecdysis and its size increases rapidly
- Ecdysis occurs multiple time until the insect reaches adulthood



HOW DOES ECDYSIS HAPPEN?

- ❖ A new exoskeleton forms underneath the old exoskeleton
- ❖ Before the new exoskeleton hardens, the insect will increase its volume by sucking in air to expand its body
- ❖ This action breaks the old exoskeleton and the insect with its new exoskeleton will emerge
- ❖ The insect will expand its body one more time before the new exoskeleton hardens

