

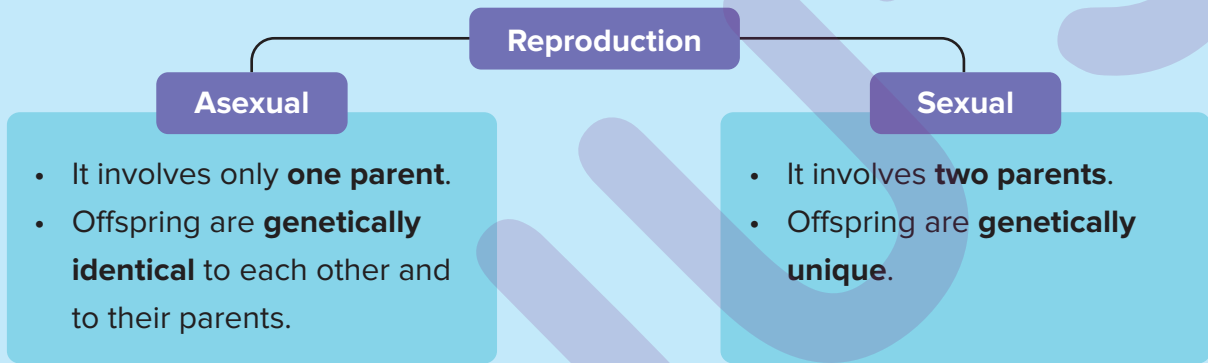


**Key Takeaways**

- Puberty
- Male reproductive system
  - Structure and functions
  - Hormonal control in males
  - Male sex act



**Prerequisites**



**Puberty**

- It is defined as the phase when the physical and sexual characters start to mature.
- Secondary sexual characters develop during this phase.
- Secondary sexual characters are the **sexually dimorphic characteristics** that are not directly involved in reproduction.

**Distinct male and female individuals exhibiting different characteristics**



Di= Two, Morphism= Forms



### Morphological dimorphism

Difference in external features



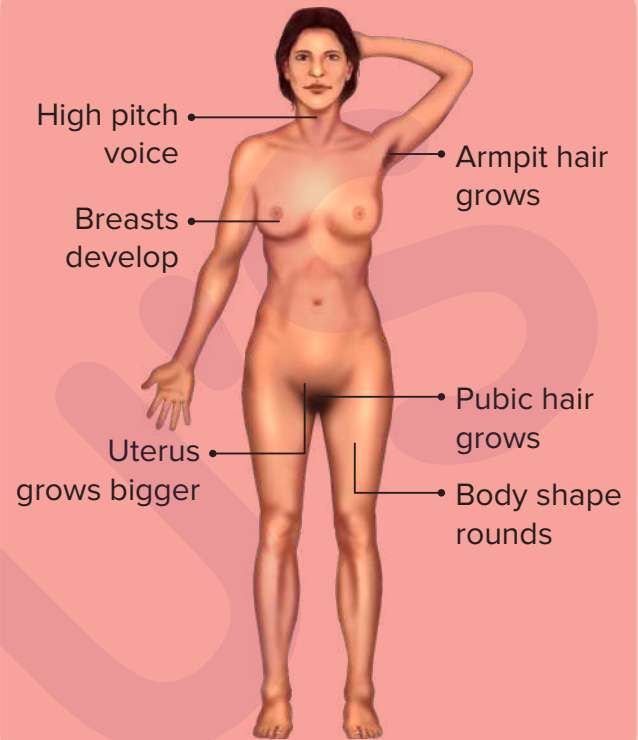
### Anatomical dimorphism

Difference in internal features

- Following changes occur at puberty:



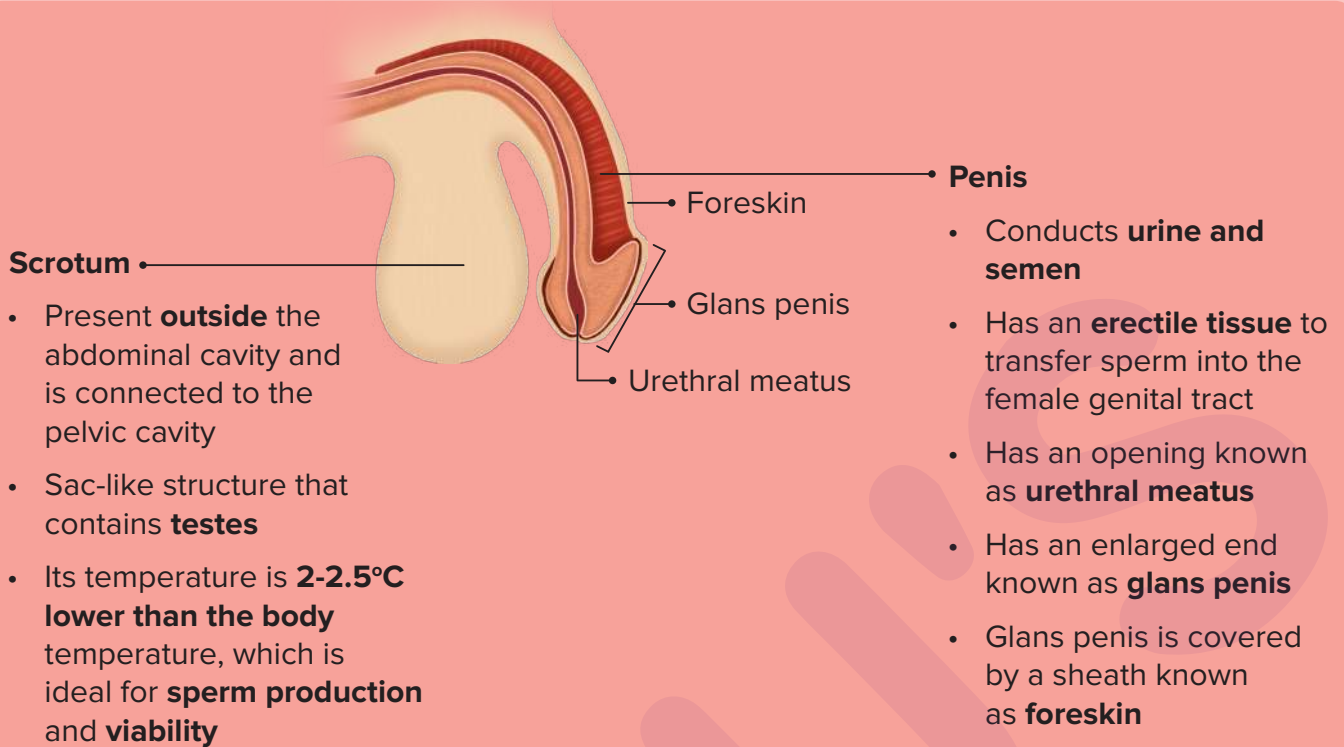
**Secondary sexual characters in males at puberty**



**Secondary sexual characters in females at puberty**

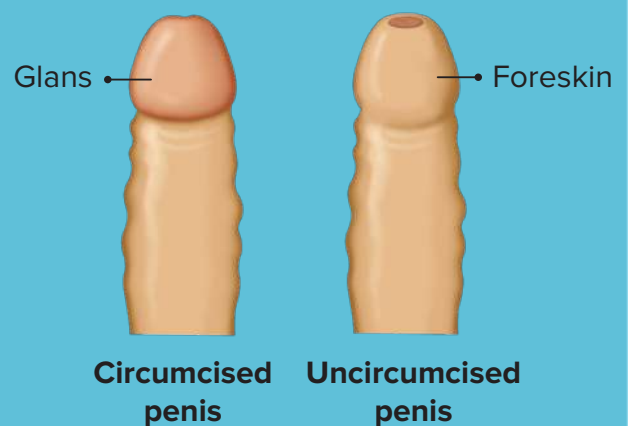
## The Male Reproductive System

### Male external genitalia

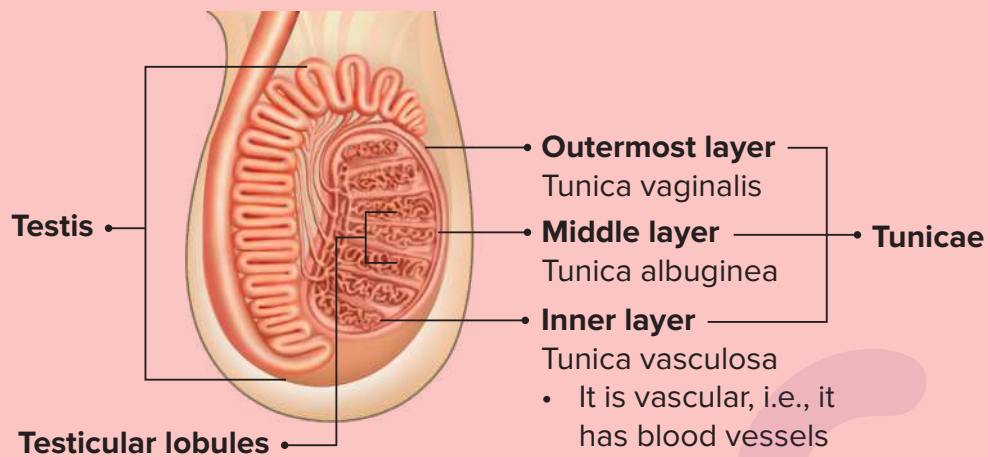


### Did you know?

- Circumcision is the **removal of the foreskin** from the human penis.
- The procedure is most often an elective surgery performed on babies and children for religious or cultural reasons.
- In sub-Saharan countries, where HIV is prevalent, it is seen that circumcised men have a lower risk of infection.
- The World Health Organization (WHO) therefore recommends the consideration of circumcision as part of a comprehensive HIV prevention program in areas with high endemic rates of HIV.



## Male internal genitalia

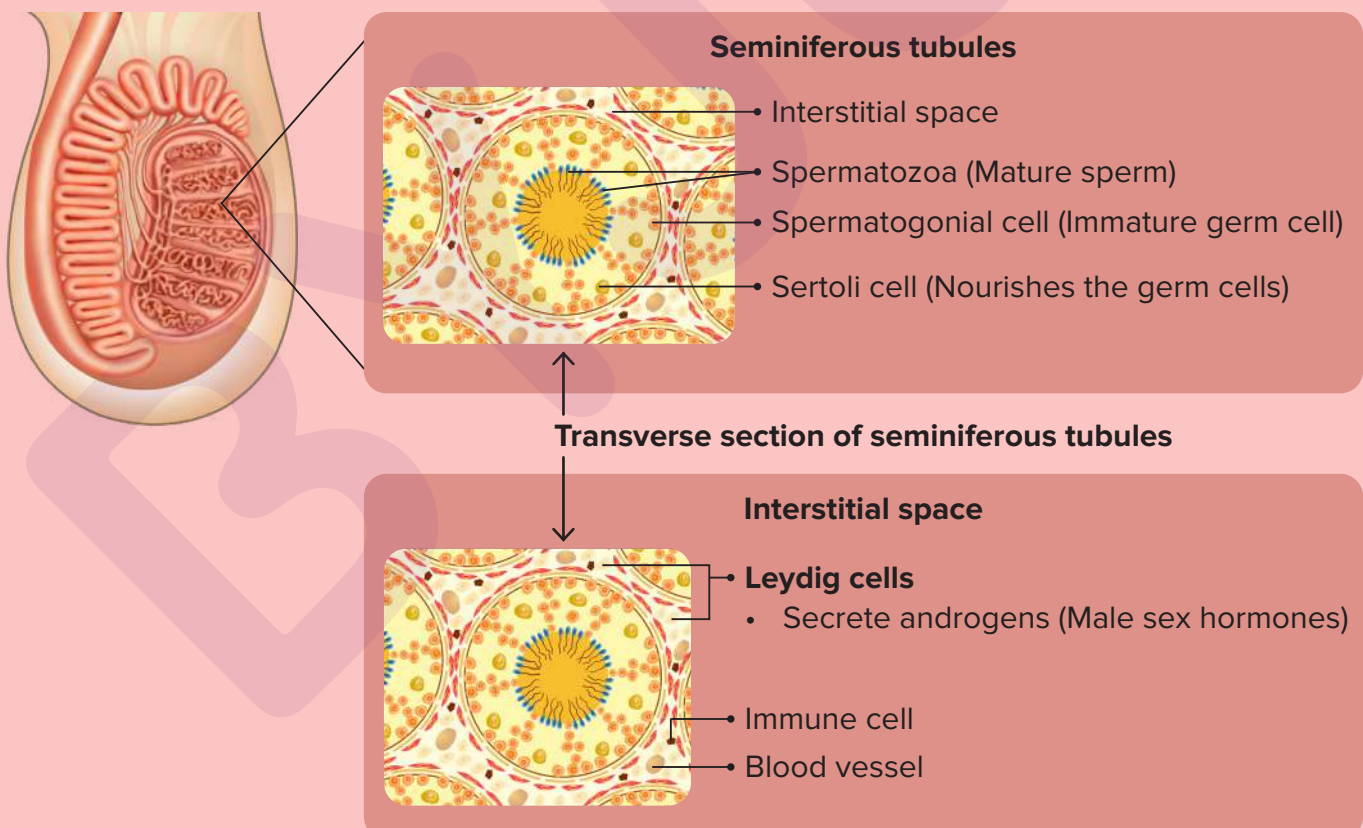


### Testes

- 4-5 cm long, 2-3 cm wide, situated inside the scrotal sac
- **Function: Production of sperms** and **secretion of androgens** (male sex hormones)
- Surrounded by three layers known as **tunicae**

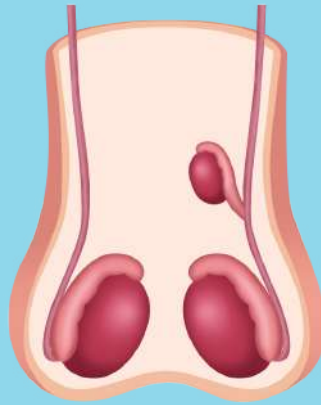
### Testicular lobules

- Each testis has about 250 compartments known as **testicular lobules**.
- Each lobule contains one to three **seminiferous tubules**.





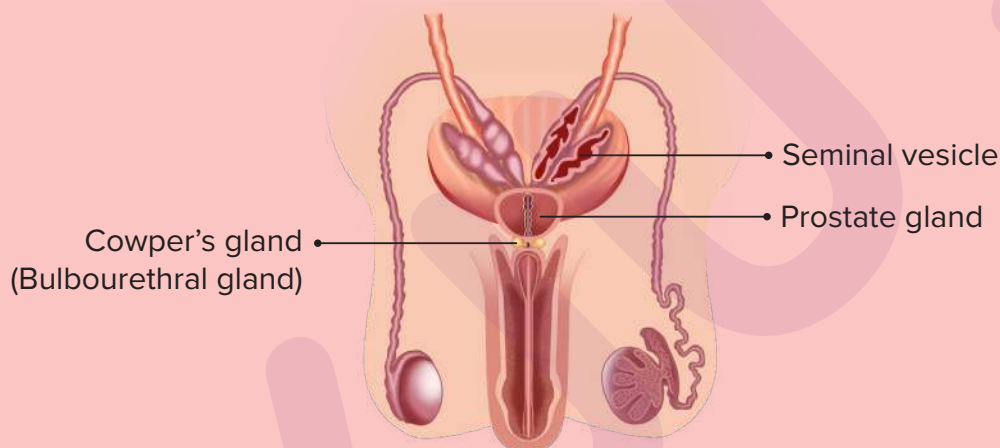
### Did you know?



### Polyorchidism

Polyorchidism (or supernumerary testes) refers to the presence of **more than two testes** and is a very rare congenital anomaly.

### Male accessory ducts and glands



#### Seminal vesicles

- **One pair** is located at the base of bladder
- Initiates **alkaline secretion** to neutralise male and female tracts
- Its secretion constitutes 60% of semen
- Its secretion contains:
  - **Fructose:** For energy
  - **Prostaglandins:** To facilitate uterine contractions
  - **Clotting proteins:** To coagulate semen after ejaculation

#### Prostate gland

- It is a **single gland** surrounding urethra
- Secretes slightly acidic fluid
- Its secretions constitute 25% of semen
- Nourishes and activates the sperms to swim

### Bulbourethral glands

- Also known as **Cowper's glands**
- Located on either side of urethra
- Secrete **mucus** to lubricate glans penis that decreases damage to sperm

### Journey of a sperm

Sperm is produced in seminiferous tubule

↓  
Rete testis

↓  
Vasa efferentia

↓  
Epididymis

↓  
Vas deferens

- It ascends to the abdomen to loop over
- It receives secretion from

← Seminal vesicles

↓  
Ejaculatory duct

It receives secretions from

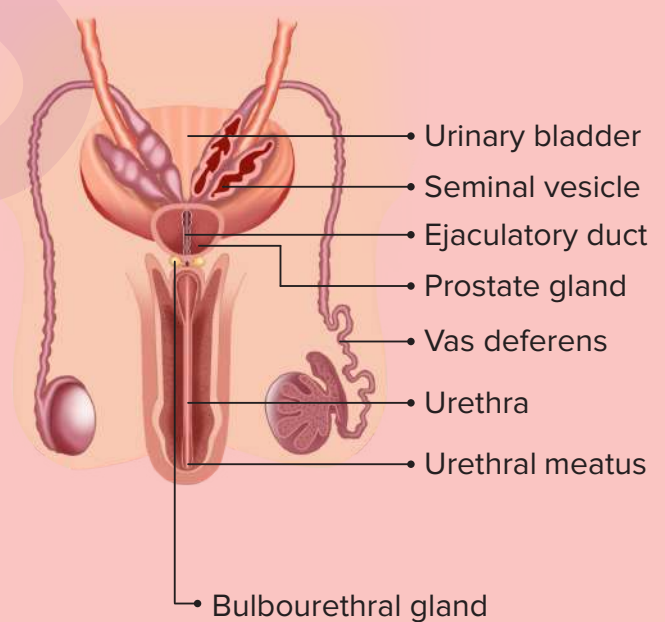
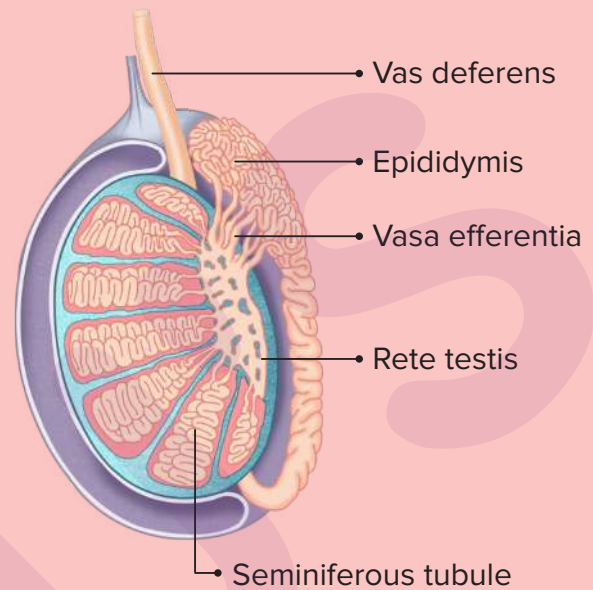
Prostate gland

← Cowper's glands

↓  
Urethra

It exits from external opening

↓  
Urethral meatus



## Seminal plasma

Consists of secretions from

Seminal vesicles

Prostate gland

Bulbourethral glands

## Semen

- Seminal plasma + Sperm = **Semen**
- It is alkaline and is ejected from penis during ejaculation.

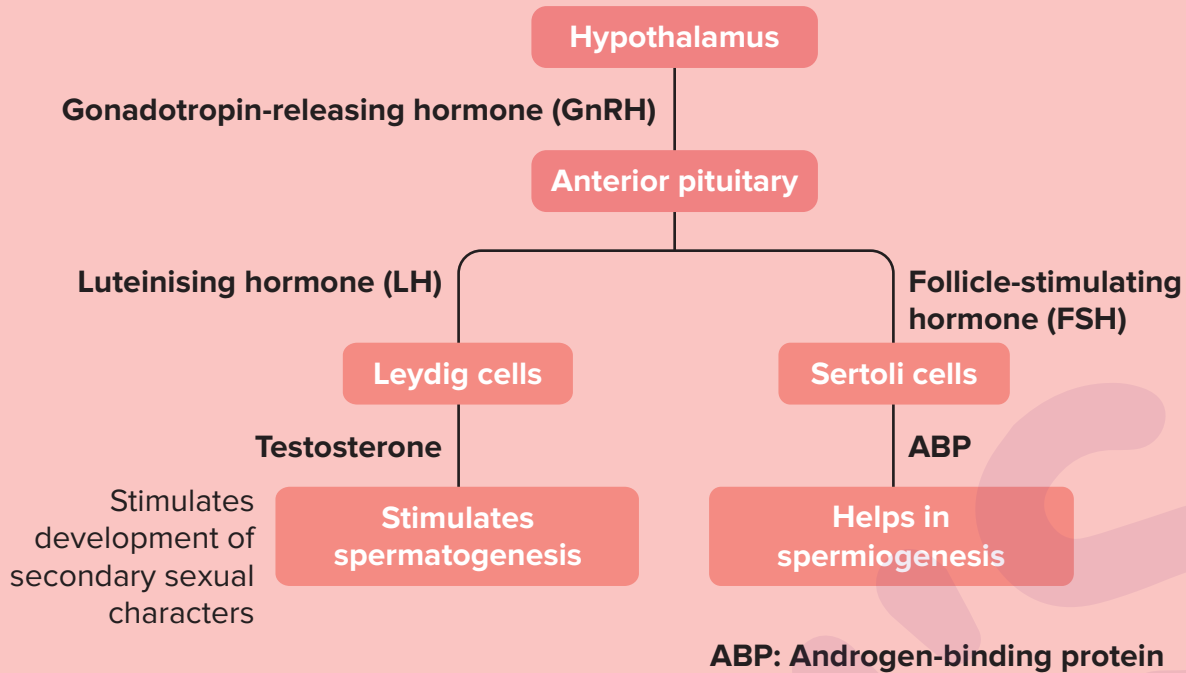


## Did you know?

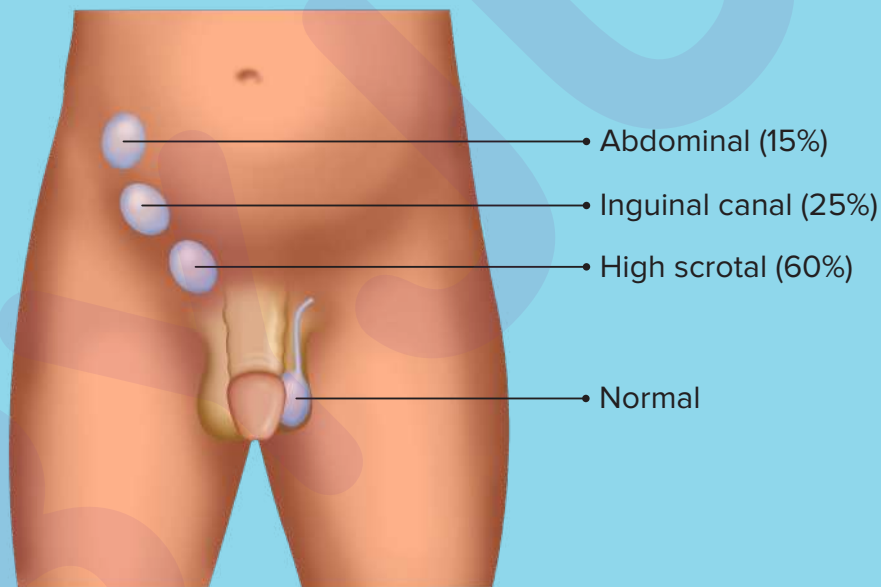


- 200-300 million sperms are released in one ejaculation

## Hormonal control in males



### Did you know?



### Cryptorchidism

- During puberty, the testes descend into the scrotum.
- Cryptorchidism is a condition in which the **testes do not descend** due to deficiency of testosterone in foetal testes.
- This leads to sterility as the testes are not at optimum temperature.
- 15% of cryptorchidism is abdominal, 25% inguinal and 60% cases are high scrotal.



## Male sex act

### Erection of penis

- Blood rushes into sinuses.
- Penis becomes stiff due to hydraulic pressure.



### Copulation

- The penis discharges the sperms into the female vagina by wavelike contractions known as ejaculation.
- At the peak of sexual stimulation, a sensation known as orgasm occurs.
- An orgasm is required for the ejaculation to occur.



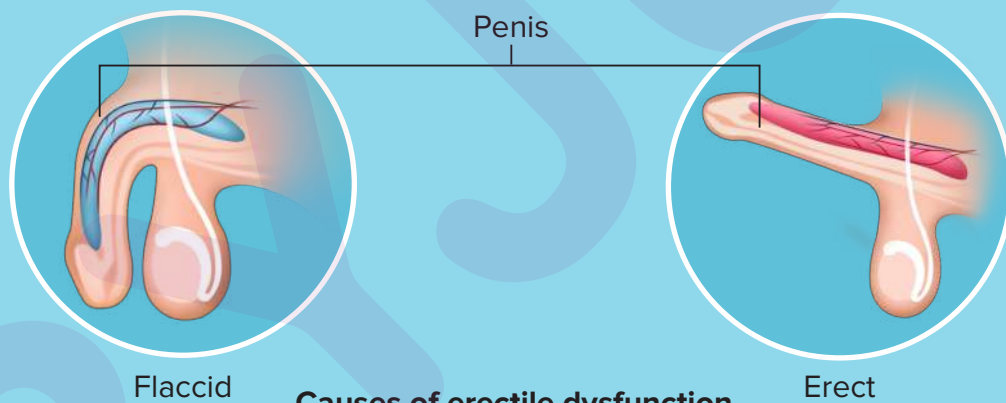
### Subsidence of erection

- The arterioles in the penis contract.
- It reduces the blood flow to the penis, which subsides the erection.



### Did you know?

- Erectile dysfunction is the inability to maintain the penis erect enough for coitus.



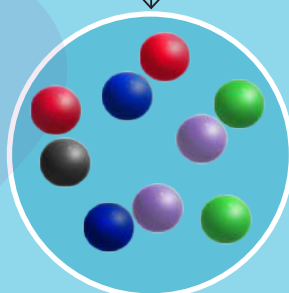
Flaccid

Erect

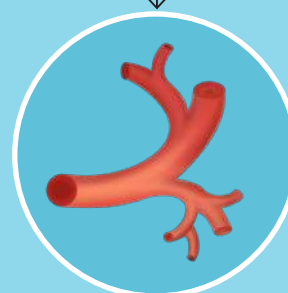
### Causes of erectile dysfunction



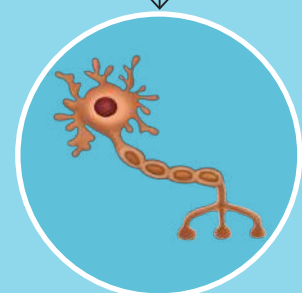
Psychological factor



Hormonal factor



Blood vessel factor



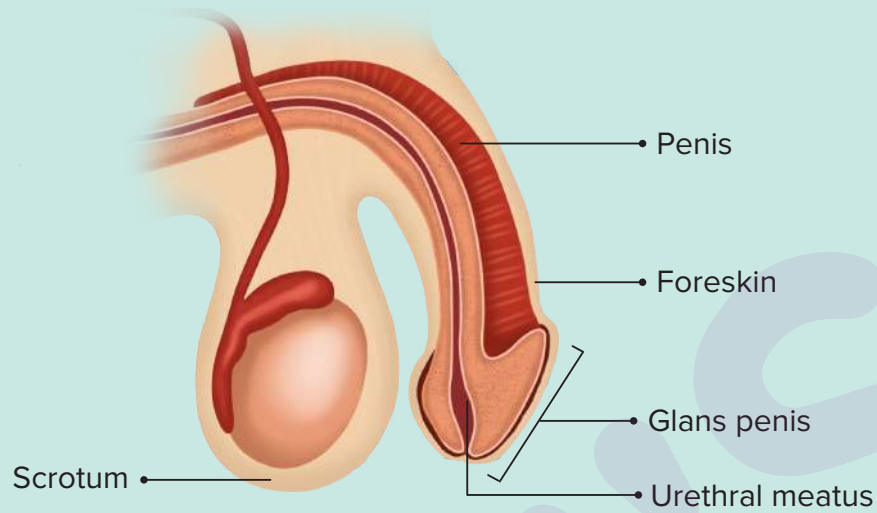
Nervous factor

- This can be treated with the help of some medication and assistive devices, such as pumps.

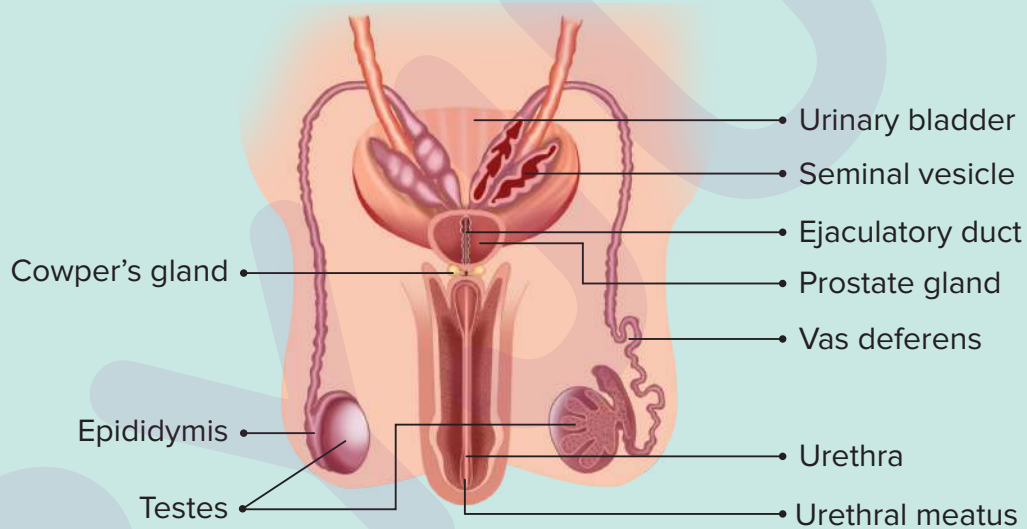


## Summary Sheet

### Male external genitalia



### Male internal genitalia



### Male accessory glands and ducts

Sperm is produced in seminiferous tubule

Rete testis

Vasa efferentia

Epididymis

Vas deferens

Seminal vesicles

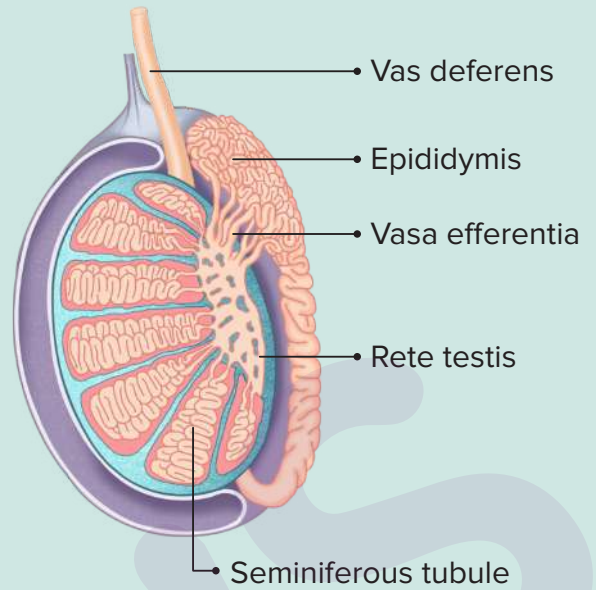
Ejaculatory duct

Prostate gland

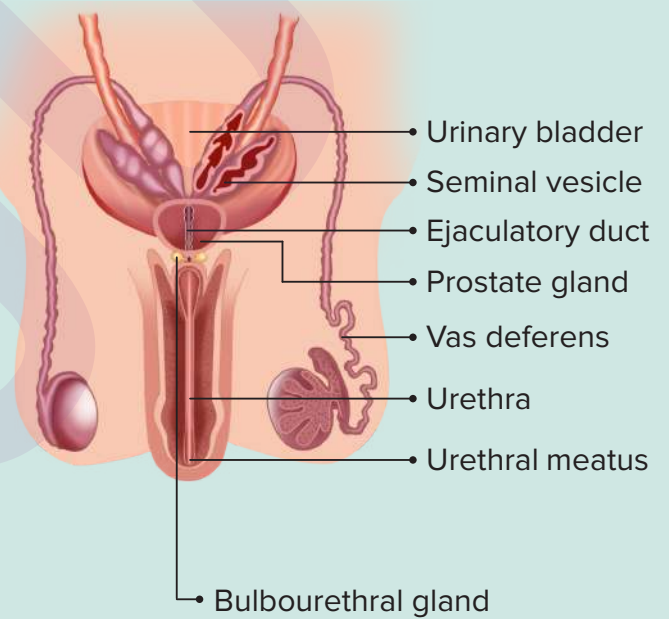
Cowper's glands

Urethra

Urethral meatus



### Journey of a sperm



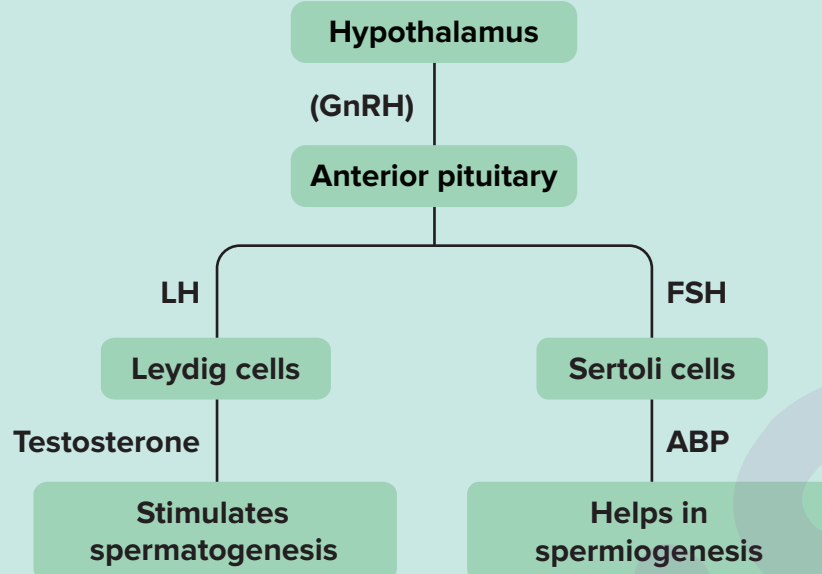
### Male sex act

Erection of penis

Copulation

Subsidence of erection

### Hormonal control in males





**Key Takeaways**

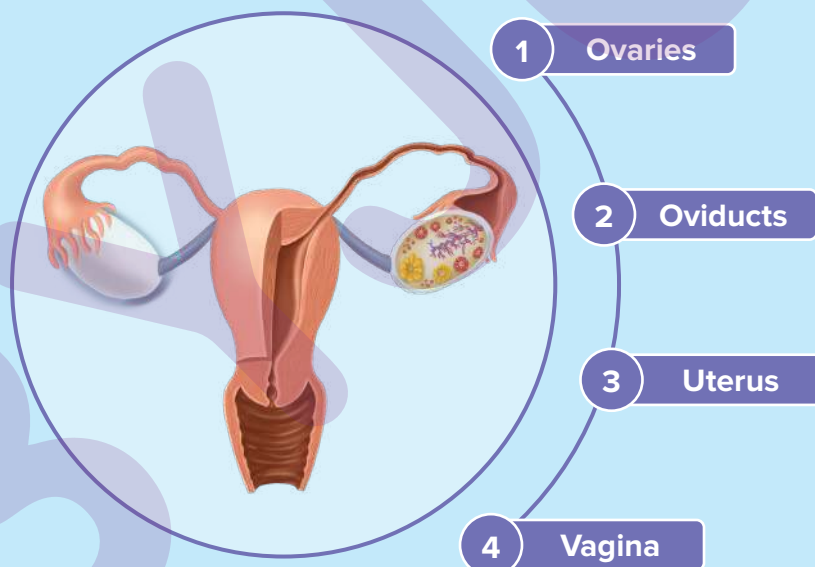
- Female reproductive system
  - Ovaries
  - Oviducts
- Uterus
  - Vagina



**Prerequisites**

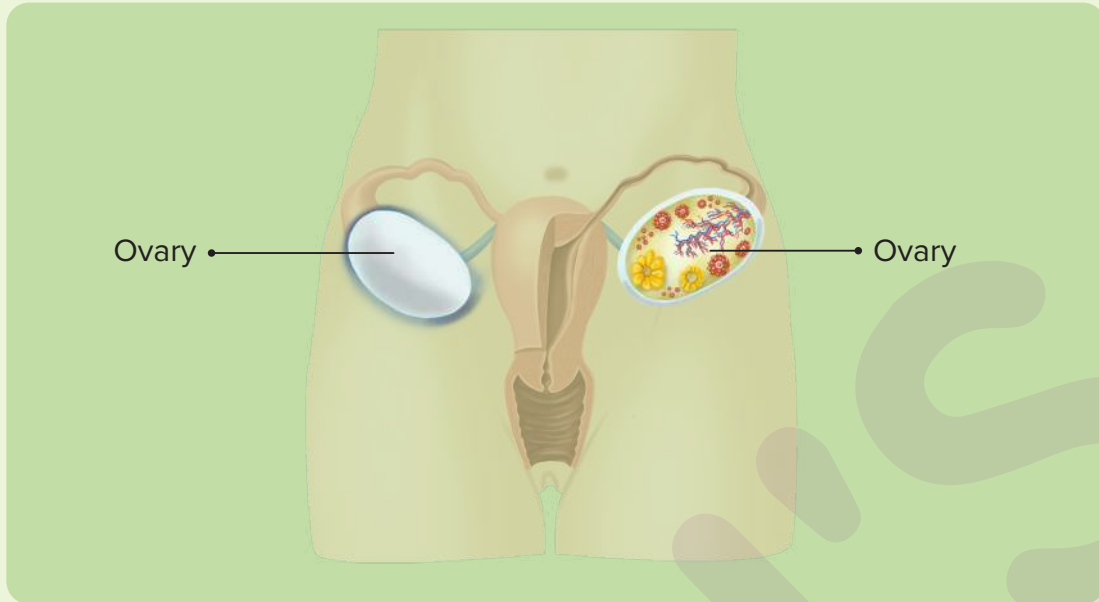
- 1. Puberty**
  - The process of changes in the body such that it becomes capable of sexual reproduction.
- 2. Secondary sexual characters**
  - Secondary sexual characters are those sexually dimorphic characteristics that are not directly involved in reproduction.

**Internal female reproductive system**

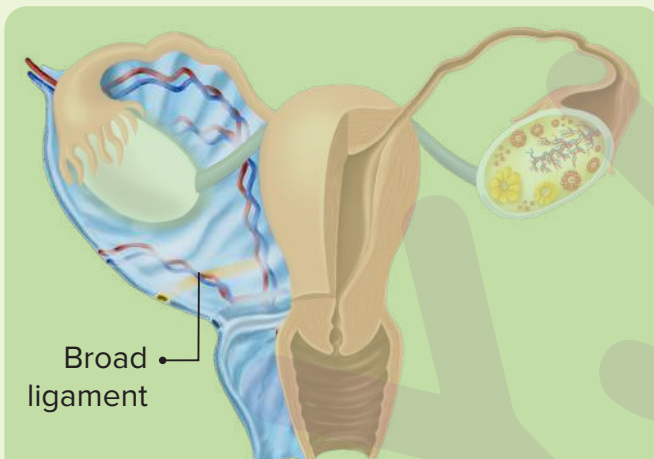


## Ovaries

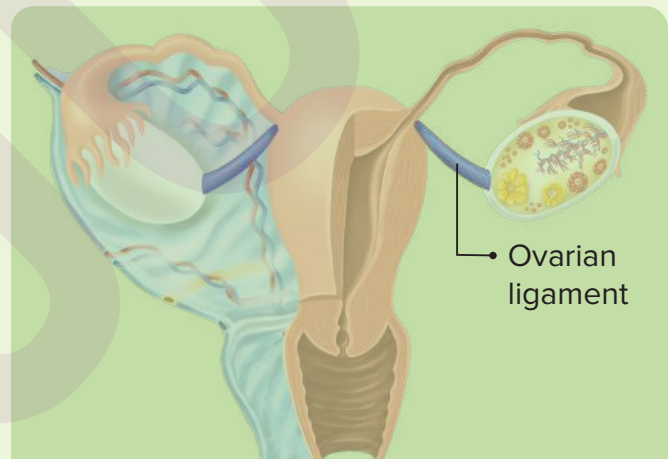
- Ovaries are the **primary female sex organs** that produce the **female gametes** (ova) and secrete several **steroid hormones** (ovarian hormones).
- The ovaries are a paired structure present in the **upper-pelvic cavity**, in the lower abdomen.



- The ovary is connected to the pelvic wall and uterus by **ligaments**.



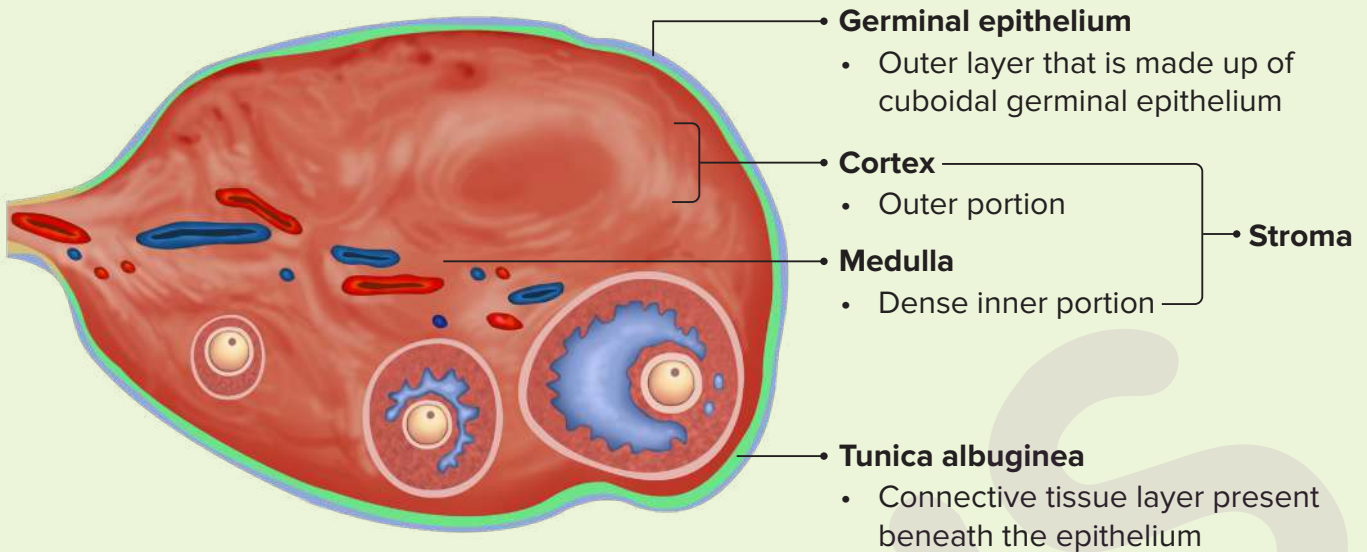
- Ovaries are attached to the lateral pelvic walls by the **broad ligament**.



- Ovaries are attached to uterus by the **ovarian ligament**.

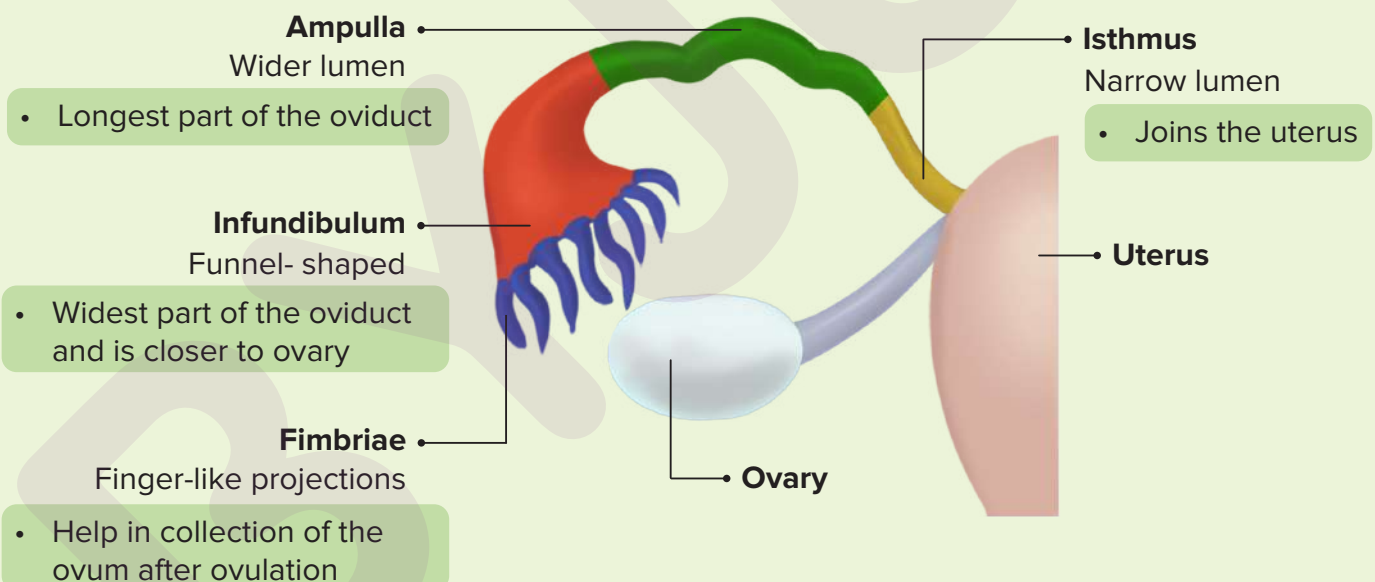
## Histology of ovaries

### The Layers of an Ovary



## Oviducts (Fallopian Tubes)

- The **oviducts or the fallopian tubes** extend from the periphery of each ovary to the uterus.
- Each fallopian tube is about **10-12 cm** long.
- It is divided into 3 parts- **Infundibulum, ampulla, and isthmus**.

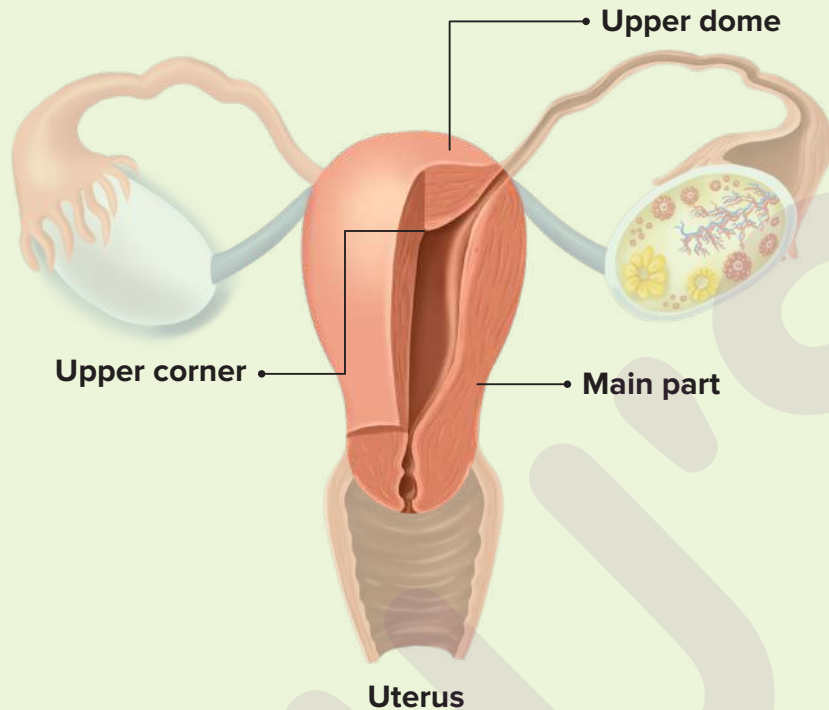


## Function of the oviducts

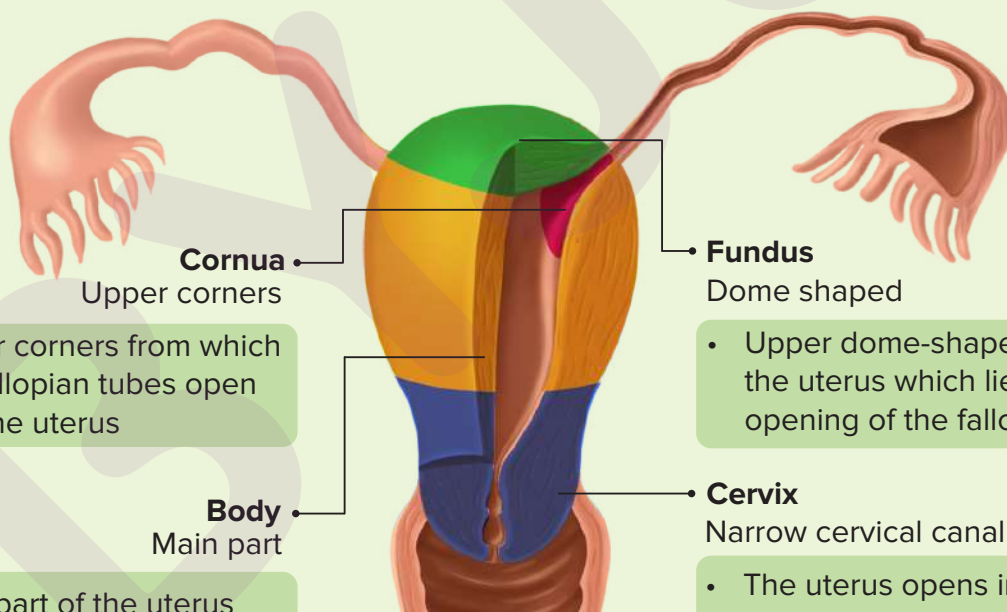
- It carries the **ovum from the ovary to the uterus**.
- The **fertilisation** of the ovum takes place normally at the **ampullary-isthmus junction**.

## Uterus

- The uterus/womb is a **single, hollow, and muscular structure**.
- The shape of the uterus is like an inverted pear.
- It lies in the pelvic cavity.
- It is supported by ligaments attached to the pelvic wall.



## Parts of the uterus



- Upper corners from which the fallopian tubes open into the uterus

- Upper dome-shaped part of the uterus which lies above the opening of the fallopian tubes

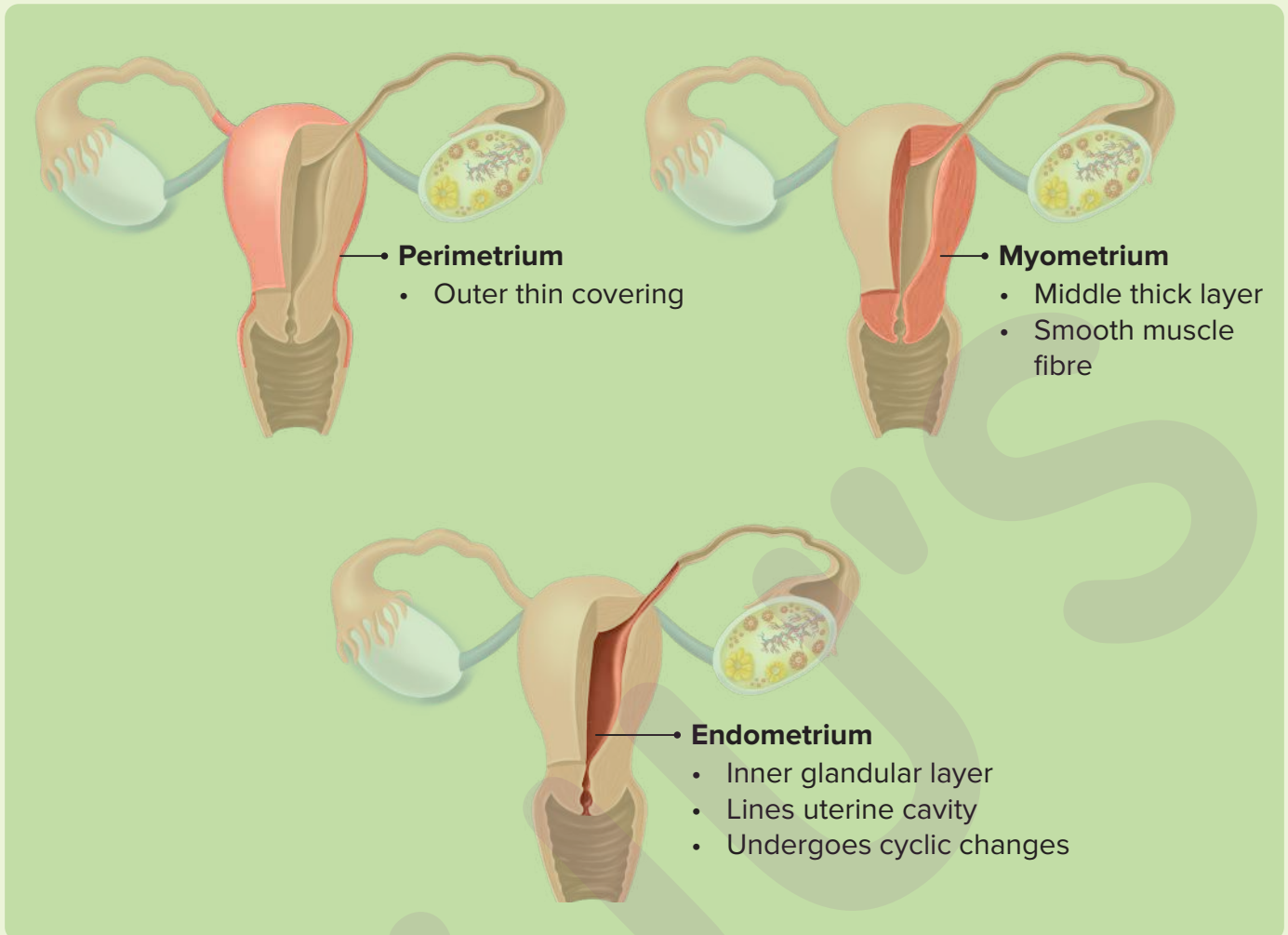
- Main part of the uterus

- The uterus opens into vagina through a narrow cervix.



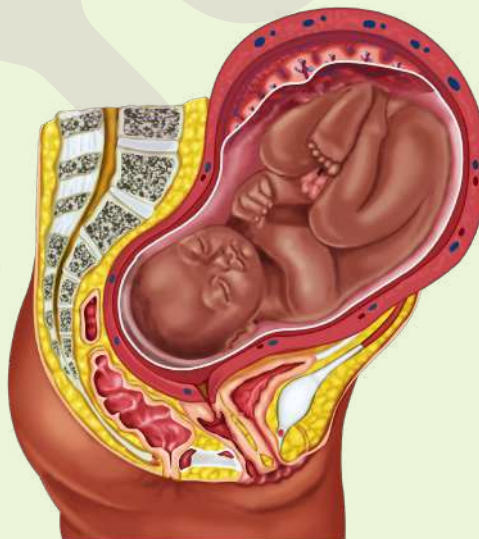
## Wall of Uterus

- It has three layers of tissue



## Function of the uterus

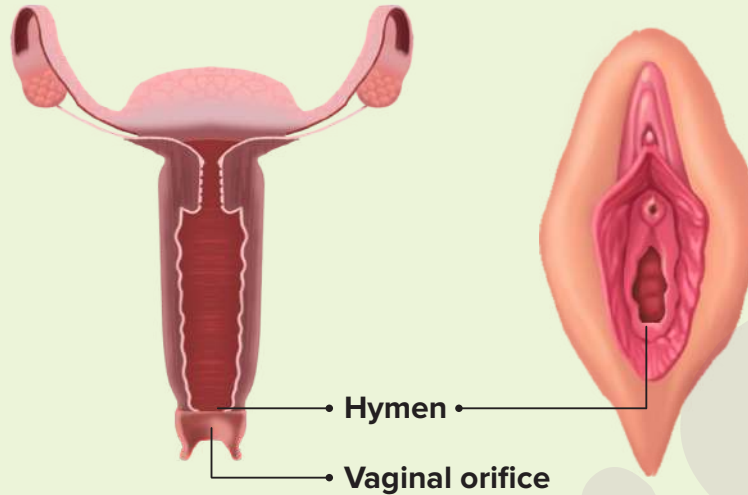
- It **protects and nourishes** the growing embryo.



Growing baby in uterus/womb

## Vagina

- The vagina receives the sperms during intercourse.
- It also forms the birth canal along with the cervix for pushing the baby out.



- The vagina is a tube around **10 cm** long and extends from the cervix to outside of body.
- It is easily **stretchable** to accommodate the penis during **intercourse** and for **childbirth**.
- The **opening of vagina** is called **vaginal orifice**.
- The opening of the vagina is often covered partially by a **membrane** called the **hymen**.
- Hymens can be of different shapes.



### Did you know?



**Stretched membrane**



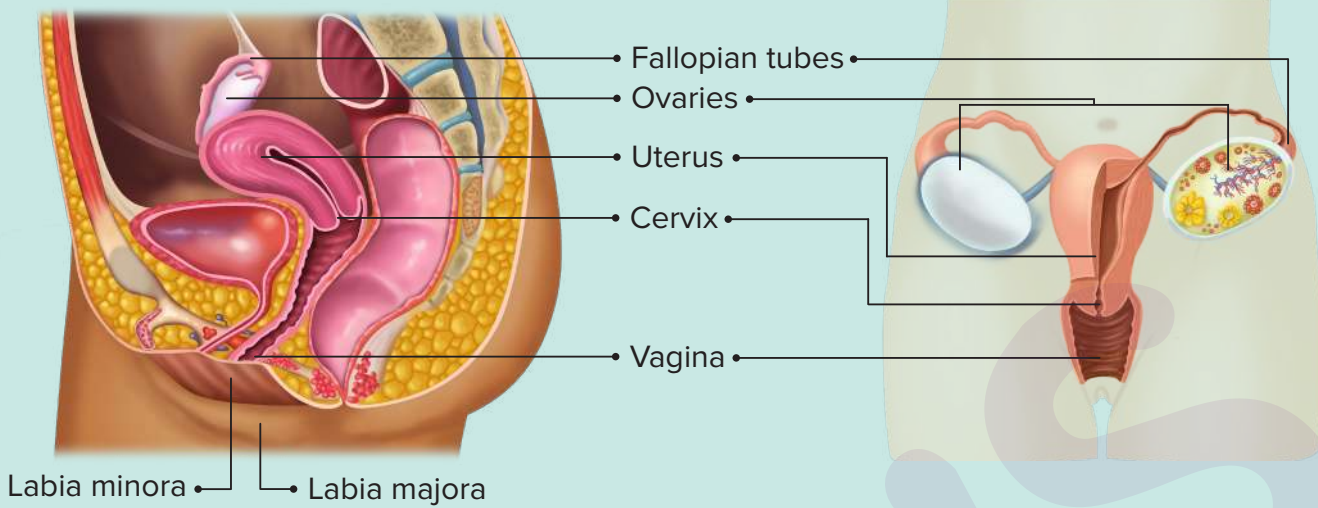
**Elastic hair-tie**

- The hymen is not like a sheet stretched over a hoop, rather it is like an elastic hair-tie (bow).
- Usually, the hymen looks like a fringe of tissue around the vaginal opening but it is not an intact piece of tissue draped across it.
- Some girls are born without a hymen, while others only have a small fringe of tissue.
- Contrary to popular belief, the hymen is not a flat piece of tissue covering the vagina, which is torn during intercourse.
  - **It can also be broken by a sudden fall or jolt, active participation in some sports like horseback riding, cycling, etc.**

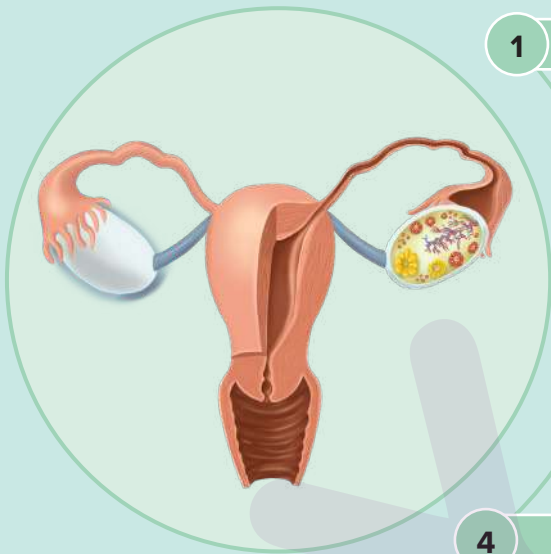


## Summary Sheet

### Female reproductive system



Labia minora      Labia majora



#### 1 Ovaries

- Primary female sex organ which produces ova and ovarian hormones

#### 2 Oviducts

- Carries **ovum from the ovary** to the uterus and is the site for fertilization

#### 3 Uterus

- Protects and nourishes the embryo

#### 4 Vagina

- **Receives the sperms** during intercourse and **forms the birth canal**

**FEMALE EXTERNAL GENITALIA, MAMMARY GLANDS,  
HORMONAL CONTROL**



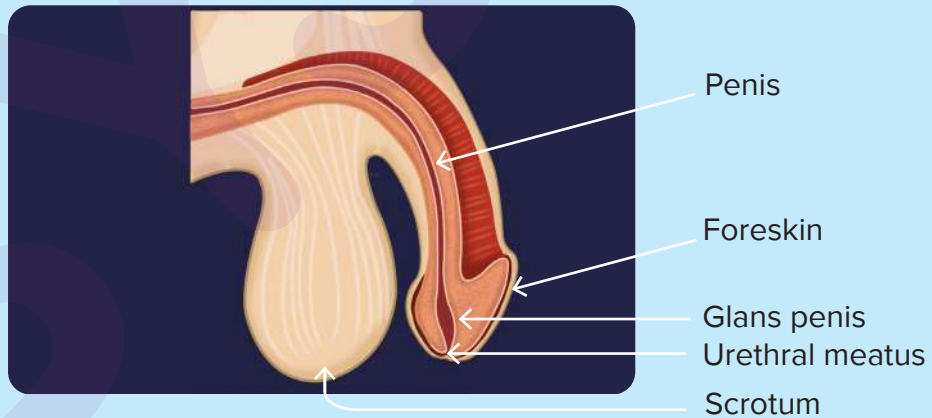
**Key Takeaways**

- Female external genitalia
  - Vulva
  - Similarities with male external genitalia
- Female sex act
- Mammary glands
  - Structure of breasts
    - ▣ Glandular tissue
  - Function of breasts
- Male mammary glands
- Hormonal control of female reproductive system

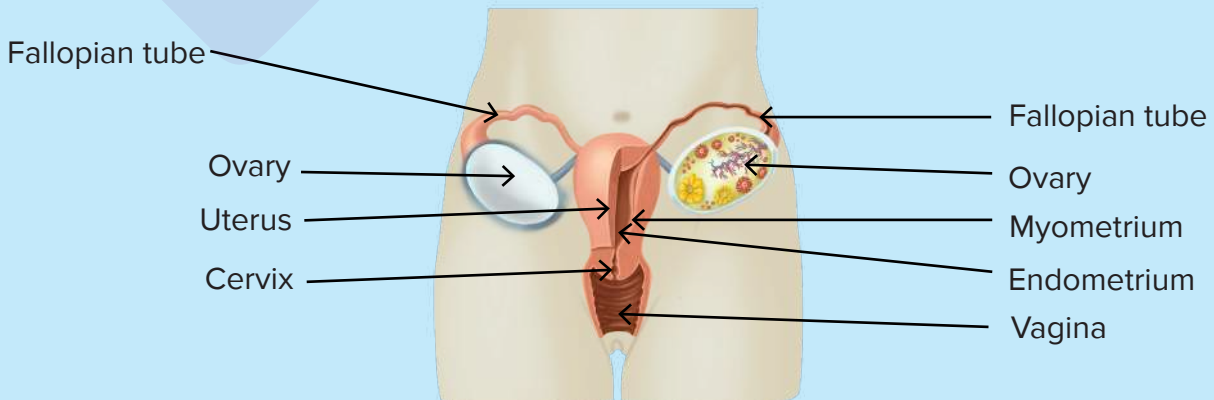


**Prerequisites**

- **Male genitalia**

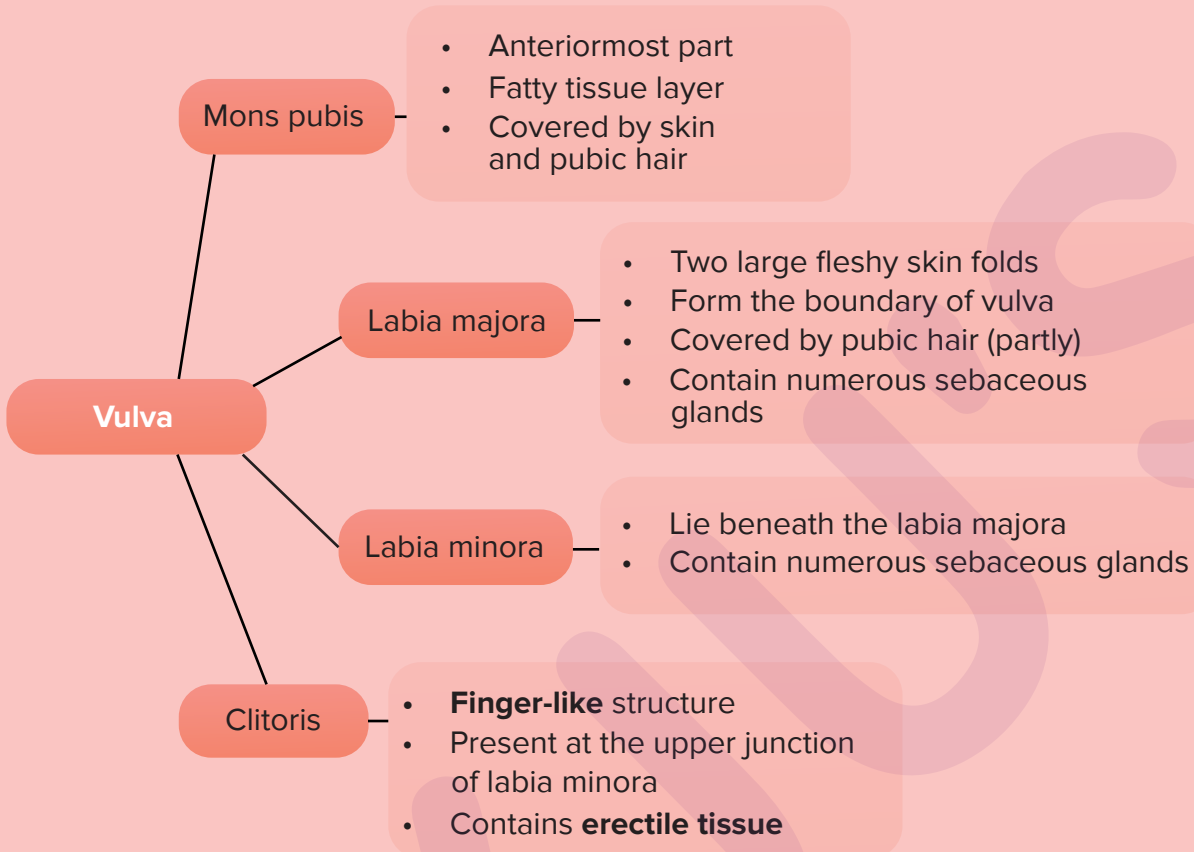


- **Female genitalia**



## Female External Genitalia

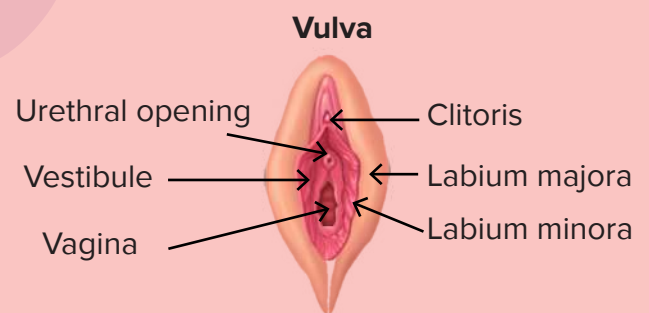
- The female external genitalia is also known as **vulva**.



### Vestibule

- It is a **wide depression** that forms the shallow cavity of the vulva.
- It is guarded on either sides by the labial folds.
- It receives
  - opening of the **vulva**
  - opening of the **urethra**

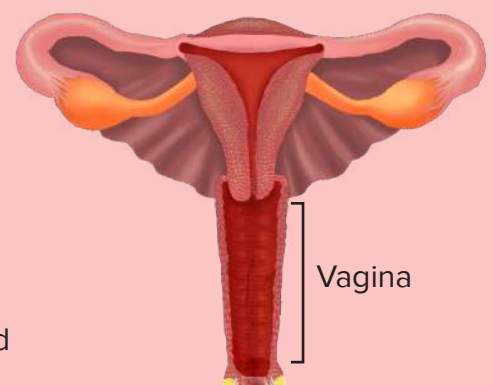
The urethral opening lies anterior to the vaginal opening.



### Vagina

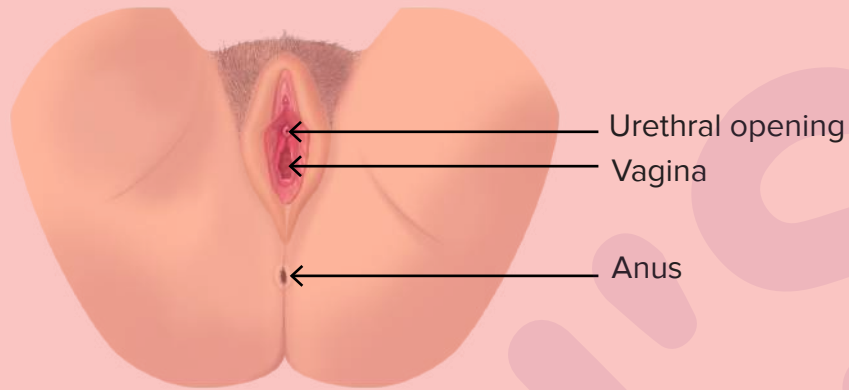
- It extends from the **vestibule to the uterus**.
- Its opening is often covered partially by a thin membrane know as **hymen**.
- It is made of a muscular tube between **3-5 inches in length**. It serves as a **birth canal** during parturition.
- It also serves to **receive the sperms** from the male penis during coitus.
- The hymen is **often torn** during the first intercourse. It could also be ruptured due to participation in **active sports** or by usage of **vaginal tampons**.

### Female reproductive system



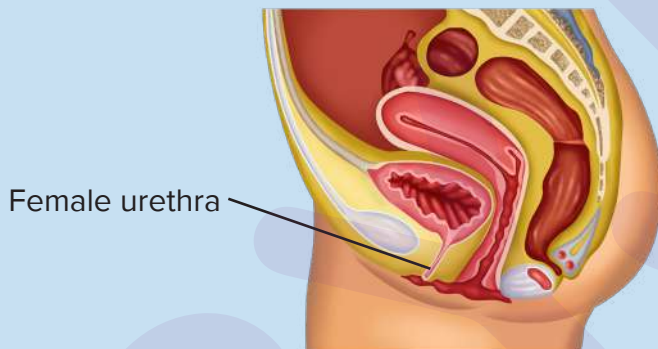
### Myth buster

- Women **do not** urinate through vagina.
- They have three portals: a urethra, vagina, and anus.

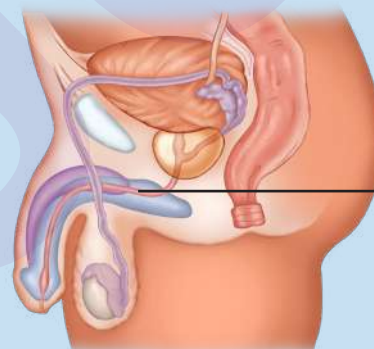


### Did you know?

The female urethra is shorter than the male urethra.



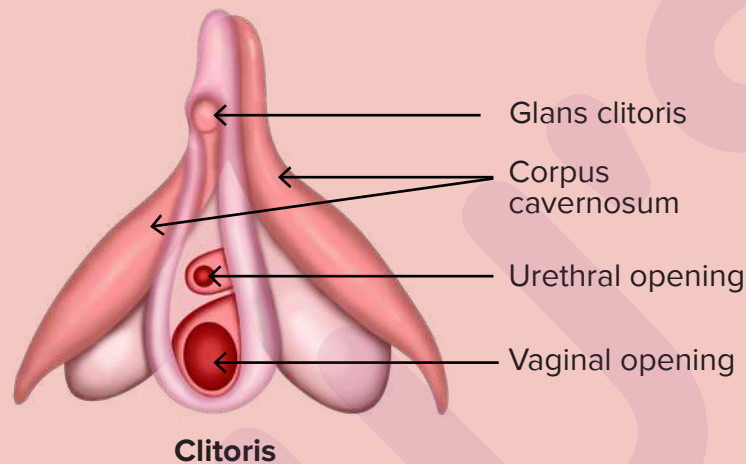
Female pelvis



Male pelvis

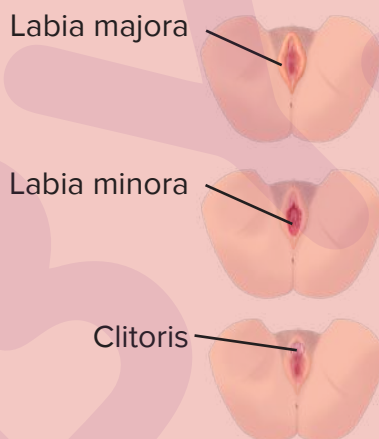
## Clitoris

- It is a **tiny finger-like structure** that lies at the upper junction of the two labia minora above the urethral opening.
- When sexually stimulated, the **corpus cavernosum** or the erectile tissue gets swollen due to the blood flow into the tissue.
- It is similar to the erection of male penis.

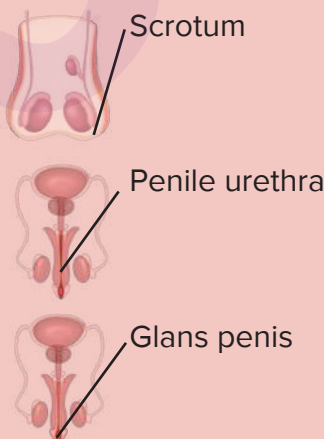


## Similarities Between Female and Male External Genitalia

### Female external genitalia



### Male external genitalia

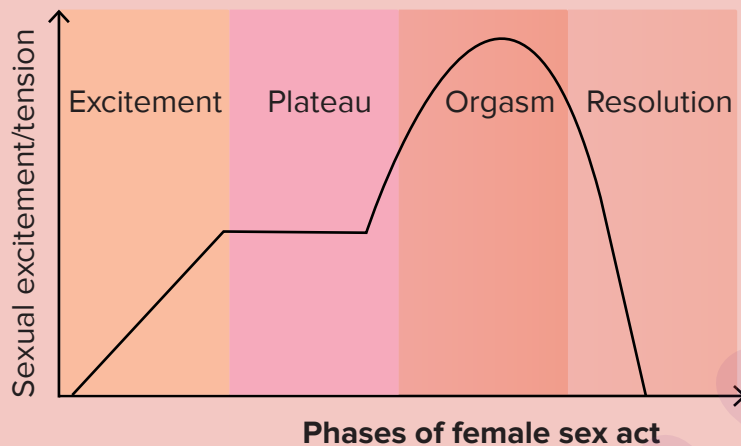


## Female genital mutilation

- Female genital mutilation (FGM) is a procedure performed on a women or a girl to **alter or injure** her genitalia for **non-medical reasons**.
- It is similar to the circumcision of foreskin of penis in males.
- It most often involves the partial or the total removal of her external genitalia.



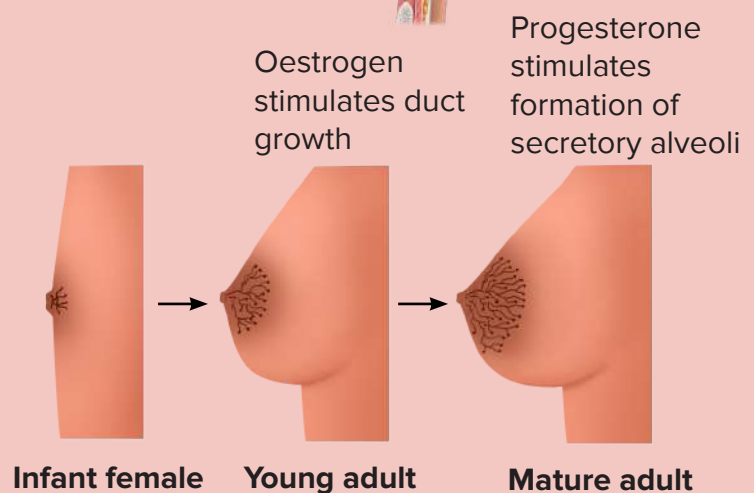
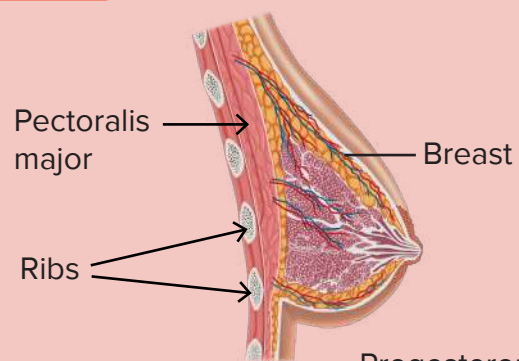
## Female Sex Act



- 1. Excitement:** Blood flow to genitals increases
  - Clitoris and labia minora swell
  - Breasts become fuller, nipples become erect
  - Vaginal lubrication takes place
- 2. Plateau:** Changes of phase 1 intensify
  - Vagina continues to swell from blood flow
  - Vagina becomes darker in colour
  - Clitoris becomes highly sensitive
- 3. Orgasm:** Blood pressure, heart rate, and breathing at highest level
  - Muscles of vagina contract
  - Sudden forceful release of sexual tension
  - Some women may expel a watery whitish fluid
- 4. Resolution:** Body returns to pre-excitement state.

## Mammary Glands

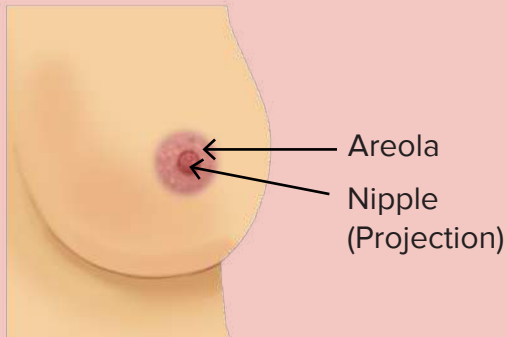
- They are **two round** structures.
- They lie over the pectoralis major muscle on the front wall of the **chest**.
- Pectoralis is a flat muscle in chest that extends from shoulder to breast bone.
- These are undeveloped until puberty.
- At puberty, they begin to develop under the influence of oestrogen and progesterone hormones.





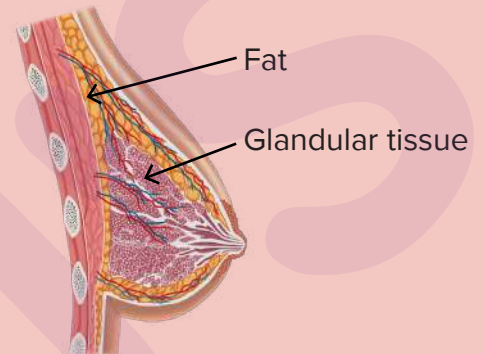
## Structure of breast

### External structure of breast



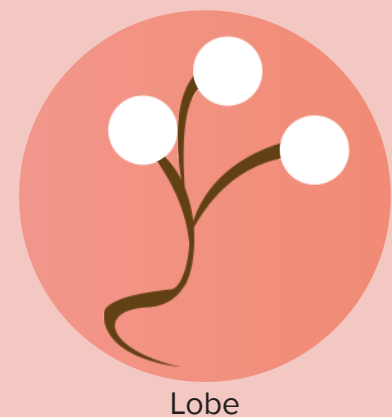
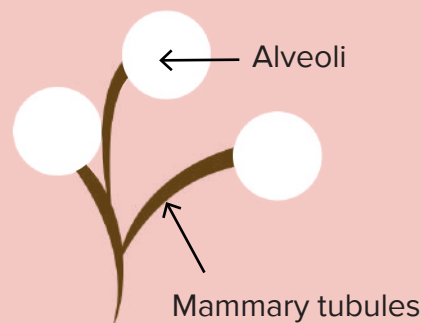
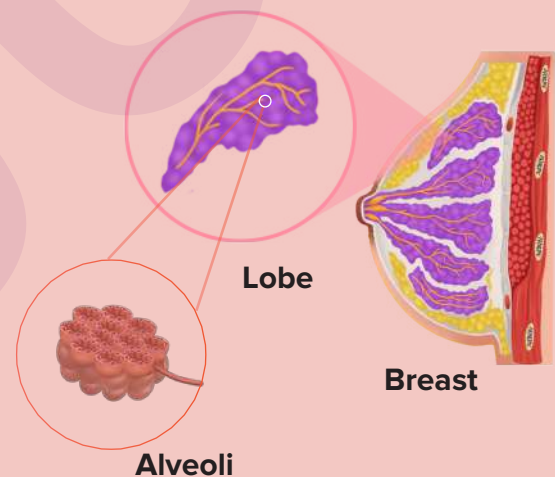
### Internal structure of breast

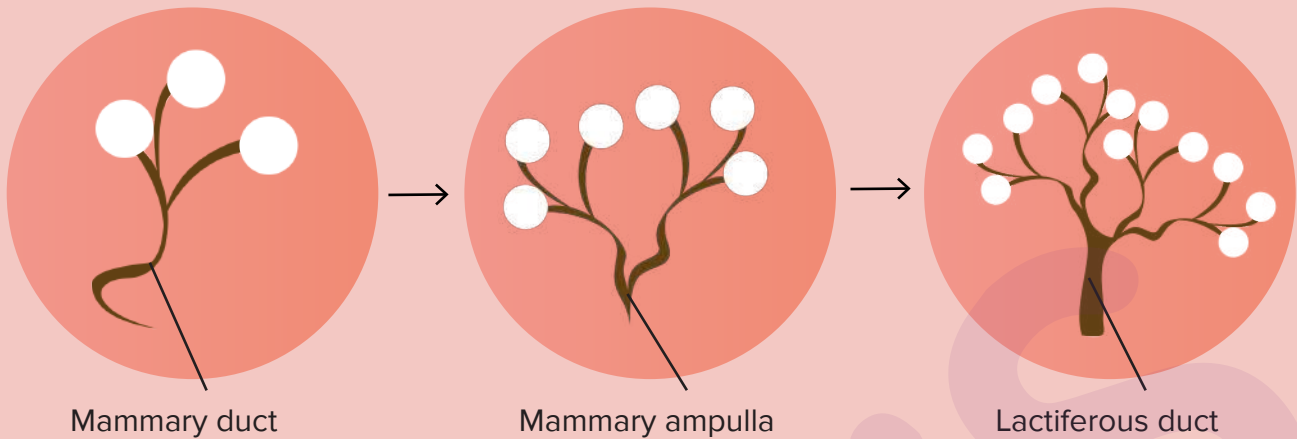
- Glandular tissue
- Fibrous/connective tissue
- Fatty/adipose tissue



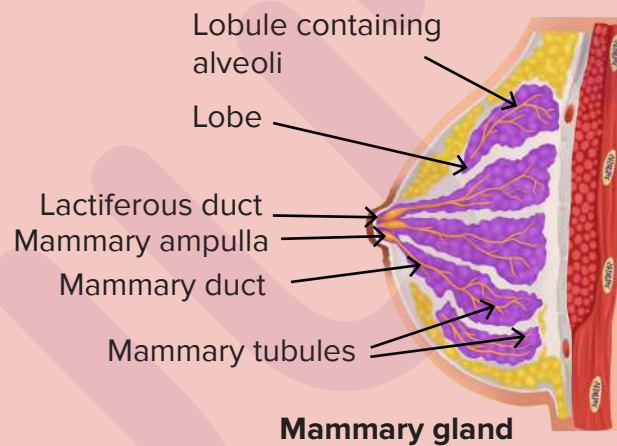
### Glandular tissue

- Glandular tissue comprises of about **15-20 mammary lobes** in each breast.
- Each lobe is made up of several clusters of milk-secreting structures know as **alveoli**.
- The cells of alveoli secrete milk, which is stored in the cavities (lumens) of alveoli.
- The alveoli open into **mammary tubules**.
- The tubules of each lobe join to form a **mammary duct**.





- Several mammary ducts join to form a wider **mammary ampulla** that is connected to the **lactiferous duct** through which milk is sucked out.



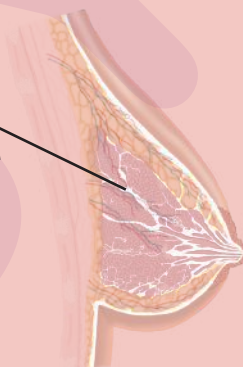
**Mammary gland**

### Glandular tissue

- Alveoli → Mammary tubules
- Tubules → Mammary duct
- Mammary duct → Mammary ampulla → Lactiferous duct

### Fibrous connective tissue

It supports the alveoli and the ducts.

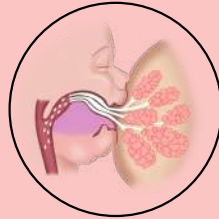
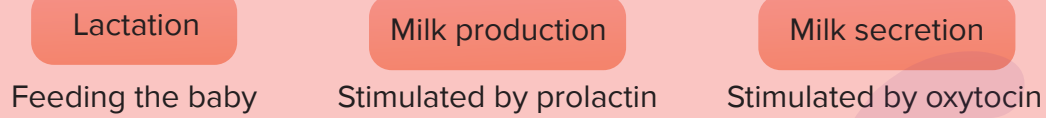


### Fatty/adipose tissue

It is present between the lobes and covers the surface of mammary glands.



## Functions of breast



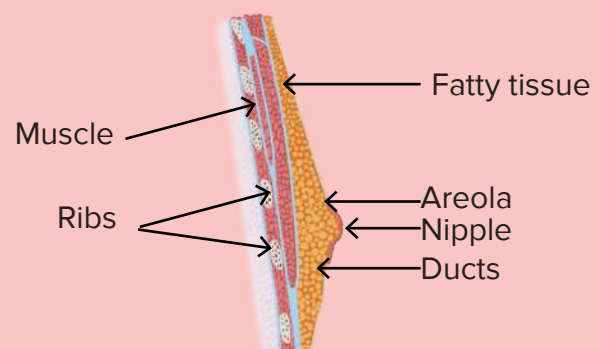
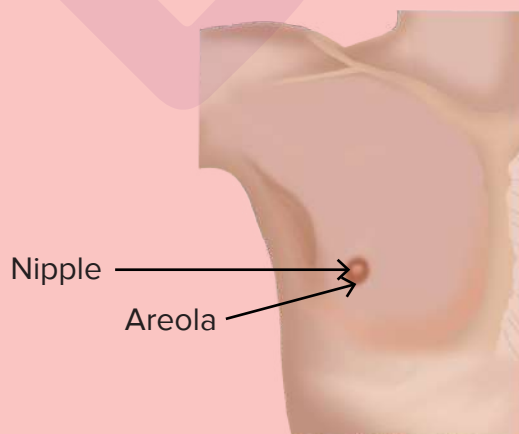
## Did you know?

- When a doctor places a newborn on its mother's chest moments after birth, **oxytocin** is released. The mother's body **temperature rises** to create a warm, comforting place for the baby to snuggle. Skin-to-skin contact calms new babies and often helps them cry less.
- Oxytocin causes a newborn to seek out and latch on to its mother's breast. The hormone floods the mother's body during breastfeeding.
- So, oxytocin does not just stimulate the secretion of milk, but also helps the new mothers to **bond with their babies**.



## Male Mammary Glands

- Mammary glands are present in males, but they are **rudimentary**.
- They do not play any role in nursing the younger ones.



- Sometimes, male breast tissue swells due to **reduced male hormones** (testosterone) or **increased female hormones** (oestrogen).
- This condition is known as **gynecomastia**.

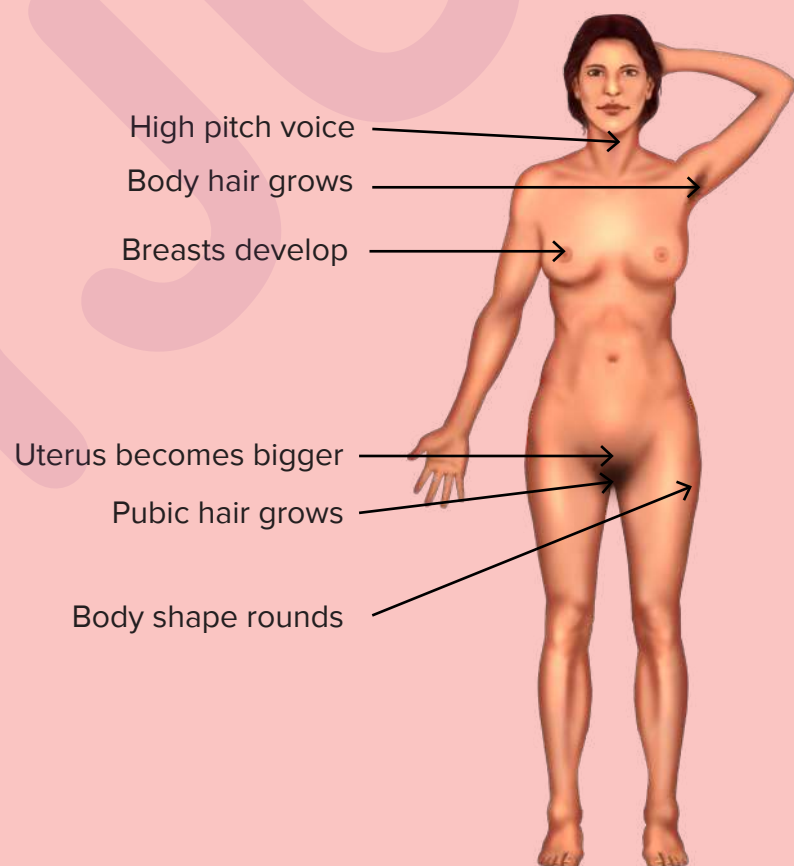
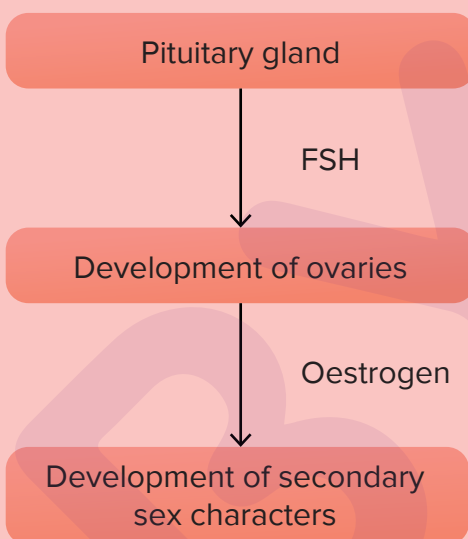


Male with gynecomastia



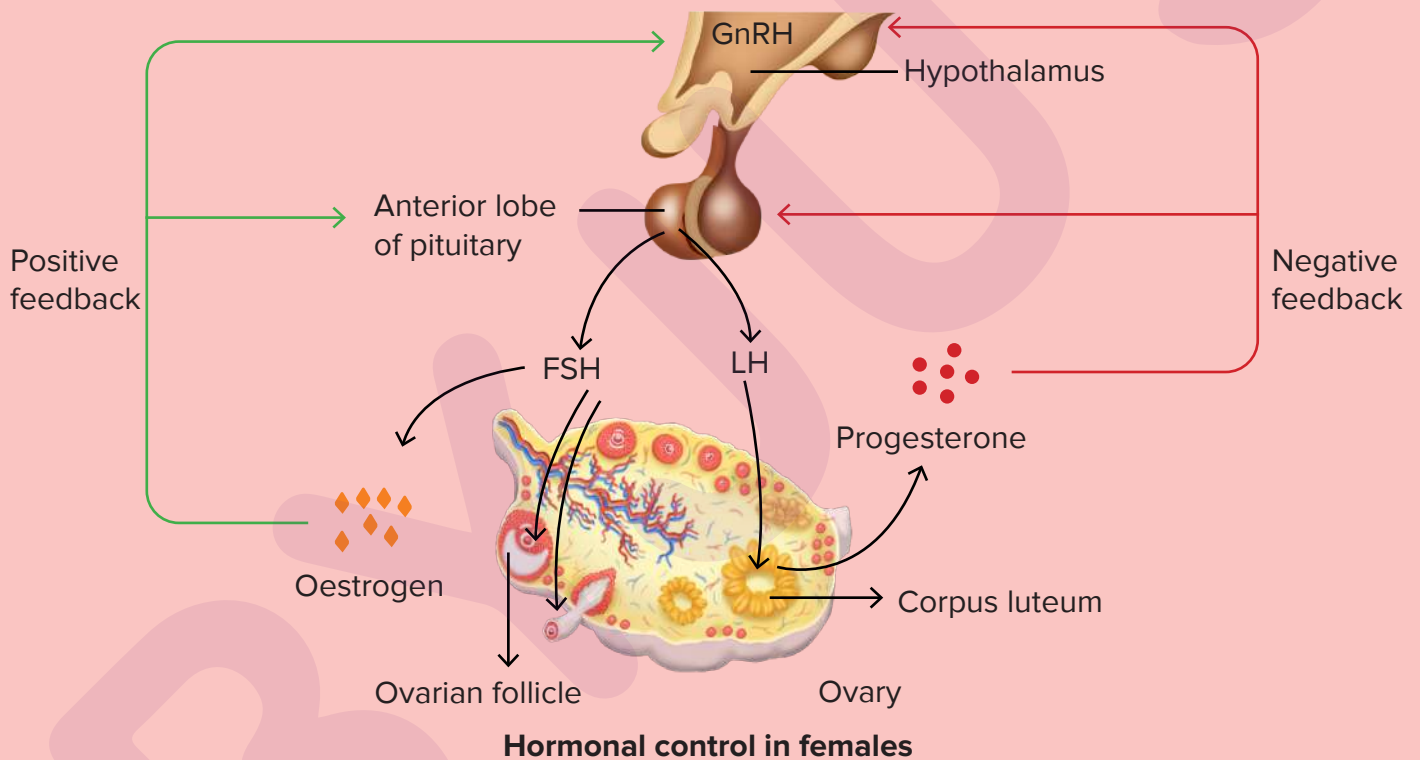
Normal male

### Hormonal Control of Female Reproductive System



At the time of puberty:

- **Gonadotropin-releasing hormone** is secreted by the **hypothalamus** that stimulates the **anterior lobe** of the pituitary to secrete **FSH** and **LH**.
- Both of these hormones stimulate the **ovary**.
- FSH stimulates the growth and development of **ovarian follicles**, and the development of the **egg** or **oocyte**.
- It also stimulates the formation of **oestrogen**.
- This in turn **stimulates** the secretion of **GnRH** and the hormones from the **anterior lobe** of the pituitary gland during ovulation. This leads to LH surge.
- LH stimulates the **corpus luteum** to secrete **progesterone**.
- The increasing levels of progesterone **inhibit** the release of **GnRH**, which in turn inhibits the release of **FSH, LH**, and **progesterone** itself.

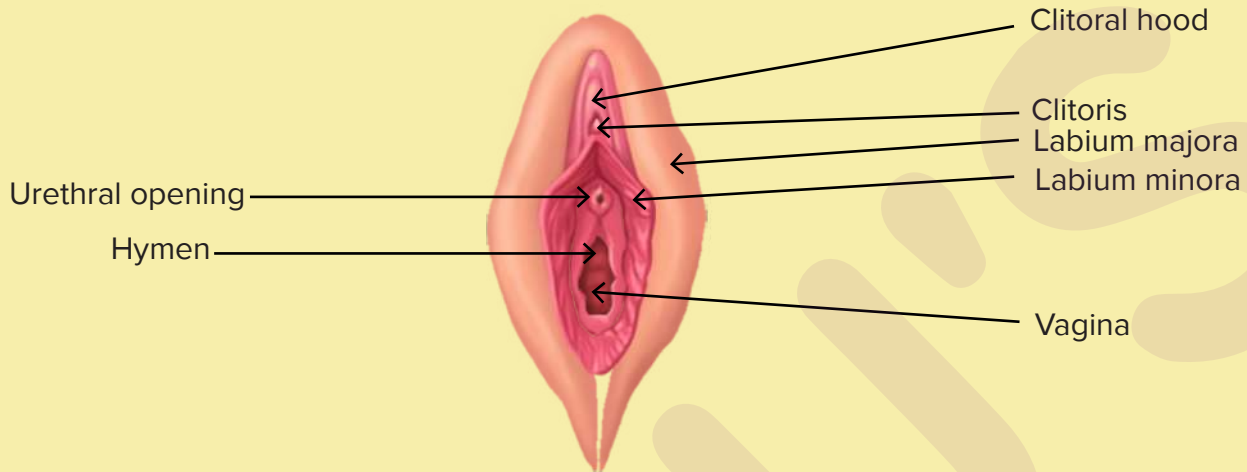




## Summary Sheet

### Female external genitalia

- The female external genitalia, known as the **vulva**, consists of the following:



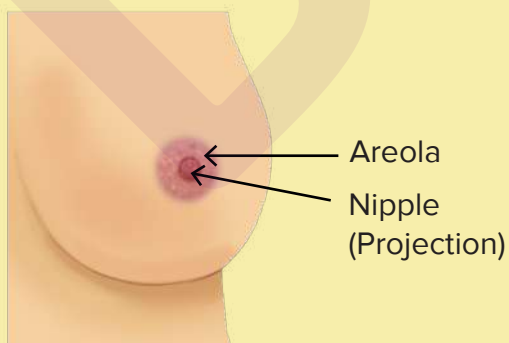
- Some of female parts are homologous with the male reproductive parts.

Female	Male
Labia majora	Scrotum
Labia minora	Penile urethra
Clitoris	Glans penis

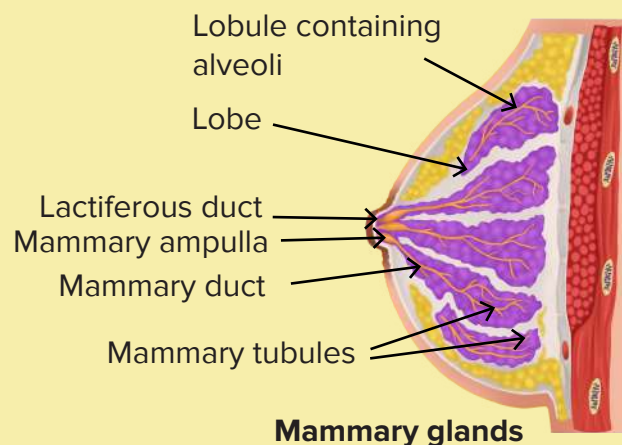
### Mammary glands

These are rounded structures present on the pectoralis major muscle on the wall of the chest.

#### External structure of breast

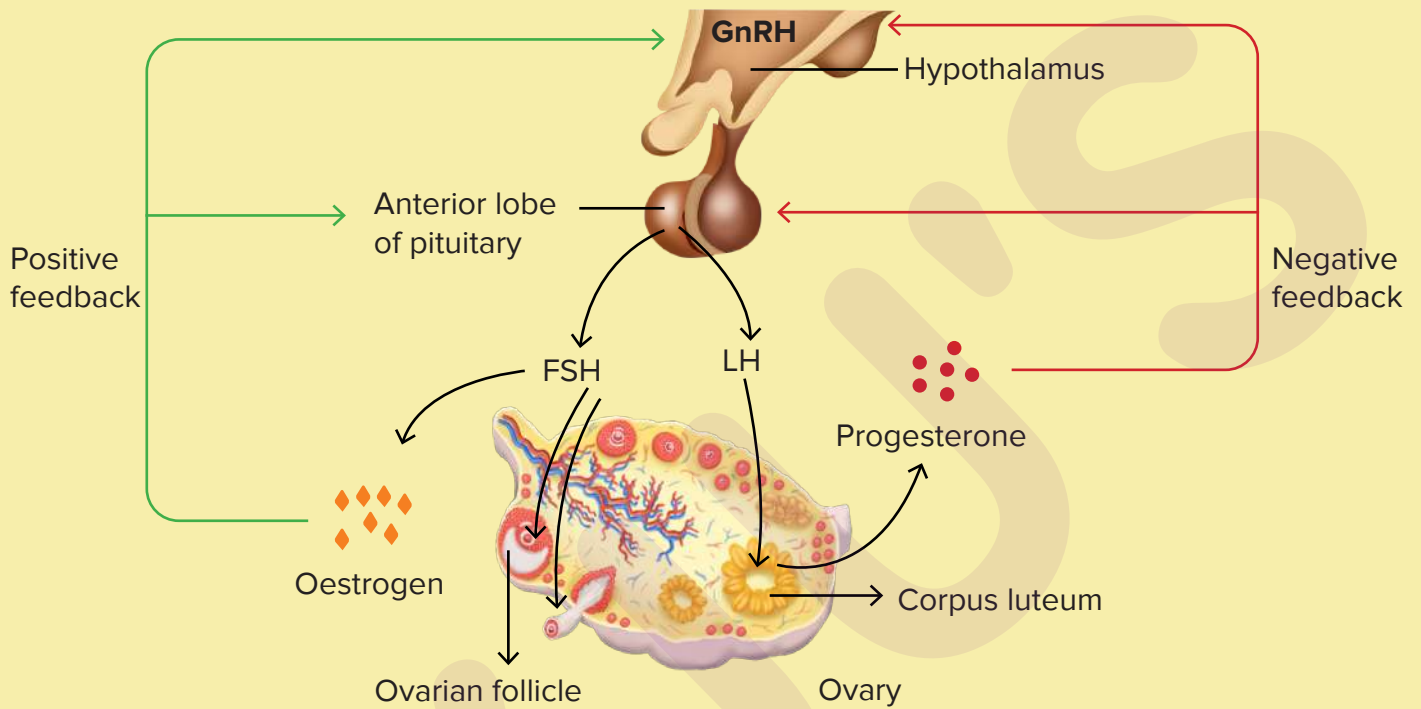


#### Internal structure of breast



## Hormonal regulation

It begins at the time of puberty and is mediated by the hypothalamus, anterior lobe of the pituitary gland, and ovaries.



# HUMAN REPRODUCTION

SPERMATOGENESIS, HORMONAL CONTROL IN MALES, STRUCTURE OF SPERM, OOGENESIS

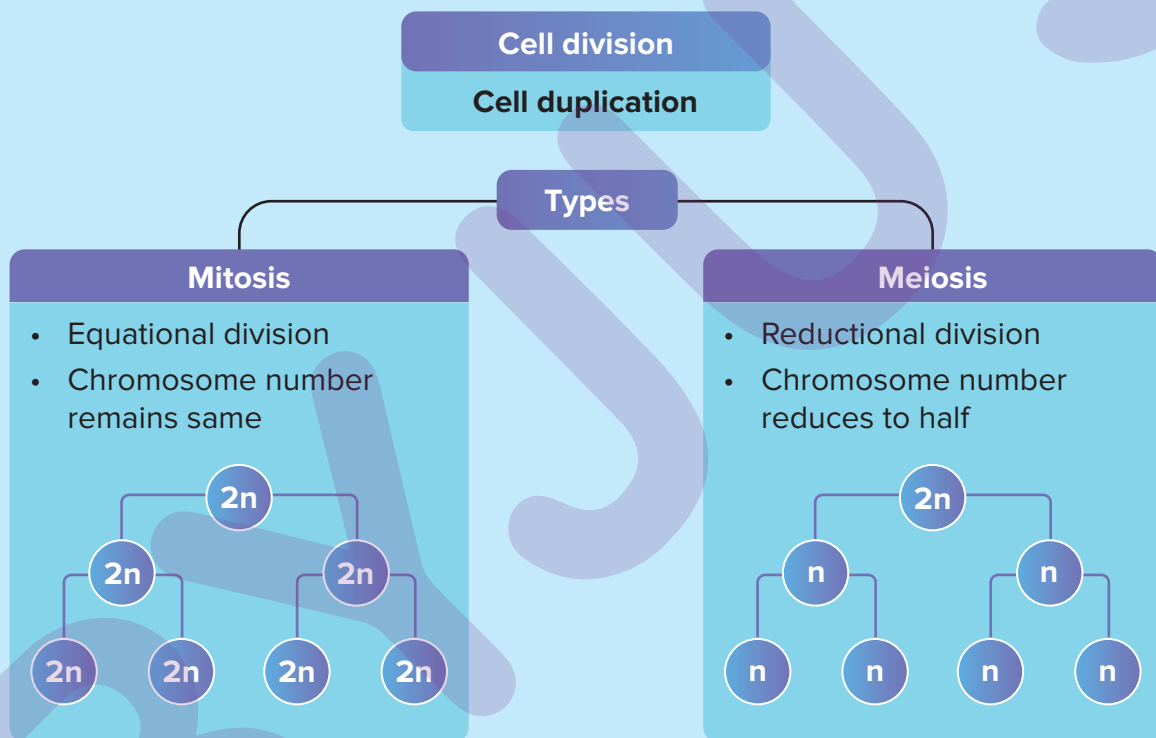


## Key Takeaways

- Spermatogenesis
- Hormonal control in males
- Sperm
  - Structure
- Oogenesis
- Spermatogenesis vs oogenesis

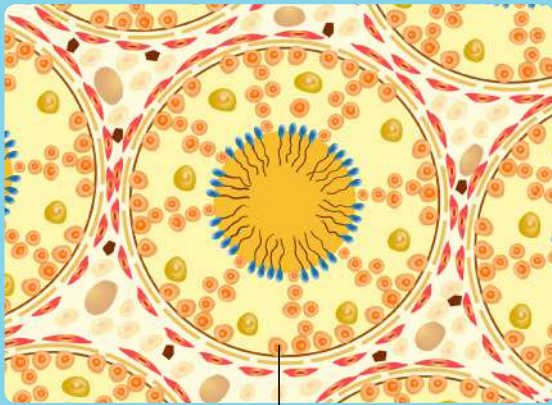


## Prerequisites



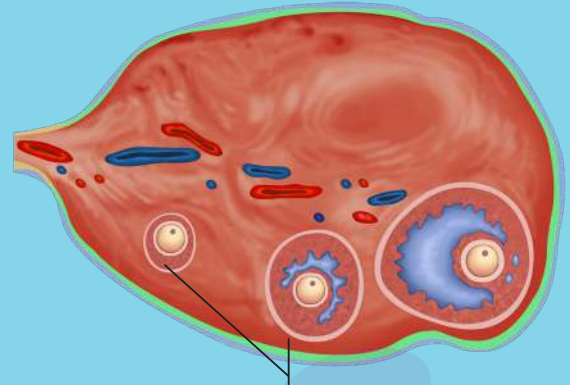


### Germ cells



#### Male germ cells

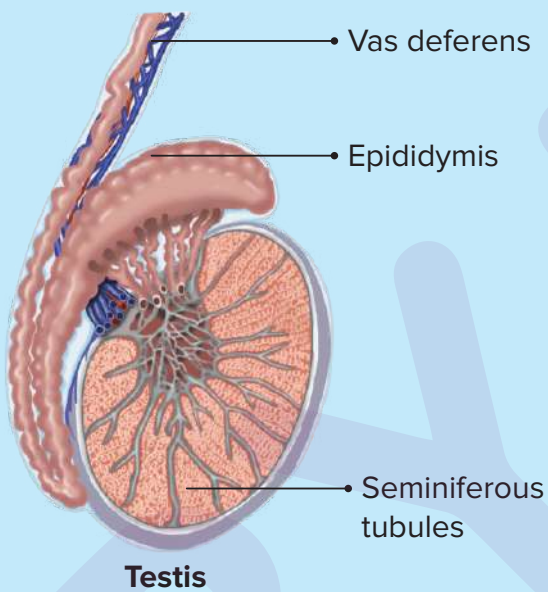
Produce male gametes



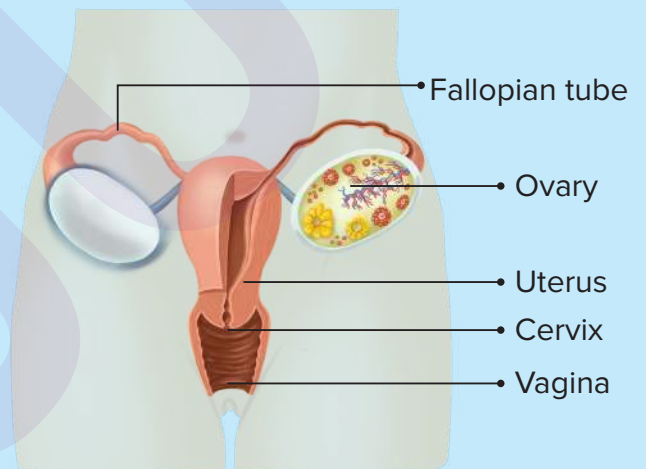
#### Female germ cells

Produce female gametes

### Male reproductive system

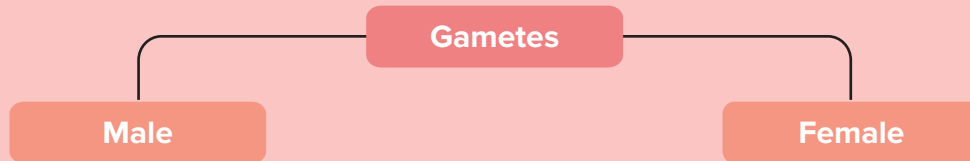


### Female reproductive system



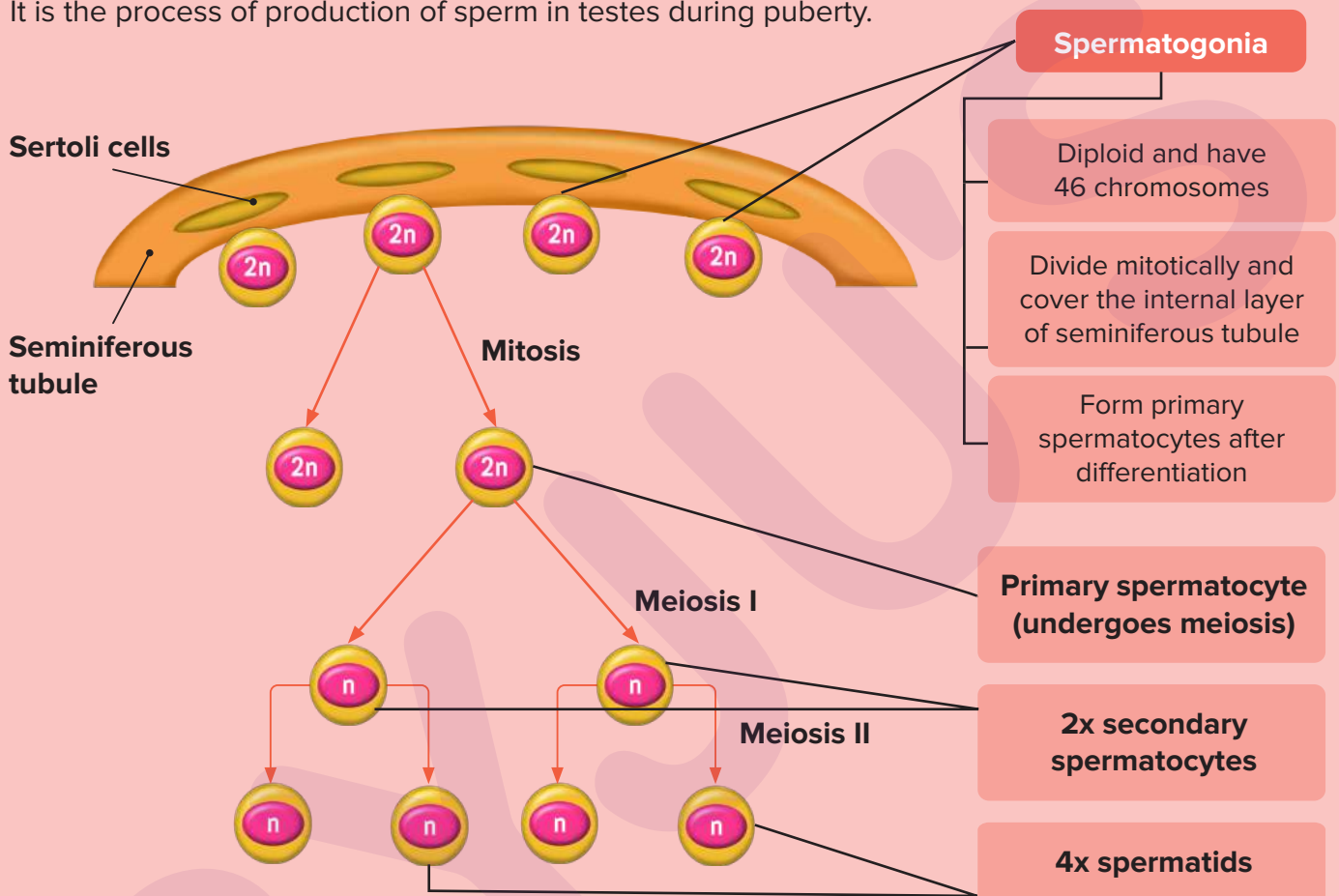
## Gametogenesis

- It is the process of production of male and female sex cells, which are necessary for the development of new offspring.



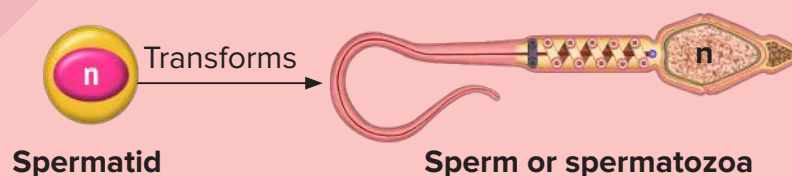
## Spermatogenesis

It is the process of production of sperm in testes during puberty.



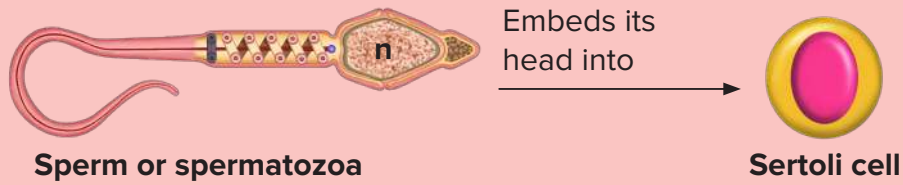
## Spermiogenesis

- It is the process of transformation of **spermatids to spermatozoa**.
- Spermatids undergo maturation which involves **addition of tail** and **development of swimming capabilities** along with other characteristic features of a sperm.



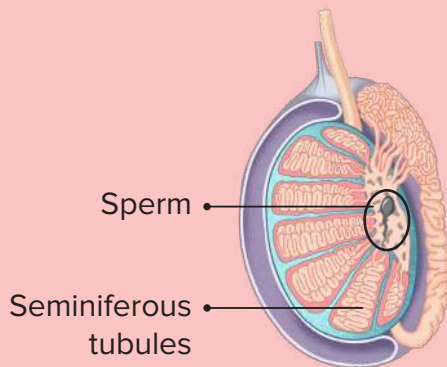
## Spermiation

- After spermiogenesis, sperm heads become **embedded in the Sertoli cells**, and are finally released from the seminiferous tubules by the process called spermiation.

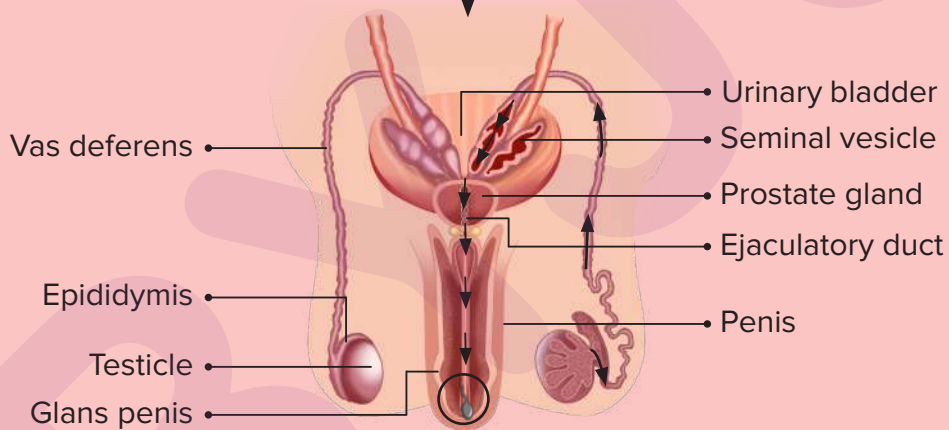


## Sperm Movement

### Spermiation: Release of sperm from seminiferous tubule



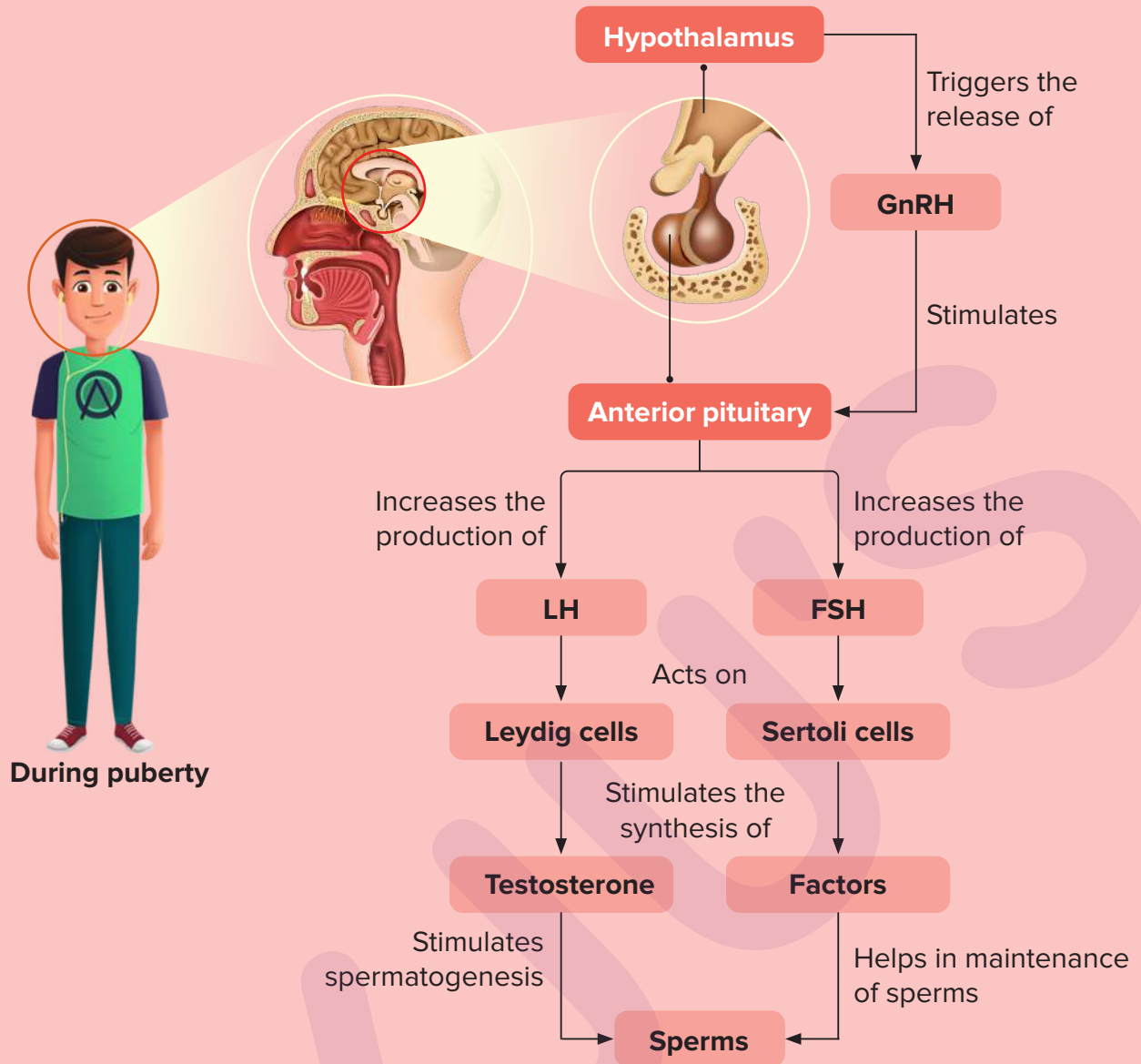
### Movement of sperm from epididymis to accessory ducts



Various secretions from bulbourethral glands, seminal vesicles, and prostate gland are essential for the maturation of sperms and their motility.

→ Indicates journey of sperm

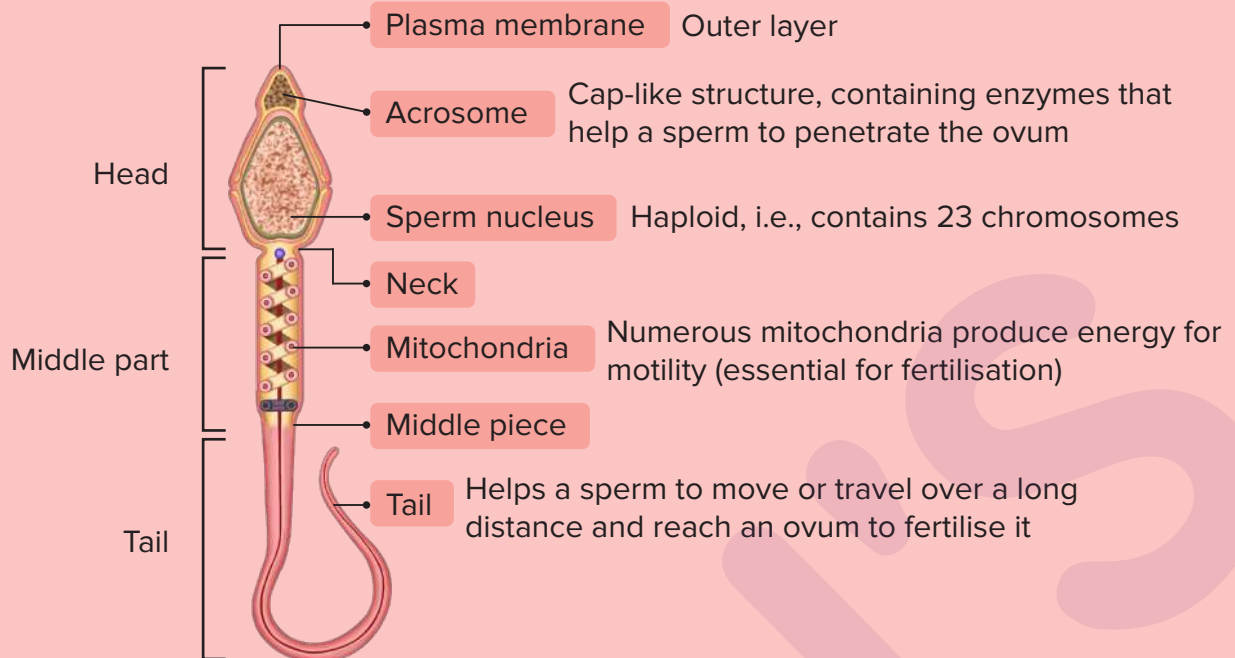
## Hormonal Control in Males



- **GnRH:** Gonadotropin releasing hormone
- **LH:** Luteinising hormone
- **FSH:** Follicle stimulating hormone

## Sperm

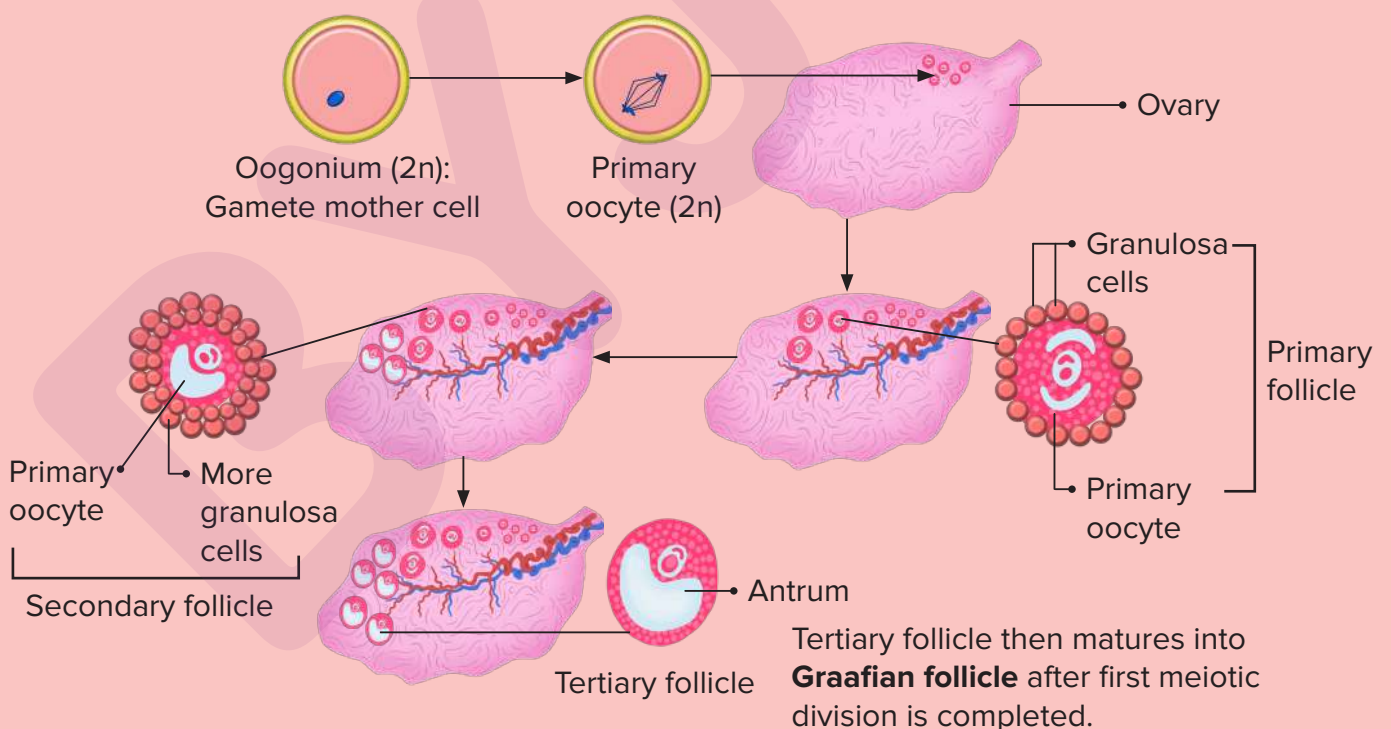
A human male ejaculates approximately **200–300 million sperms**, out of which at least 60% sperms must have normal size and shape, and at least 40% of them must show vigorous motility.



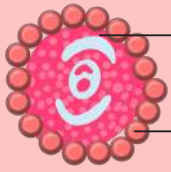
Structure of sperm

## Oogenesis

- It is the process of **formation of mature female gametes** during puberty.



### Points to remember



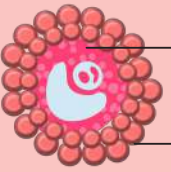
**Primary oocyte**

Present in the ovary during the embryonic stage itself

**Granulosa cells**

Guide and protect the developing oocyte

**Primary follicle**



**Primary oocyte**

More layers of granulosa cells are formed around the secondary follicle.

**Granulosa cells**

**Secondary follicle**



**Primary oocyte**

**Antrum**

The **fluid-filled cavity**, known as antrum, signifies the transformation of secondary follicles into tertiary follicles.

**Tertiary follicle**



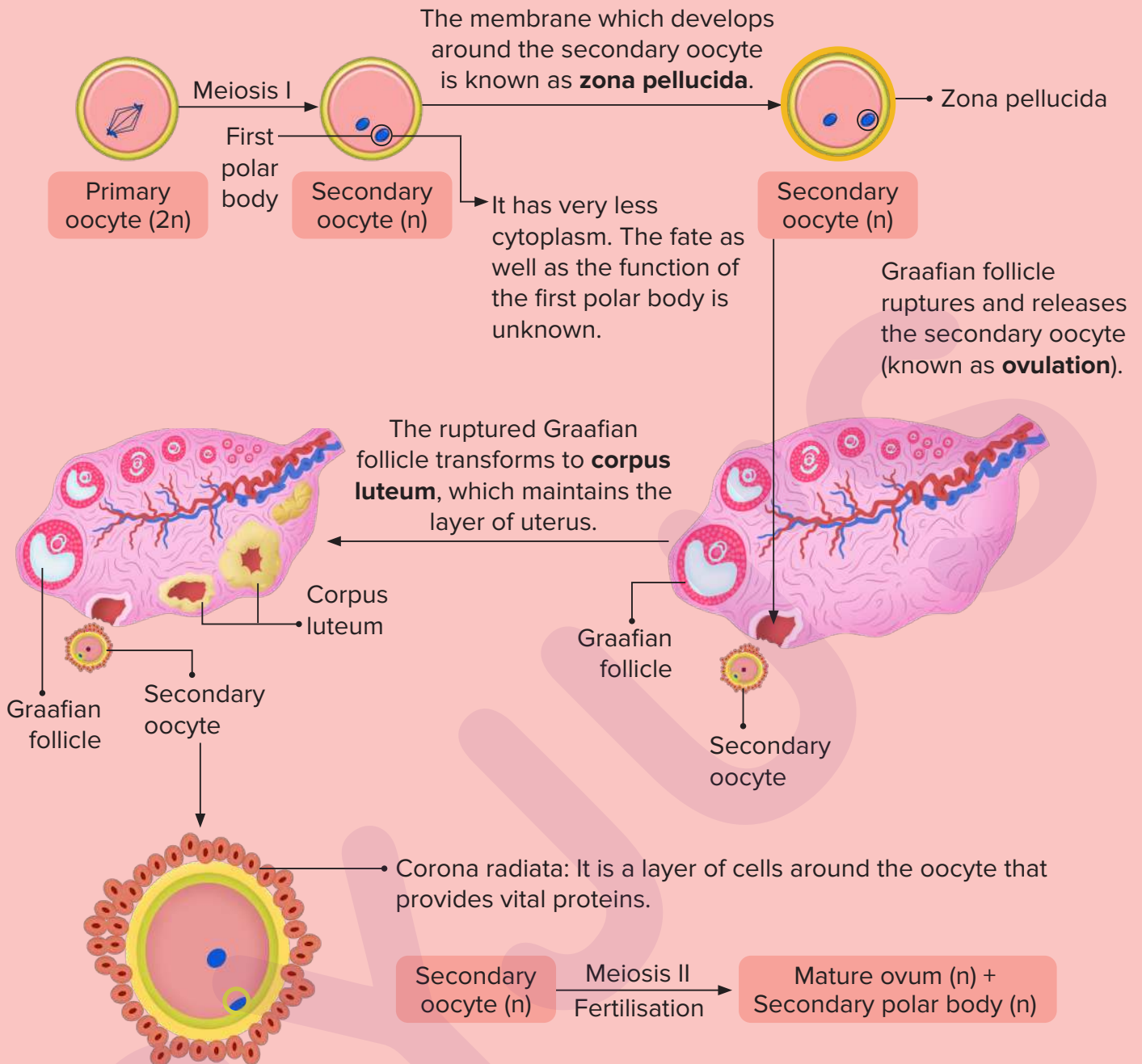
### Did you know?

#### Ova development in embryo





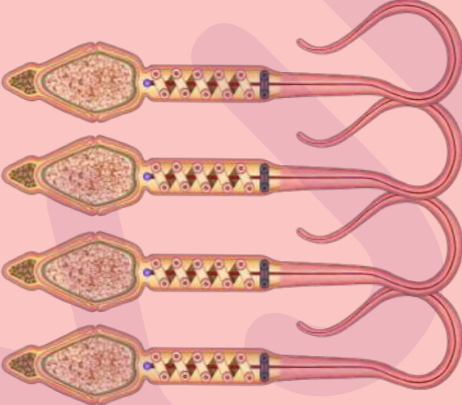
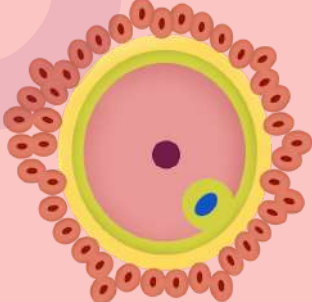
- Oogenesis starts during embryonic stage.
- Millions of gamete mother cells are formed in each ovary by mitosis.
- No more oogonia are formed or added after birth.
- It means that a baby girl already has all the cells that will become ova before she comes out of the womb.

## Events leading to ovulation



- Primary oocyte is **arrested at the Prophase I** stage of meiosis during the embryonic stage.
- At puberty, the primary oocyte in the tertiary follicle grows in size to become Graafian follicle and completes its first meiotic division.

## Spermatogenesis vs Oogenesis

Category	Spermatogenesis	Oogenesis
Gamete formation begins	<p>Occurs at puberty</p> 	<p>Begins at embryonic stage and completes at puberty</p> 
Number of gametes released	<p>Millions of sex cells, i.e., sperms are formed at a time</p> 	<p>Only one sex cell, i.e., ovum is formed at a time</p> 
Number of stages	<p>It has five stages.</p> <p><b>Spermatogonia</b></p> <p>↓</p> <p><b>Primary spermatocyte</b></p> <p>↓</p> <p><b>Secondary spermatocyte</b></p> <p>↓</p> <p><b>Spermatids</b></p> <p>↓</p> <p><b>Spermatozoa</b></p>	<p>It has four stages.</p> <p><b>Oogonia</b></p> <p>↓</p> <p><b>Primary oocyte</b></p> <p>↓</p> <p><b>Secondary oocyte</b></p> <p>↓</p> <p><b>Ovum</b></p>



<p><b>Meiosis results in</b></p>	<p>Equal cells (spermatids)</p>	<p>Unequal cells- small polar bodies, and one large ovum</p>
<p><b>Type of cell division</b></p>	<p>Both the types of gametes are formed by meiosis.</p>	
<p><b>Initiation of gamete release</b></p>	<p>The release of both the types of gametes begin from puberty</p>	



**Summary Sheet**

**Gametogenesis**

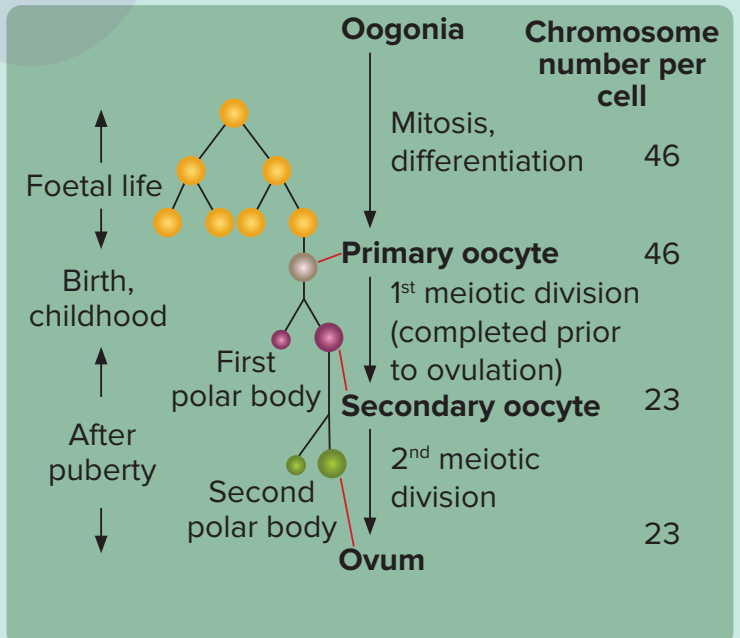
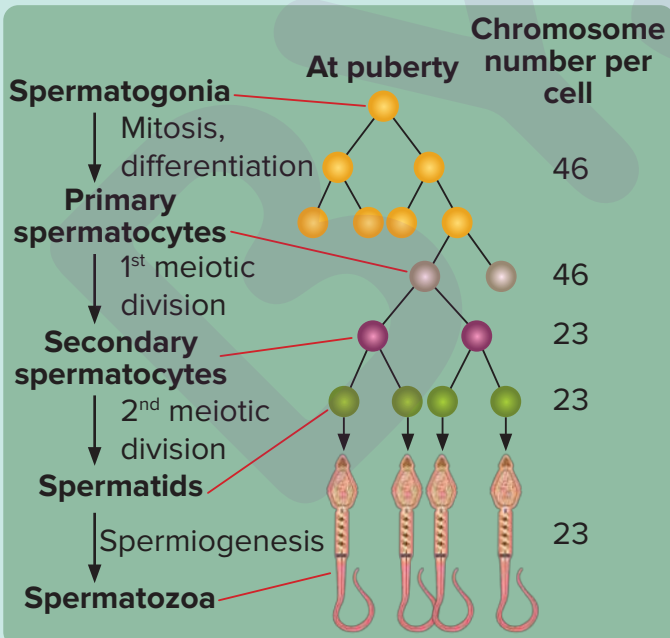
It is the process of production of male and female gametes necessary for the development of offspring.

**Spermatogenesis**

It is the process of production of sperms in testes during puberty.

**Oogenesis**

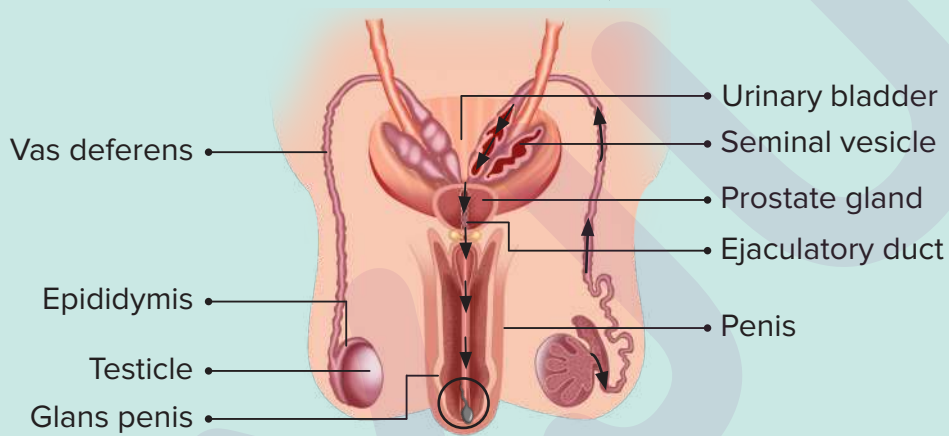
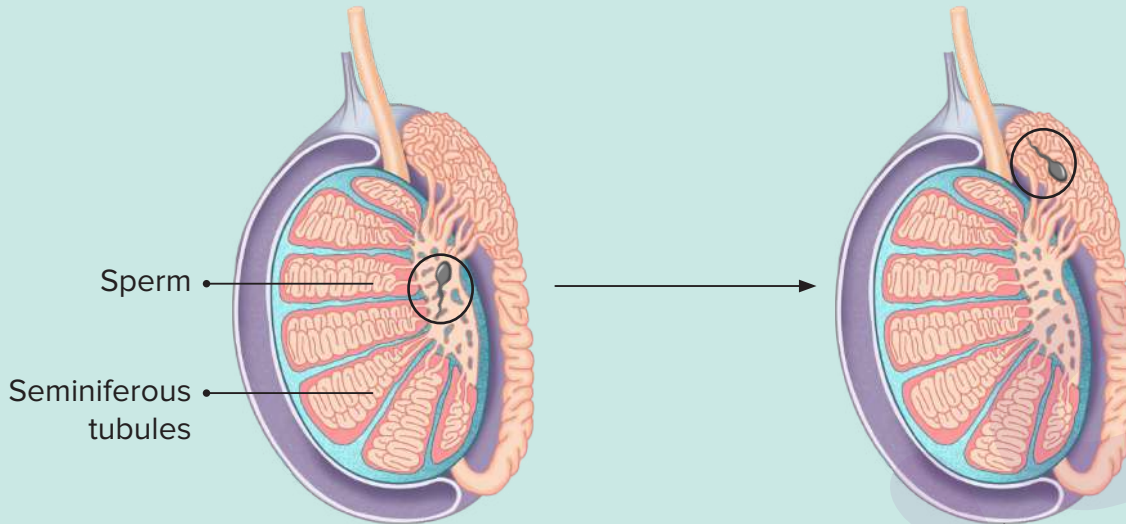
It is the process of formation of mature female gamete during puberty.



## Sperm movement

**Spermiation: Release of sperm from seminiferous tubule**

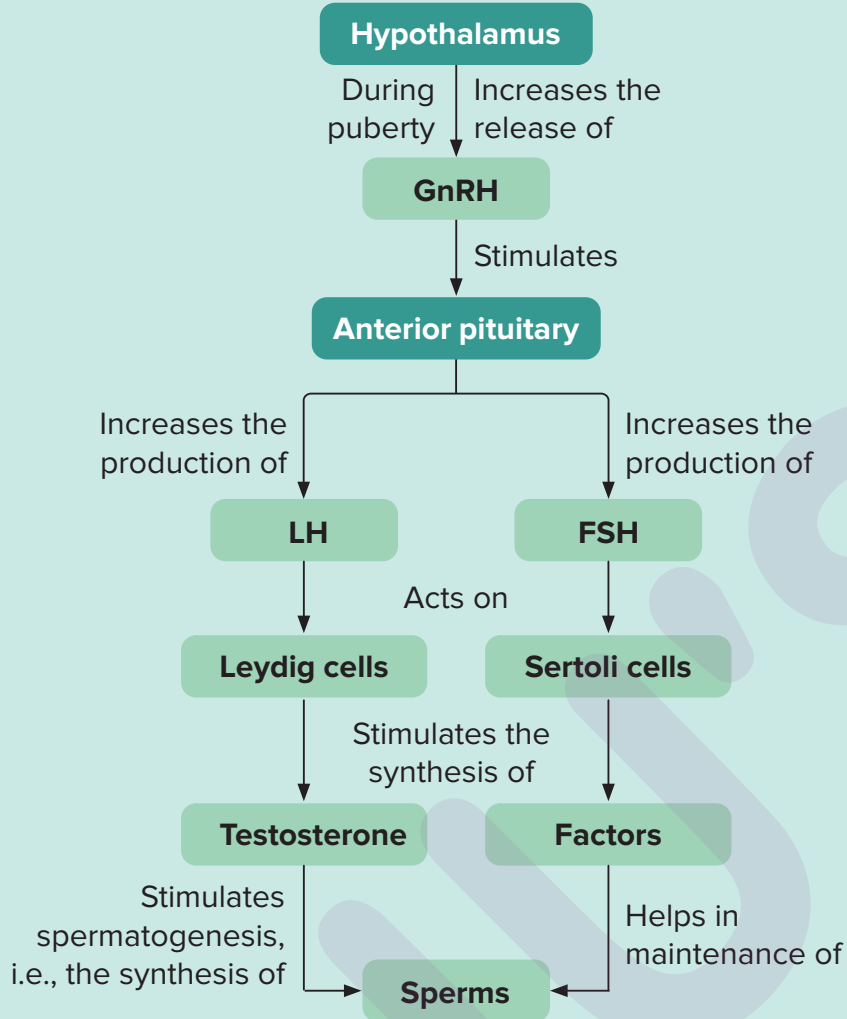
**Movement of sperm from epididymis to accessory ducts**



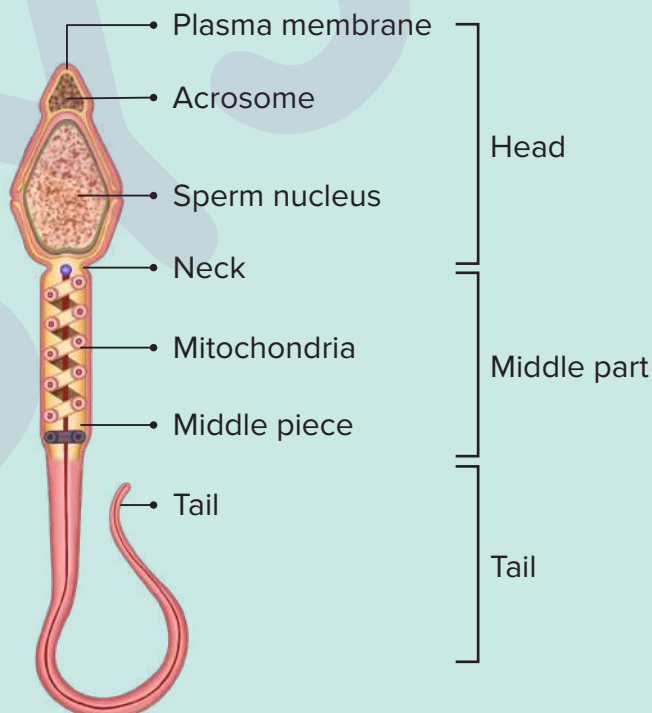
Various secretions from bulbourethral glands, seminal vesicles, and prostate gland are essential for the maturation of sperms and their motility.

→ Indicates journey of sperm

### Hormonal control in males



### Structure of sperm



# HUMAN REPRODUCTION

## EVENTS OF FERTILISATION, IMPLANTATION AND GENDER OF THE BABY



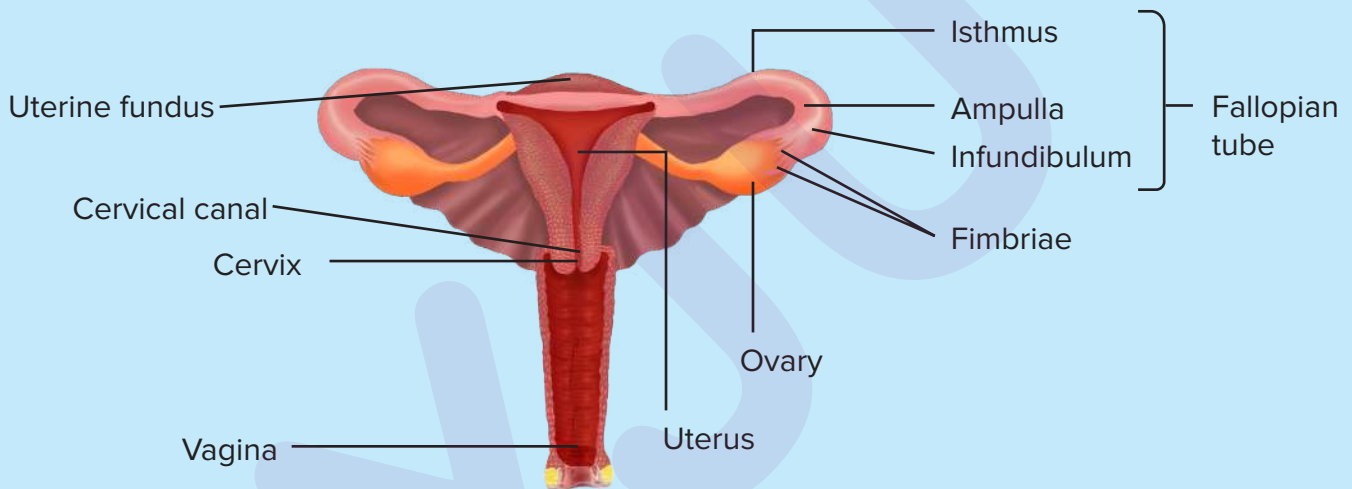
### Key Takeaways

- Journey of male and female gametes
- Implantation
- Steps of fusion of gametes
- Gender of the baby

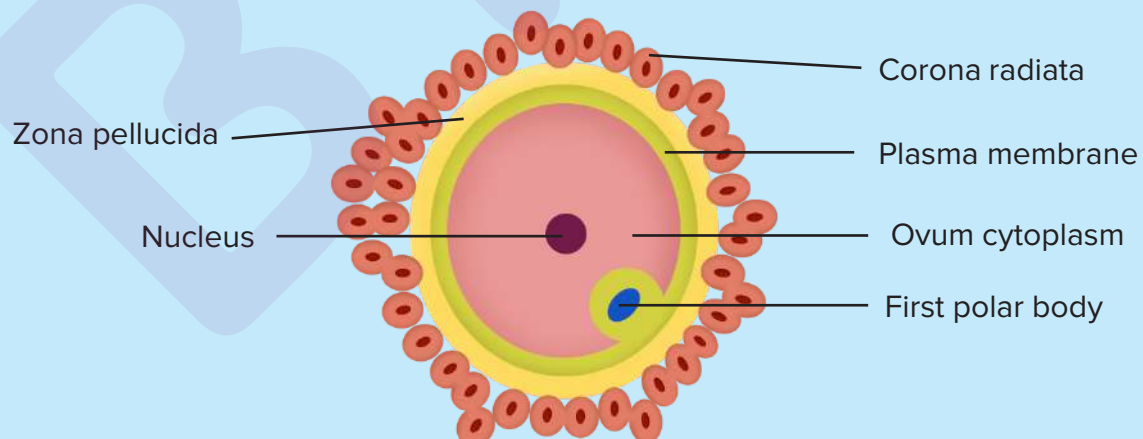


### Prerequisites

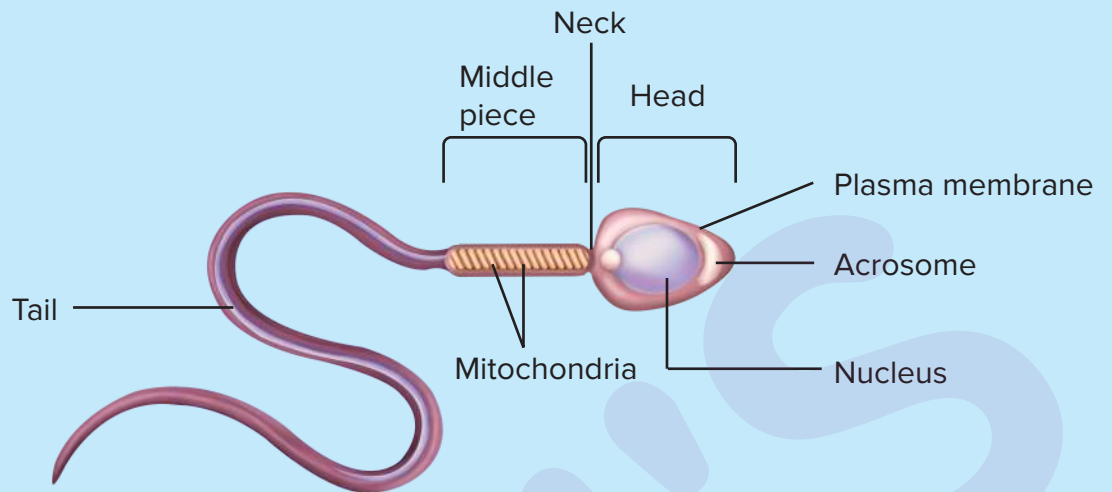
- **Female reproductive system**



- **Secondary oocyte**

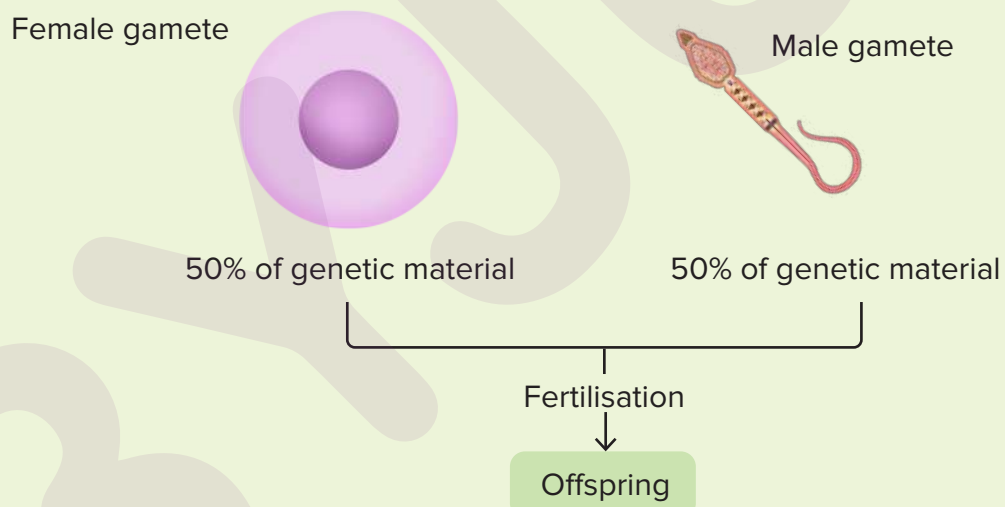


- **Human sperm**



### Fertilisation

- It is the fusion of male and female gametes to produce a new organism.



- For fertilisation to occur, male and female gametes must meet at some point, and then undergo fusion. Fertilisation has three events.

### Events of fertilisation

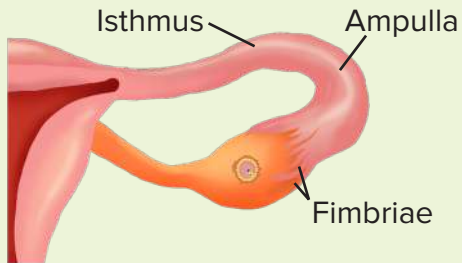
Journey of ovum

Journey of sperm

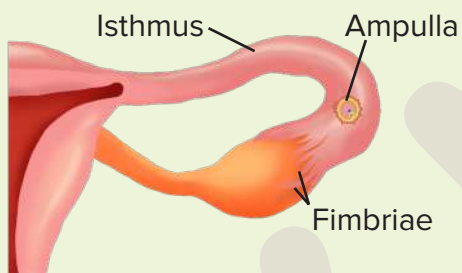
Fusion of sperm and ovum

## Journey of Male and Female Gametes

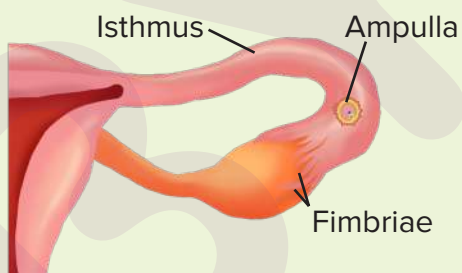
### Journey of ovum



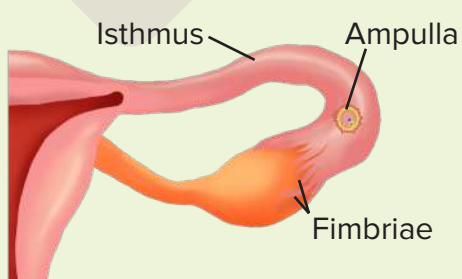
By ovulation, the fimbriae of the fallopian tube would have moved closer to the ovary. Fimbriae sweep over its surface, and the **finger-like projections** direct the ovum into the fallopian tube.



Once inside the fallopian tube, the **ciliated cells** of the fallopian tube transport the secondary oocyte further.



With the help of cilia, the secondary oocyte moves forward to reach the **ampulla region**.



Here, the secondary oocyte **awaits sperm** for fusion.

### Journey of sperm

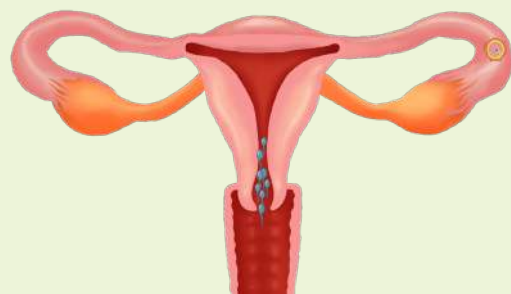
- **Erection:** This is copulation's first step.
- Blood rushes into sinuses and the penis becomes stiff and erect.
- Penis is then inserted into the female vagina.



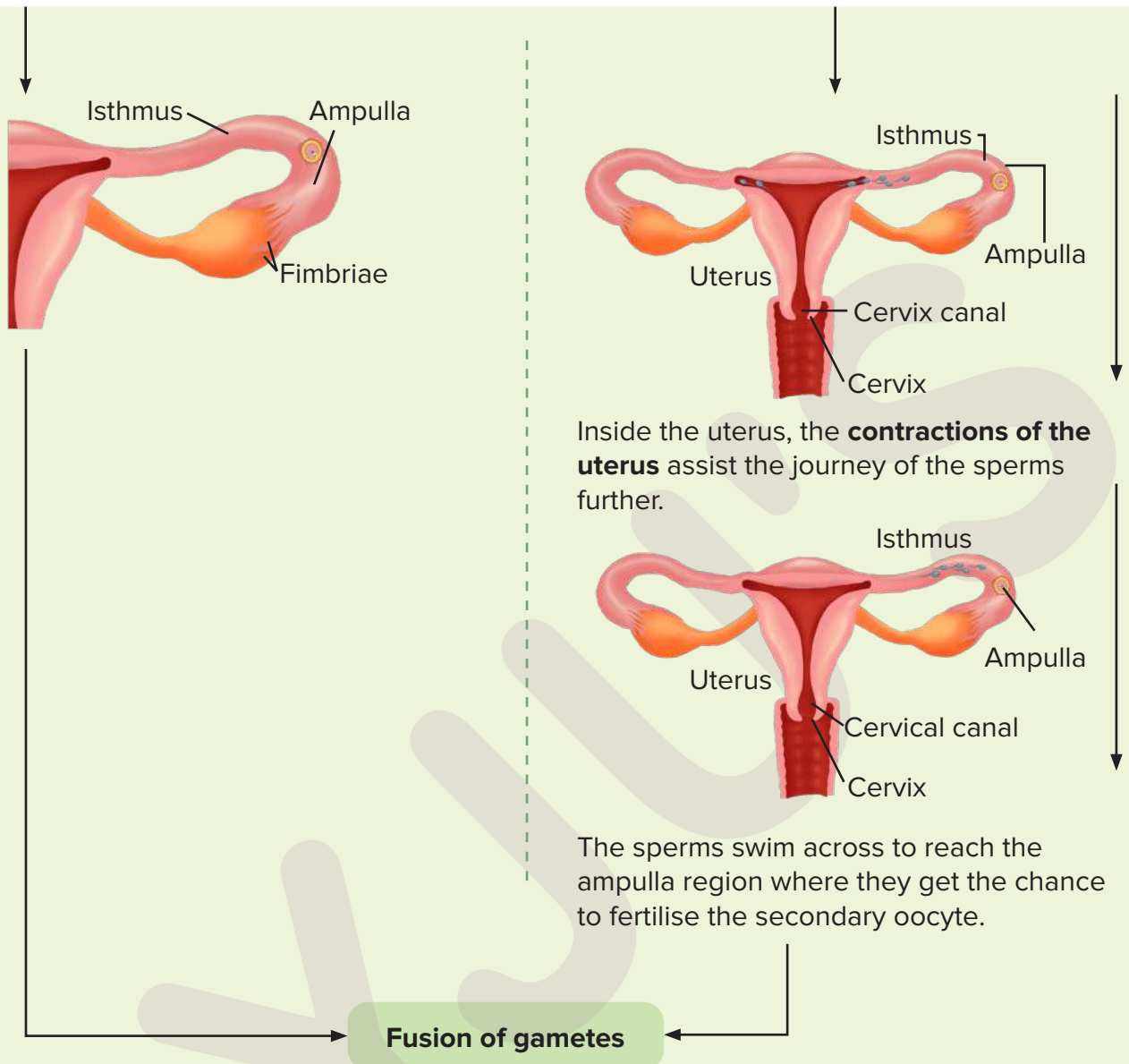
- **Stimulation:** The insertion of the penis inside the vagina causes stimulation.
- At the peak of sexual stimulation, a sensation known as **orgasm** occurs. This is required for ejaculation to occur.
- Stimulation helps in releasing **lubricating fluid** from both the penis and vagina.



- **Ejaculation:** Following stimulation, sperms are ejaculated. The penis discharges the sperm by wave-like contractions.
- During insemination, millions of sperms are deposited in the vagina.
- These motile sperms swim rapidly inside the vagina.



- Sperms pass through the cervix and enter the cervical canal.
- A number of these sperms die in the acidic environment of the vagina.
- However, many survive due to the protective elements provided in the semen.
- The sperms then swim through the **cervical canal**, towards the **uterus**, and then on to the **fallopian tubes**.



- It occurs in the region of the **ampulla**.
- The first sperm that reaches the ovum has the highest chances of fusing with it.
- Among the many sperms that reach the ovum, **one of the sperms** passes between the cells of the corona radiata to reach the zona pellucida layer.
- Once the sperm reaches zona pellucida, it binds to a receptor on the zona pellucida and initiates the acrosomal reaction.

### Steps of Fusion of Gametes

The hydrolytic/digestive enzymes released due to acrosomal reaction degrade the zona pellucida. This enables the sperm to penetrate the zona pellucida layer and plasma membrane of the ovum.

The ovum releases certain chemicals when a sperm enters its cytoplasm

These chemicals block the receptors on zona pellucida of the ovum, thereby blocking the entry of other sperms. This is known as **zona reaction**.

The nucleus of sperm is released into the cytoplasm of the ovum leaving behind the middle piece and tail of the sperm. The nucleus of the sperm is now termed as the **male pronucleus**.

Entry of the sperm activates the ovum. Release of sperm nucleus induces the **completion of second meiotic division** of the secondary oocyte.

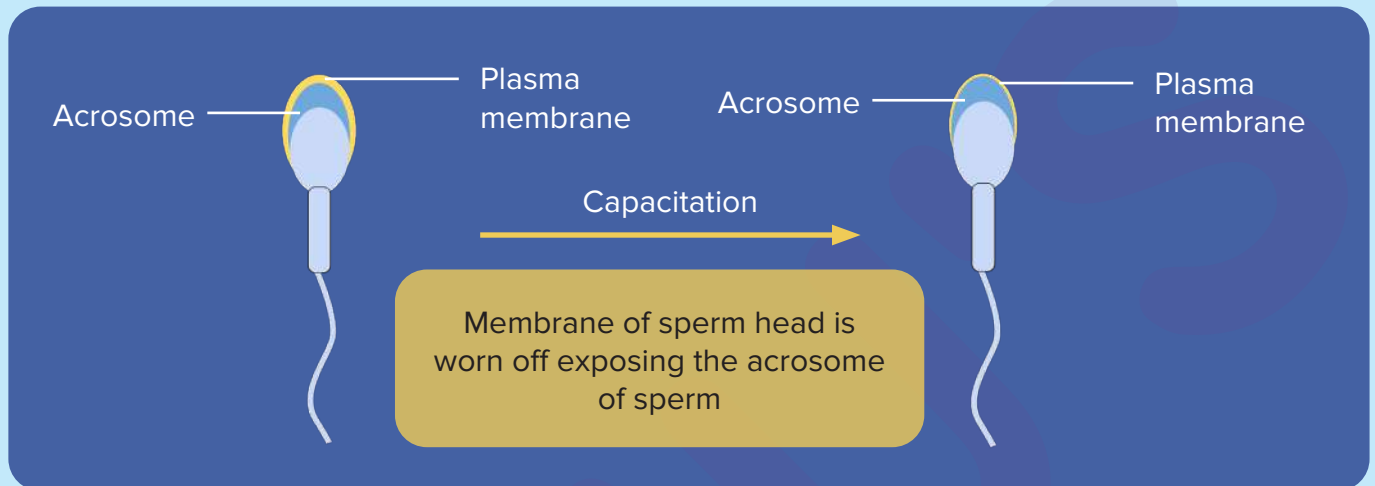
The second meiotic division results in the formation of a **second polar body** and a haploid ovum (ootid).

Soon the haploid nucleus of the sperm and that of the ovum fuse together to form a **diploid zygote**.



## Capacitation

- **Capacitation** is the modification in a sperm which **increases its ability to penetrate and fertilise the ovum**.
- A large number of **calcium ions are pumped into sperms** by the viscous fluid of the glands present in the fallopian tube. These help to increase sperm-tail mobility in a whip-like movement.

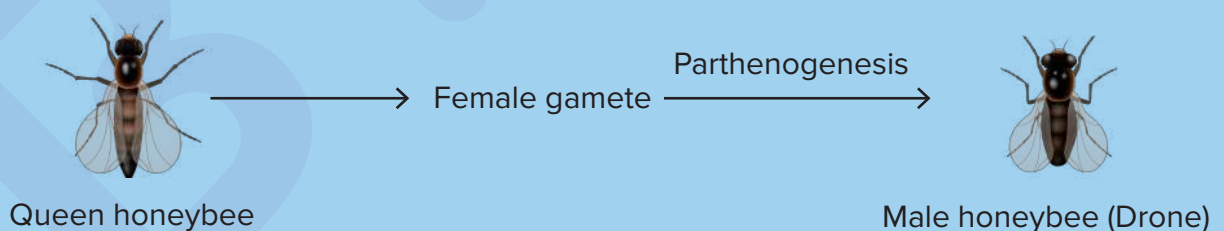


- During capacitation, the medium inside the uterus wears off the plasma membrane of the sperm head. This exposes the contents of the acrosome of the sperm (for example, hyaluronidase), making it highly penetrable.
- Thus, sperms which have reached the uterus have a higher probability of fertilising the ovum.

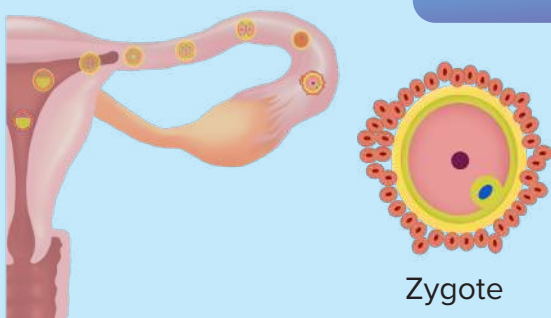


### Did you know?

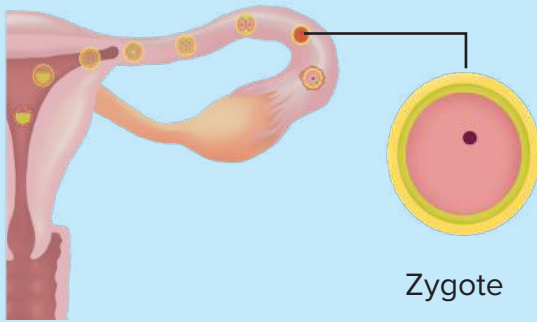
- Male honeybees develop through a process called parthenogenesis.
- Parthenogenesis is a reproductive process that involves development of a female gamete into new organism without fertilisation.



## Events Leading to Implantation

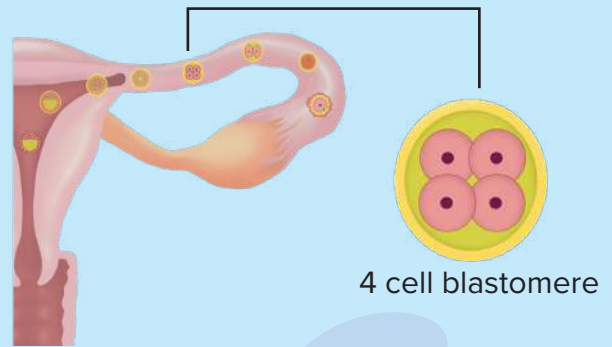


Implantation is the process by which an **embryo attaches** to the endometrial surface of the **uterus**.



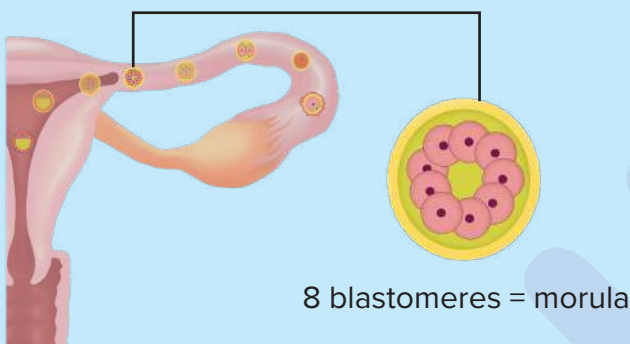
### Day 1 of fertilisation:

On day 1, the zygote starts moving towards the isthmus and initiates the mitotic division.



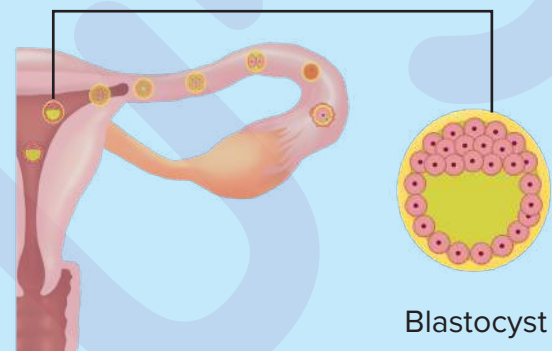
### Day 3 of fertilisation:

On day 3, the zygote undergoes second mitosis to form **4-celled blastomeres**.



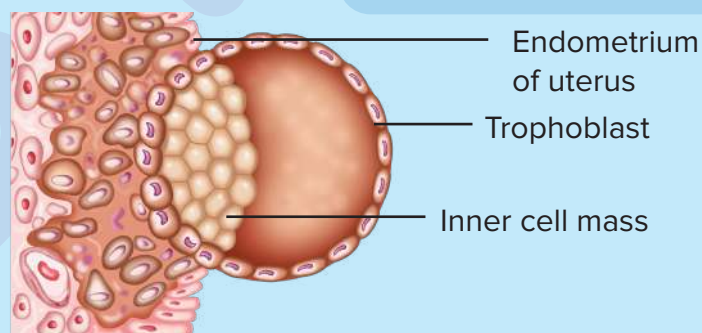
### Day 4 of fertilisation:

- On day 4, third mitosis is completed and an 8-celled blastomere is formed.
- The embryo with **8-16 blastomeres** is also known as **morula**.



### Day 6-7 of fertilisation:

- The morula continues to divide and transforms into a blastocyst, as it moves further into the uterus. On days 6-7, early blastocyst is formed.
- Some of the cells are arranged into an outer layer known as **trophoblast**. Some cells form the **inner cell mass**.

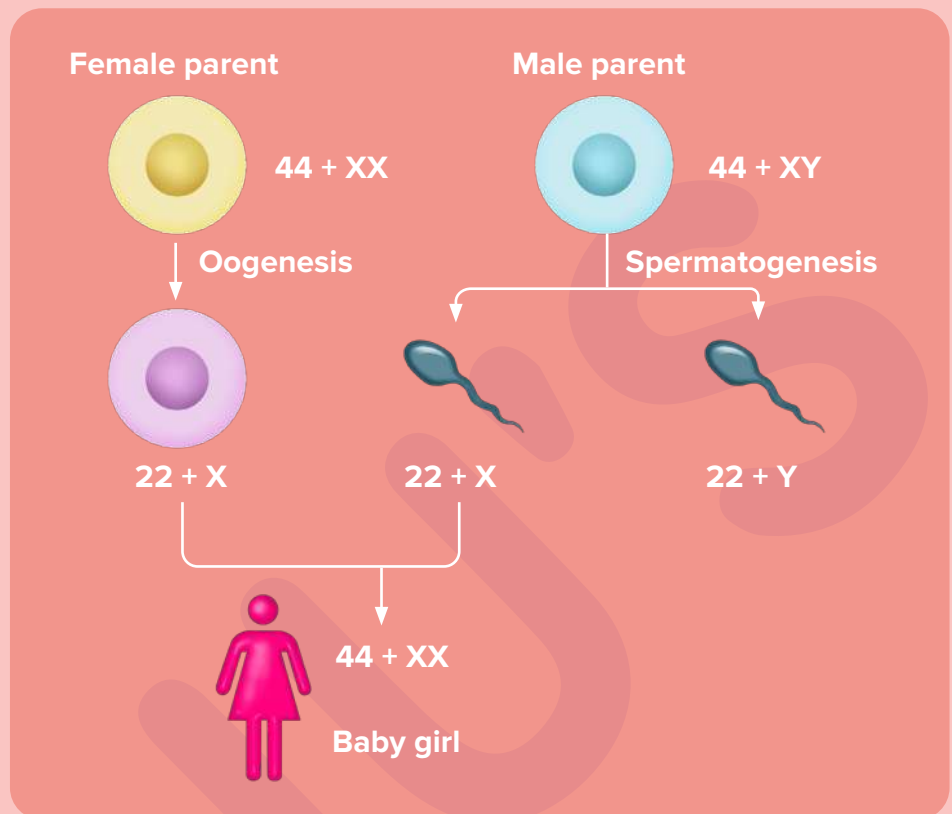


### Day 8-9 of fertilisation:

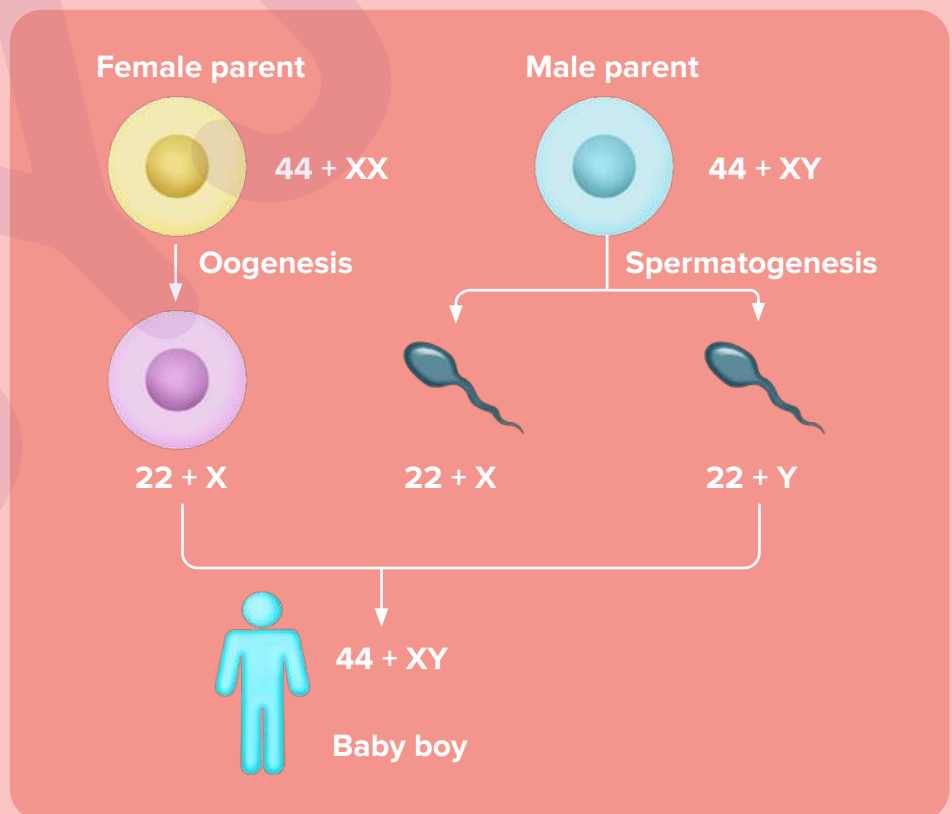
- The blastocyst comes in contact with the uterine wall.
- During implantation, the endometrium of the uterus thickens to support the implantation.
- The trophoblast layer then gets attached to the endometrium and the inner cell mass differentiates to form the embryo.
- After attachment of blastocyst, the uterine cells divide rapidly and cover the blastocyst. On the 11<sup>th</sup> day of fertilisation, the blastocyst becomes fully embedded in the endometrium of the uterus.

## Gender of the Baby

- When the ovum ( $22 + X$ ) fuses with sperm having  $22 + X$  chromosomes, it results in a zygote having  **$44 + XX$**  chromosomes. This results in the birth of a **baby girl**.



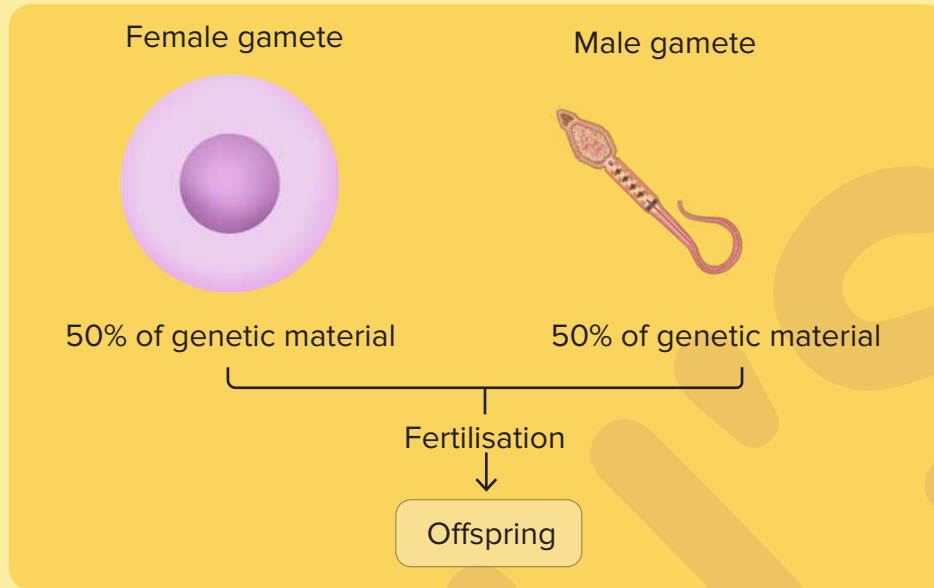
- When the ovum ( $22 + X$ ) fuses with the sperm having  $22 + Y$  chromosomes, it results in a zygote having  **$44 + XY$**  chromosomes. This results in the birth of a **baby boy**.



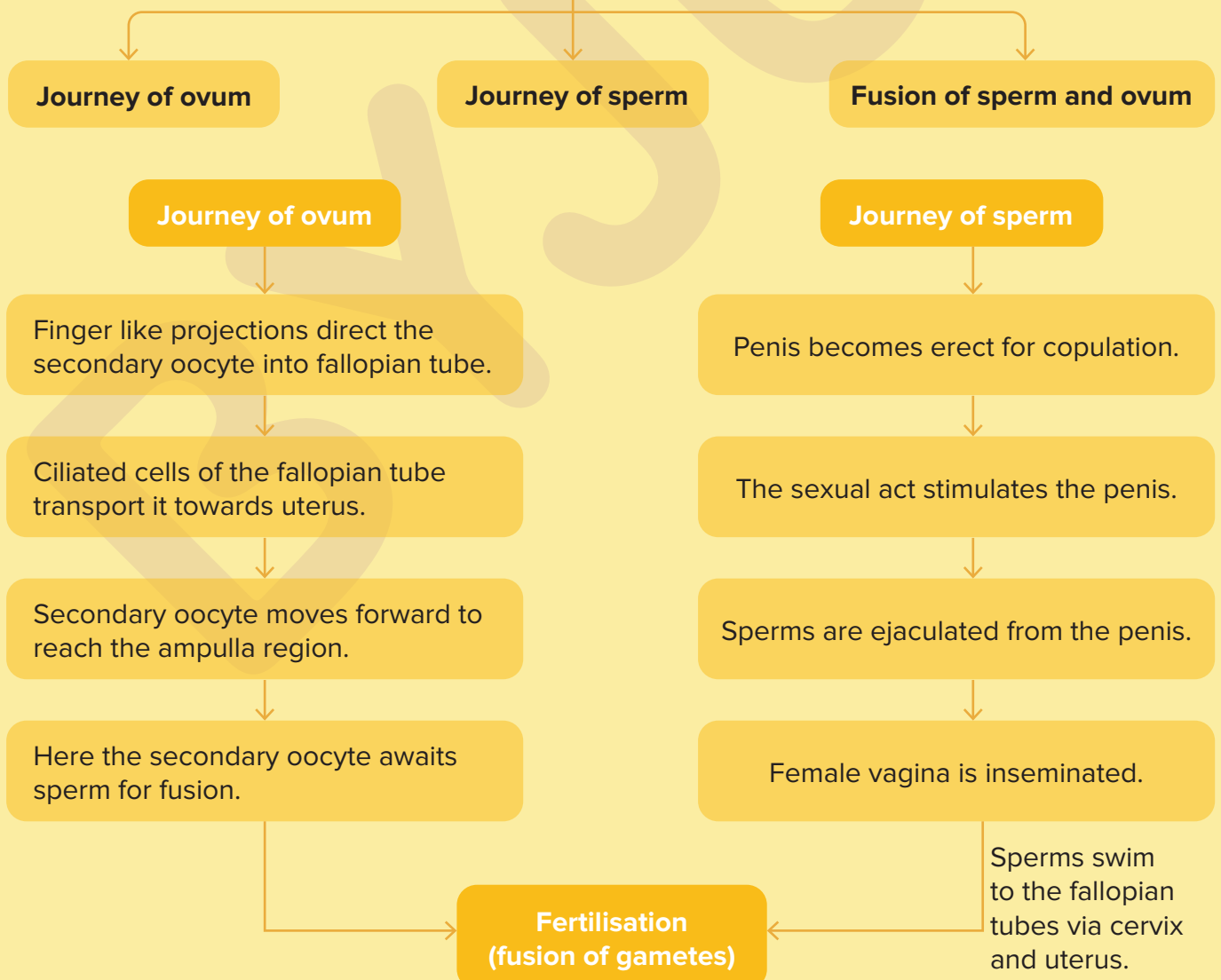
- Hence, the gender of the baby is determined by the father and not by the mother.



## Summary Sheet



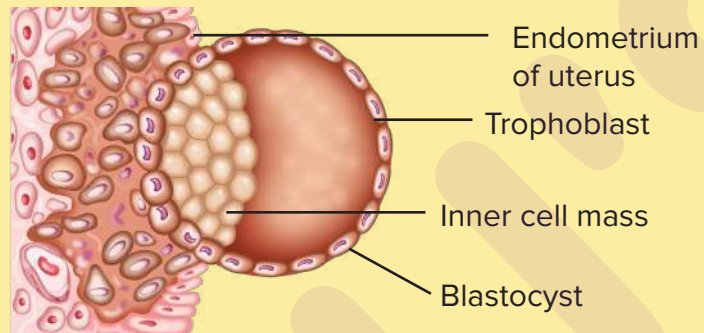
### Events of fertilisation



- After deposition of sperms in the female's vaginal tract, it undergoes certain changes known as **capacitation**.
- The haploid nucleus of the sperm, and that of the ovum fuse together to form a **diploid zygote**.

### Implantation

- It is the process by which **the blastocyst attaches to the endometrium** of uterus.





### Key Takeaways

- Post implantation events
  - » Gastrulation
  - » Formation of placenta
  - » Gestation
  - » Foetal ejection reflex
- Parturition
- Lactation



### Prerequisites

- Steps involved in the formation of the embryo

01

#### **Transfer of gametes**

Ovum and sperms are transported to the ampulla region of the fallopian tube

02

#### **Fertilisation**

Fusion of ovum and sperm to form zygote

03

#### **Development of zygote**

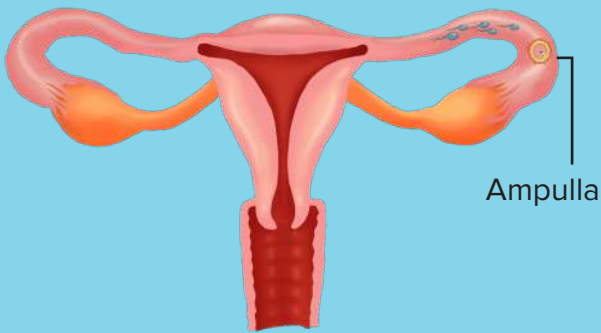
Zygote undergoes cleavage and gives rise to blastocyst

04

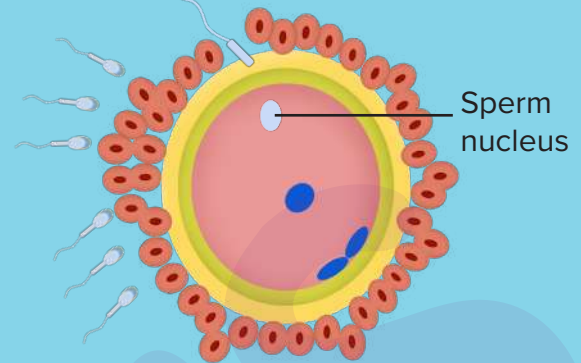
#### **Implantation**

The blastocyst gets embedded in the endometrium of uterus

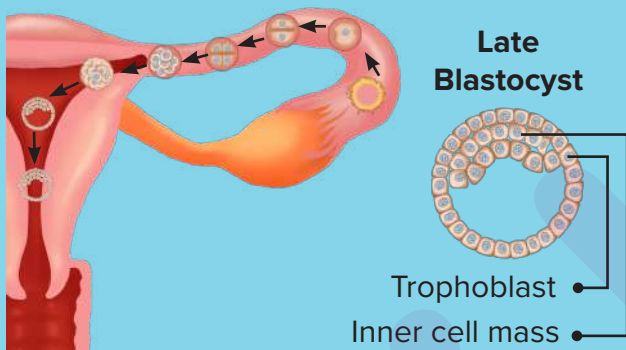
### Transfer of gametes



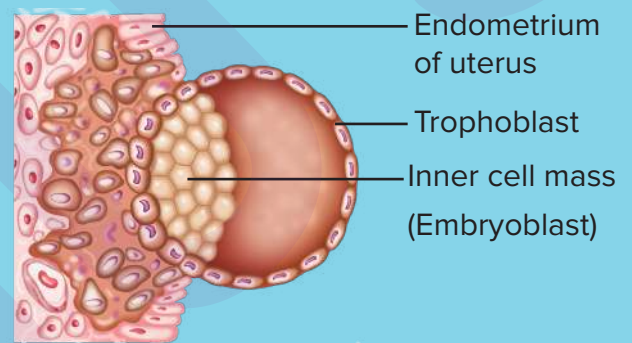
### Fertilisation



### Development of zygote



### Implantation



### Post Implantation Events

- The blastocyst formed after mitotic division of the zygote gets implanted into the endometrium of the uterus.
- Blastocyst has two types of cell layers:
  - » Outer trophoblast
  - » Inner cell mass or embryoblast
- Placenta formation and gastrulation are important processes that follow implantation.

Trophoblast

+

Endometrium



Placenta

Inner cell mass

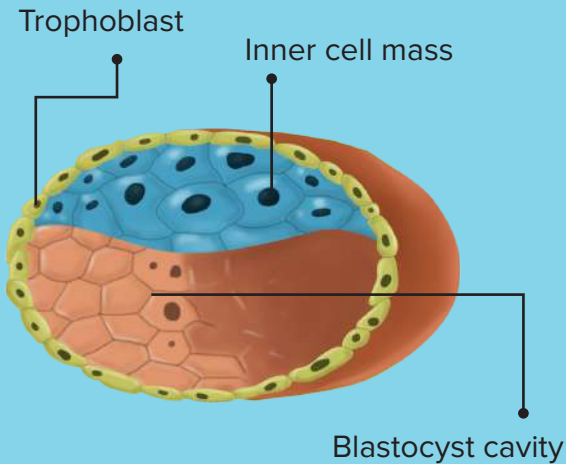
Gastrulation

Germinal layers

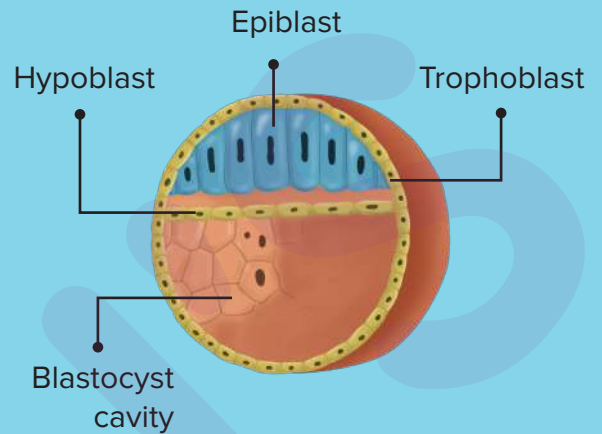
### Gastrulation

The process by which the inner cell mass gives rise to a structure with various **germinal layers** is known as **gastrulation**.

- Gastrulation and formation of placenta takes place simultaneously.
- Gastrulation involves the movement of blastomeres from their original place to the other sites, where they finally settle. These cellular movements are termed as **morphogenetic movements**.

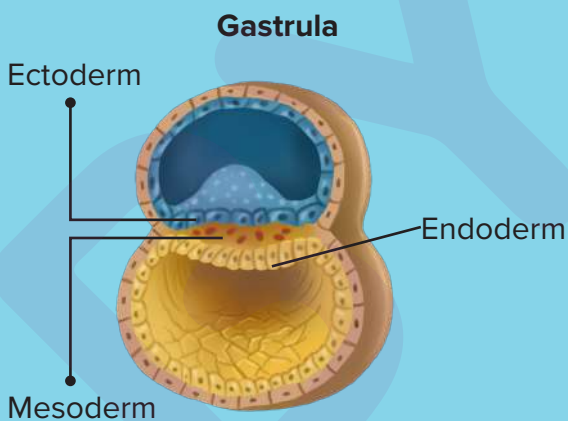


The **blastocysts have inner cell mass**, which help in the structural changes and formation of cylindrical cells.

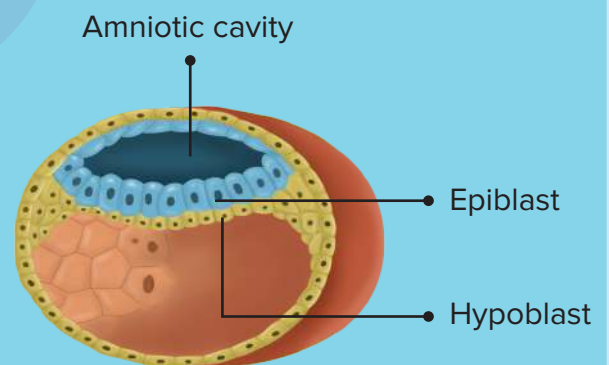


The embryoblast cells start dividing from the bottom and separate from the top. The two types of cells formed are as follows:

- **Epiblast** on the top
- **Hypoblast** in the bottom



- The hypoblast undergoes division and gives rise to the three germinal layers.
  - » **Ectoderm**
  - » **Mesoderm**
  - » **Endoderm**
- The structure thus formed is known as **gastrula**.



- A fluid starts accumulating in between the epiblast, forming a cavity known as the **amniotic cavity**. The fluid is known as **amniotic fluid**.
- The **amniotic fluid** acts as a **shock absorber** and protects the developing foetus.



## Germinal layers

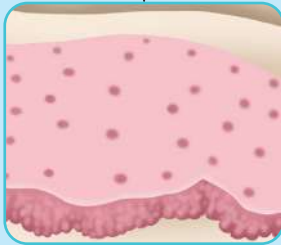
Ectoderm

Mesoderm

Endoderm

- These germinal layers further give rise to various organs and organ systems.

## Ectoderm (external layer)



Skin cells of epidermis

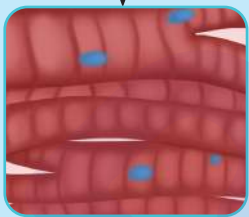


Neurons



Pigment cells

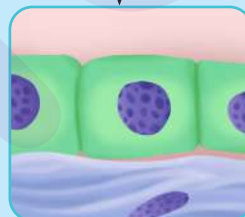
## Mesoderm (middle layer)



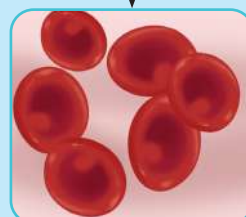
Cardiac muscle cells



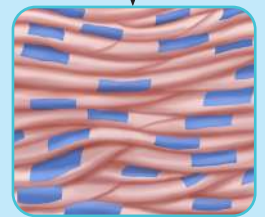
Skeletal muscle cells



Tubule cells of the kidney



Red blood cells

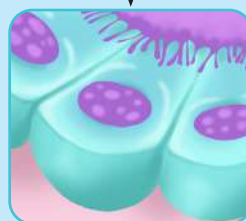


Smooth muscle cells (in gut)

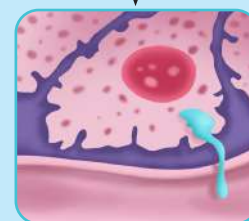
## Endoderm (internal layer)



Lung cell (alveolar cell)



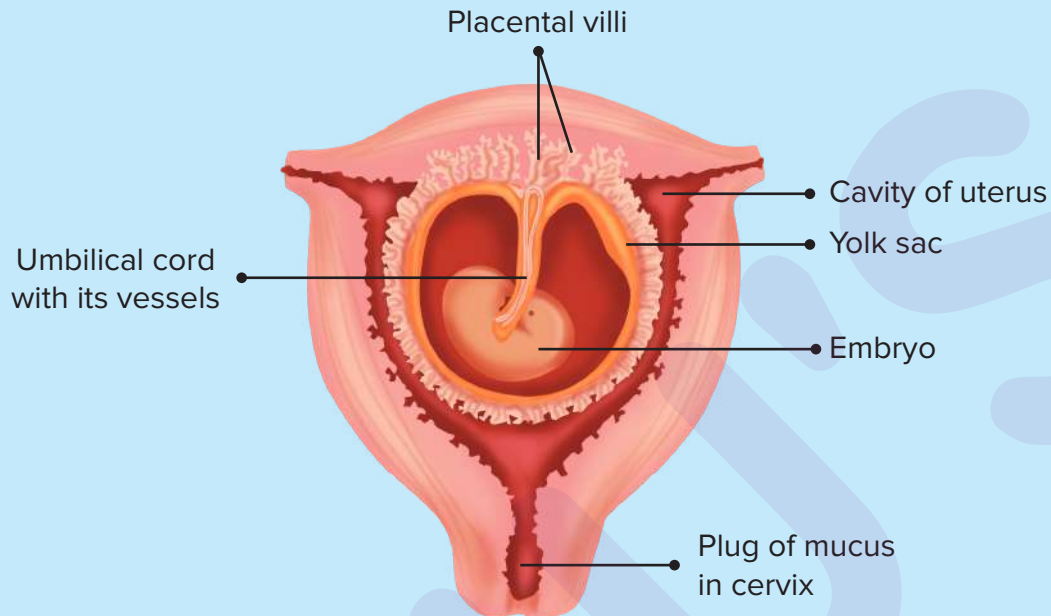
Thyroid cells



Digestive cells

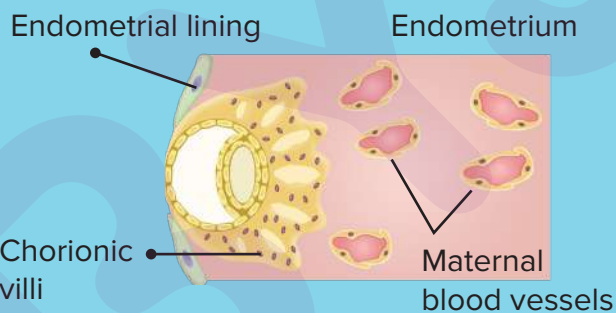
## Placenta

- It is a temporary organ that **connects** the mother and the foetus.

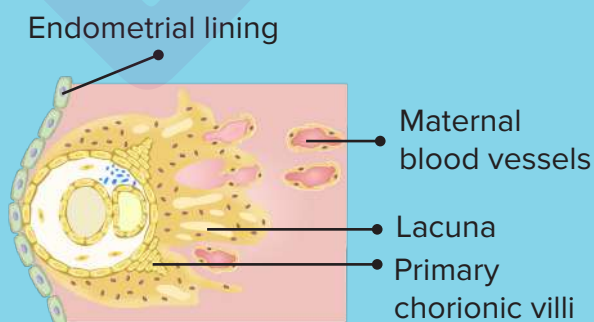


## Placenta formation

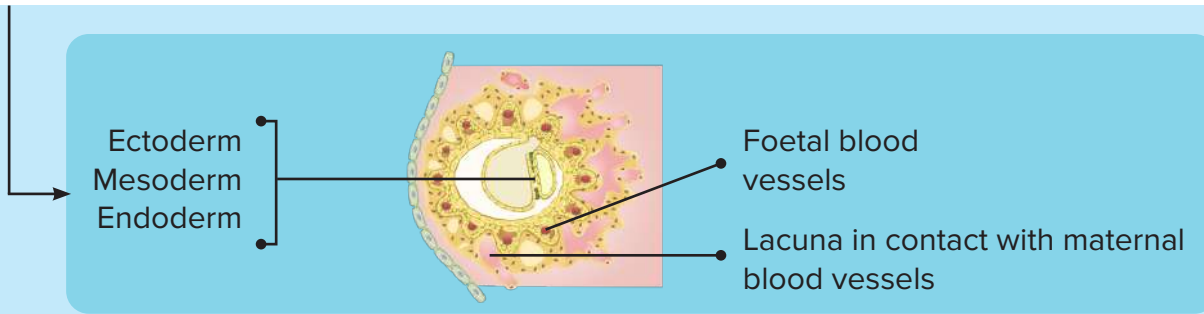
To nourish the embryo, the endometrium undergoes some changes before implantation.



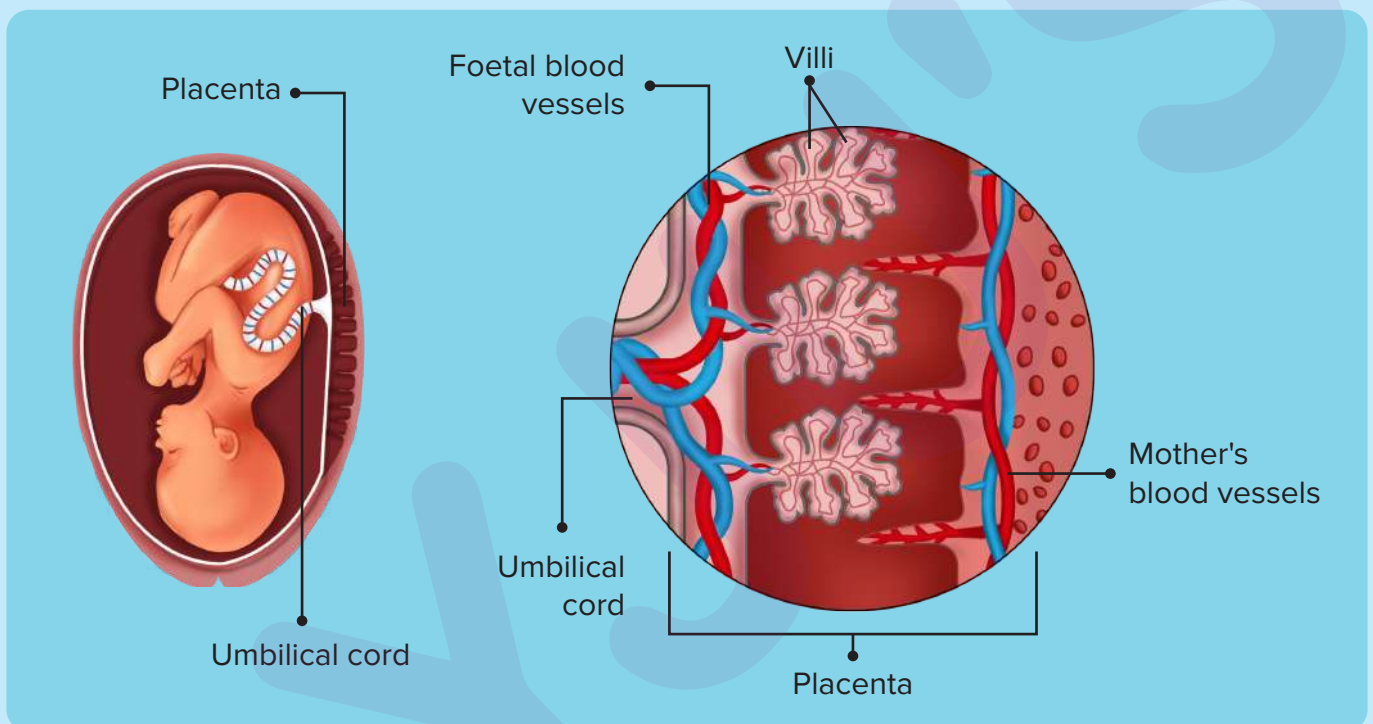
- Endometrial lining thickens** due to the supply of many blood vessels.
- After the implantation, the **trophoblast gives rise to the chorionic villi** that come in contact with the maternal blood vessels of the endometrium.



- The spaces between the growing villi from trophoblast is known as **lacuna**.
- The maternal blood vessels come in contact with these empty spaces.
- The cells developing from the trophoblast also have the **foetal blood vessel**.



- The maternal blood vessels and the foetal blood vessels give rise to the **placenta**.
- Simultaneously, changes also happen in the inner cell mass.
- The inner cell mass then gives rise to the germinal layers: **ectoderm, mesoderm, and endoderm**.
- The developing foetus then gets connected to the placenta via the umbilical cord.



### Functions of placenta

- **Nutrients** from the mother are supplied to the foetus via placenta.
  - » Mother is the source of **oxygen** for the developing foetus.
  - » Foetus also **returns carbon dioxide** and **excretory products** to the mother.
  - » These products are then excreted out of the mother's body.



- The placenta releases several hormones only during pregnancy. Thus, it acts as a temporary endocrine gland.
  - » It releases the following hormones:
    - i. **Human chorionic gonadotropin (hCG)**
    - ii. **Human placental lactogen (hPL)**
    - iii. **Relaxin**
  - » The placenta also releases a **certain** amount of **oestrogen** and **progesterone**.
  - » It confers **passive immunity** to the foetus by transferring **antibody IgG**. These antibodies work against **diphtheria, scarlet fever, smallpox, measles, etc.**
  - » **Placenta** acts as a **protective barrier**. It protects the foetus from germs and pathogens circulating in the mother's blood.
  - » It **stores glycogen** and acts as a food reserve **for the foetus**.

### Functions of hormones secreted by placenta



**hCG**

- It promotes **progesterone** secretion by **corpus luteum**.
- Progesterone is an extremely important hormone for maintaining pregnancy.
- Corpus luteum is a structure formed from the remaining cells after ovulation.



**hPL**

- It regulates metabolism in the foetus.



**Relaxin**

- It **relaxes** the **ligaments** of the **pelvis**.
- It helps in **widening of the cervix**.
- It helps in **childbirth**.
- It is also produced by ovary.



**Oestrogen  
and  
Progesterone**

- Oestrogen stimulates the growth of **myometrium**.
- Progesterone makes endometrium **viable for implantation**.



### Did you know?



A preliminary pregnancy test can be done at home.

- The **urine sample** has to be dropped over the allocated area on the strip.
- If the **strip shows two lines**, it's **positive for pregnancy** and if it shows **one line**, it is **negative for pregnancy**.
- This is a preliminary test done for confirmation.
- The strip has antibodies that help in measuring the presence of **hCG** in the urine.



Two lines



One line

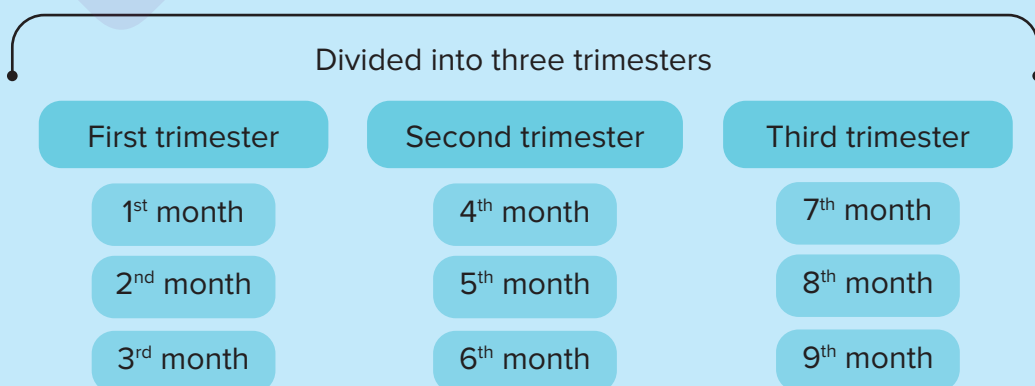
The specialist who deals with pregnancy is known as an **obstetrician**.



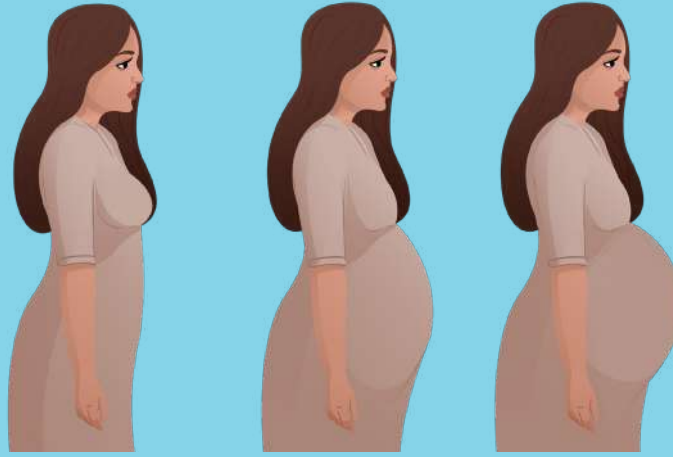
### Gestation

- The **duration of pregnancy** is known as the gestation period.
- The first four weeks of the pregnancy include **ovulation**, **fertilisation**, implantation, and gastrulation.

**Pregnancy is generally 40 weeks or 9 months long.**



### Instances in the life of a pregnant woman: Pregnancy calendar



1 trimester

2 trimester

3 trimester

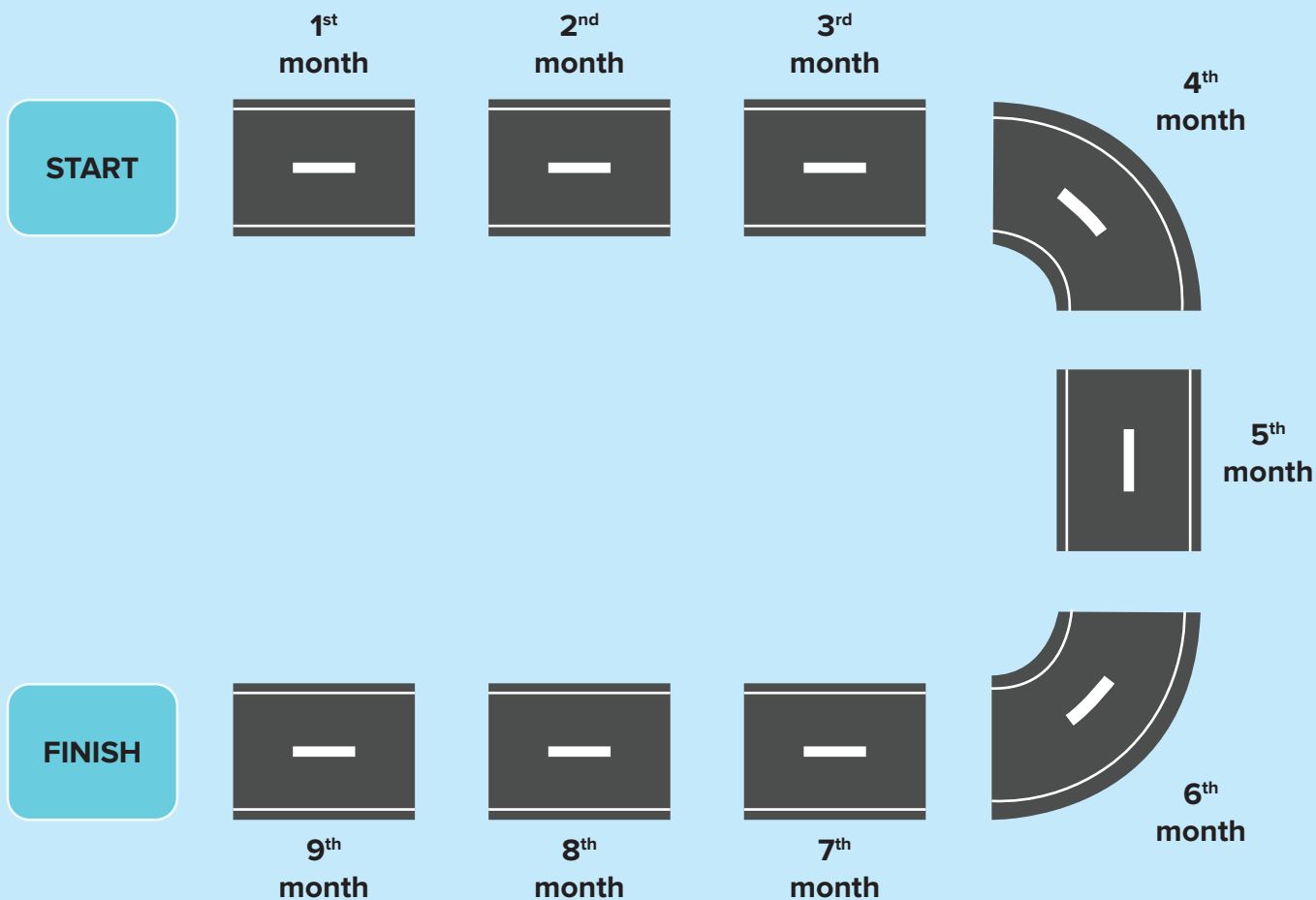
- Every trimester brings in several changes in the foetus.

#### Gestation period / Pregnancy - 40 weeks

TRIMESTER	MONTHS	WEEKS
1 <sup>st</sup>	1	0 - 4
2 <sup>nd</sup>	2	5 - 8
	3	9 - 13
	4	14 - 17
3 <sup>rd</sup>	5	18 - 22
	6	23 - 27
3 <sup>rd</sup>	7	28 - 31
	8	32 - 35
	9	36 - 40

- After gastrulation, there is a development of different organs and organ systems in the embryo.

## Changes in the embryo



### 4 Weeks



### 36 Weeks to go

**Trimester:** First  
**Month:** 1<sup>st</sup>

**Important development:**  
Formation of heart

**First trimester**

- The size of the embryo is that of a strawberry seed.
- The major organ systems begin to form, specifically the **brain** and the **heart**, by the end of four weeks.
- The heart starts beating.
- The arm buds and optic pits become visible.

### 8 Weeks



### 32 Weeks to go

**Trimester:** First  
**Month:** 2<sup>nd</sup>

**Important development:**  
Limbs and digits begin to develop

**First trimester**

- Foetal physical features become more noticeable; limbs and digits begin to develop.

12 Weeks

28 Weeks to go



**Trimester:** First  
**Month:** 3rd

**Important development:**  
Placenta is fully developed.

**First trimester**

- The placenta is **fully functional** and takes over the hormone production to sustain the pregnancy.
- The inner ear, liver, pancreas, spleen, and gallbladder start developing, and the pharyngeal arches develop.
- The eyes, nose, leg buds, stomach, and kidney precursors start developing; hands appear as flat paddles.
- Lungs and lymphatic system, primary sex organs start developing; arms and legs lengthen and digits start appearing.
- The external ears start appearing; nipples, hair follicles, and most of the organs start developing by this time.

16 Weeks

24 Weeks to go



**Trimester:** Second  
**Month:** 4<sup>th</sup>

**Important development:**  
Taste buds develop, ability to hear develops.

**Second trimester**

20 Weeks

20 Weeks to go



**Trimester:** Second  
**Month:** 5<sup>th</sup>

**Important development:**  
The first movement is seen in this month.

**Second trimester**

24 Weeks

16 Weeks to go



**Trimester:** Second  
**Month:** 6<sup>th</sup>

**Important development:**  
Eyelashes are formed, fine hair grows.

**Second trimester**

28 Weeks

12 Weeks to go



**Trimester:** Third  
**Month:** 7<sup>th</sup>

**Important development:**  
Frequency of eye movements increase.

**Third trimester**

32 Weeks

8 Weeks to go



**Trimester:** Third  
**Month:** 8<sup>th</sup>

**Important development:**  
The sleep wake cycle is regulated.

**Third trimester**

36 Weeks

4 Weeks to go



**Trimester:** Third  
**Month:** 9<sup>th</sup>

**Important development:**  
The foetus turns upside down.

**Third trimester**

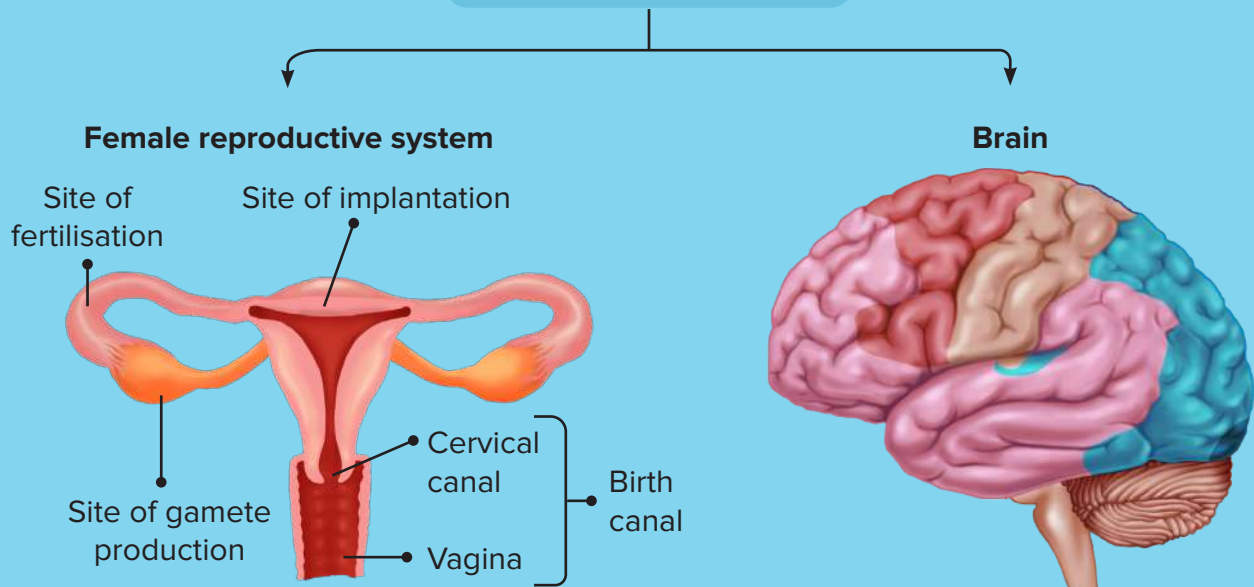


## Foetal ejection reflex

- The foetal ejection reflex involves **uterine contractions** that are generated by the placenta when the foetus is fully developed.
- This reflex is seen during the time of parturition.

The foetal ejection reflex involves the interaction between the female reproductive system and the brain

### Foetal ejection reflex



The fully developed foetus starts **pushing down** the birth canal.

This results in the **stretching** of the cervix.

Stretching sends **nerve impulses** to the **hypothalamus**.

The hypothalamus then, sends the impulse to the **posterior pituitary**.

Posterior pituitary secretes **oxytocin** into the blood stream.

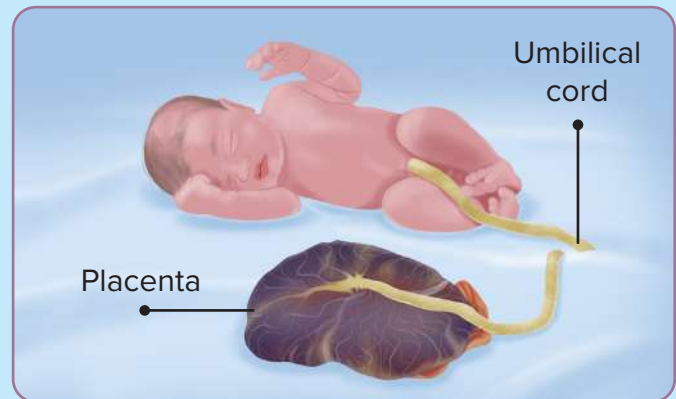
The **blood flows** to the target organ which is the uterus.  
Myometrium is the muscular layer that lies behind the endometrium.  
Myometrium + Endometrium = uterus wall

The oxytocin stimulates the **myometrium** of the uterus. This results in increased **contractions** of the uterus.

The contraction of the uterus helps the foetus to move through the birth canal. Ultimately, **parturition** happens.

## Parturition

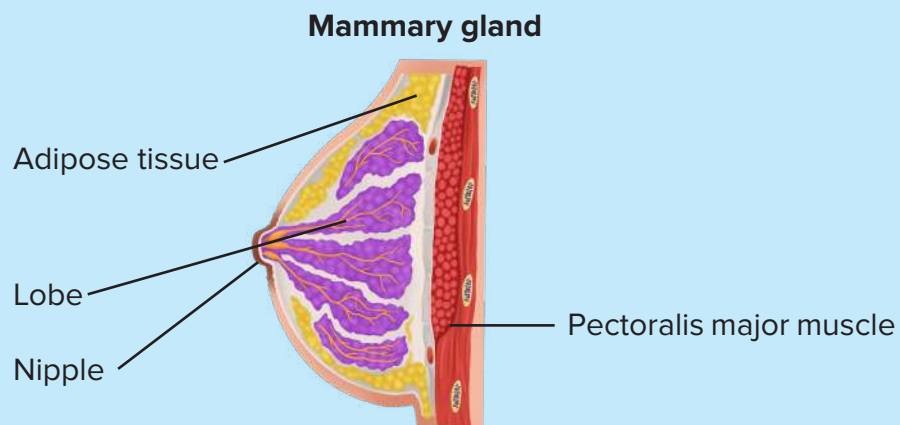
- The process of delivery of the foetus or **childbirth** is known as **parturition**. This is induced by a complex neuroendocrine mechanism.
- The fully developed foetus and the placenta initiate the signals.
- These cause **contraction of the uterus** and these contractions are known as foetal ejection reflex.



- The placenta is also expelled out of the uterus, as soon as the foetus is delivered.
- After delivery, the foetus is known as a baby.

## Lactation

- The mammary glands undergo differentiation, and **produce milk** towards the end of pregnancy. This process is known as lactation.
- Breast-feeding is the process of feeding the milk to the baby, which is produced by the mammary glands.



- **Colostrum** is the milk produced by the mother in the initial few days of lactation.
- Colostrum is extremely crucial for the **immunity** of the newborn and is rich in several **antibodies**.
- Thus, breastfeeding the newborn especially in the initial days is extremely important.
- The **colour of colostrum** is **yellowish** than the milk that will be produced after some days.

**Colostrum** - milk produced in the initial days of lactation, **rich in antibodies especially IgG**



### Summary Sheet

#### Post implantation events

- The blastocyst has two types of cells—the **outer trophoblast** and **inner cell mass**.
- During the post implantation events, the trophoblast along with the endometrial lining contributes to the formation of **placenta** and the inner cell mass will further divide to give rise to the **germinal layers**.

Trophoblast

+

Endometrium



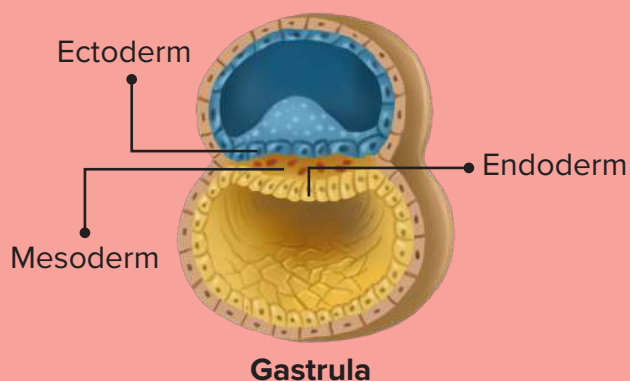
Placenta

Inner cell  
mass

**Gastrulation**



Germinal  
layers

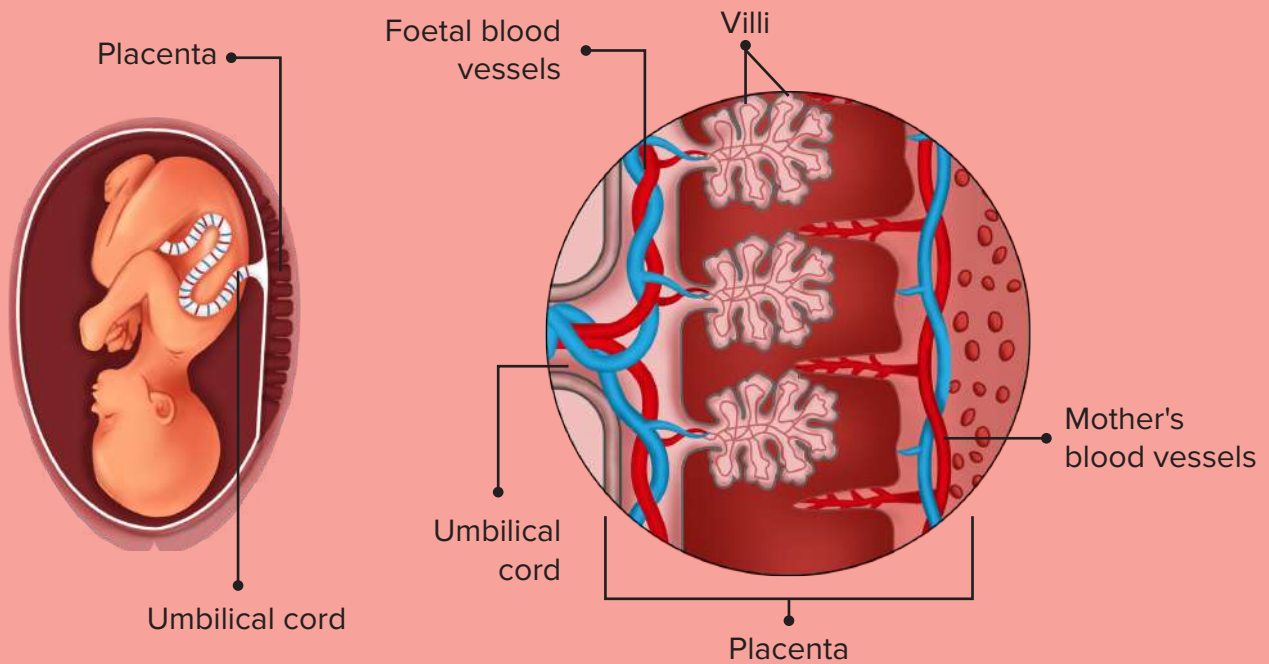


**Gastrulation:** The process by which the inner cell mass gives rise to a structure called **gastrula** that has various **germinal layers**.

## Placenta

Placenta refers to the temporary vascular organ found in mammals, which attaches the foetus to the uterus of the mother during pregnancy.

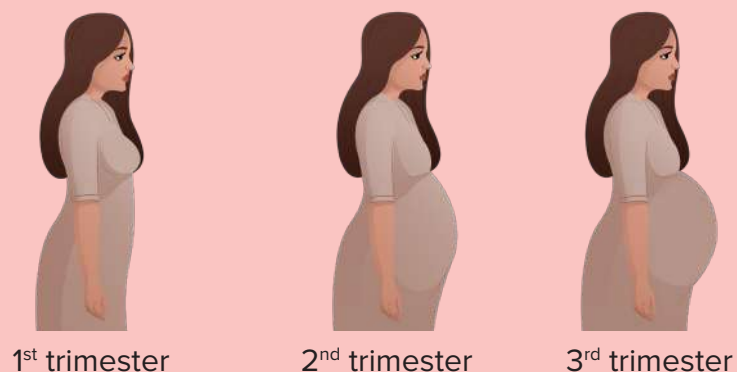
The placenta is exclusive to mammals. The umbilical cord connects the foetus to the placenta, facilitating the transfer of materials.






### Functions of placenta

- It is the passage that unites the foetus to the mother.
- Transmission of **nutrients** and **oxygen** from mother to the foetus occurs through the placenta.
- It also facilitates the transfer of **carbon dioxide** and **waste materials** from the foetus to mother's body who excretes out all this waste.

### Pregnancy calendar

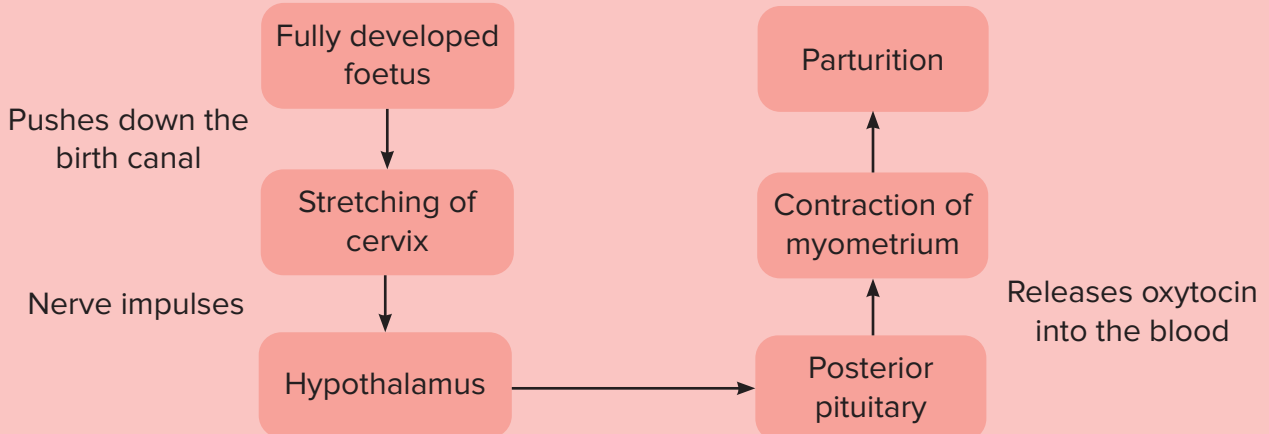


### Gestation period / Pregnancy - 40 weeks

TRIMESTER	MONTHS	WEEKS
1 <sup>st</sup> 	1	0 - 4
	2	5 - 8
	3	9 - 13
2 <sup>nd</sup> 	4	14 - 17
	5	18 - 22
	6	23 - 27
3 <sup>rd</sup> 	7	28 - 31
	8	32 - 35
	9	36 - 40

- The process of delivery of the foetus or childbirth is known as parturition. This is induced by a complex neuroendocrine mechanism.

### Parturition



**Colostrum** - milk produced during the initial days of lactation, rich in **antibodies** especially IgG



# HUMAN REPRODUCTION

## MENSTRUAL CYCLE, MENARCHE AND MENOPAUSE



### Key Takeaways

#### • Menstrual cycle

- ◆ Ovarian cycle
  - Follicular phase
  - Luteal phase
- ◆ Menstruation/Menstrual phase

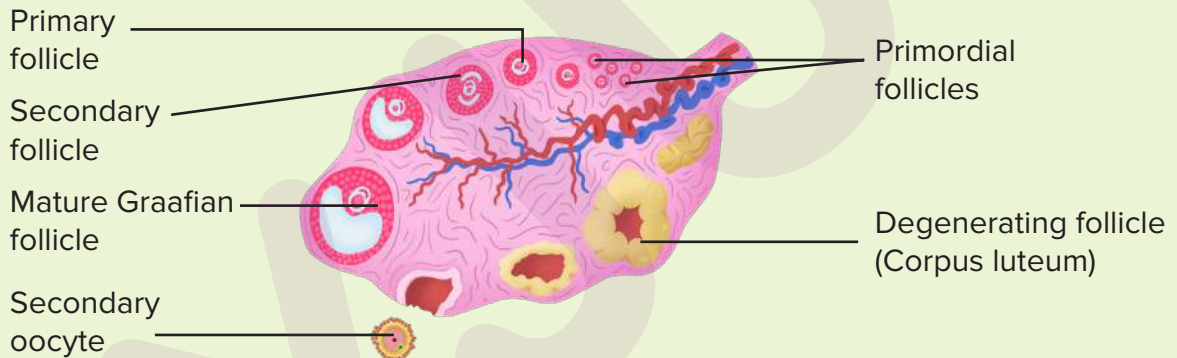
#### • Menarche and menopause

- ◆ Uterine cycle
  - Proliferative phase
  - Secretory phase

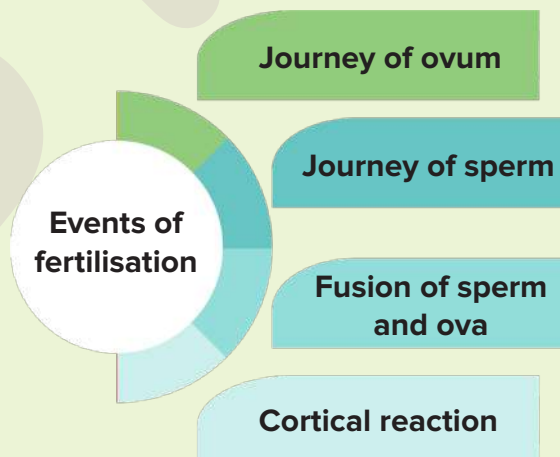


### Prerequisites

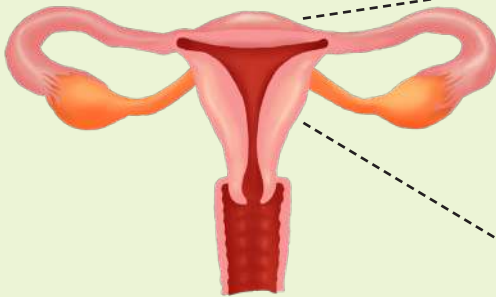
#### Ovulation



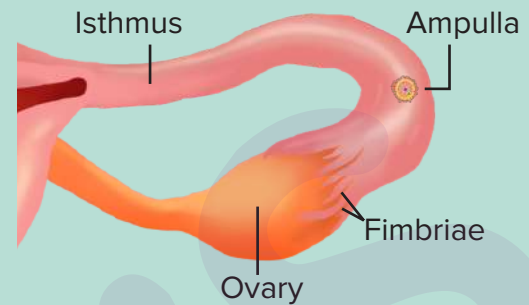
#### Events of fertilisation



### Fertilisation: Journey of ovum



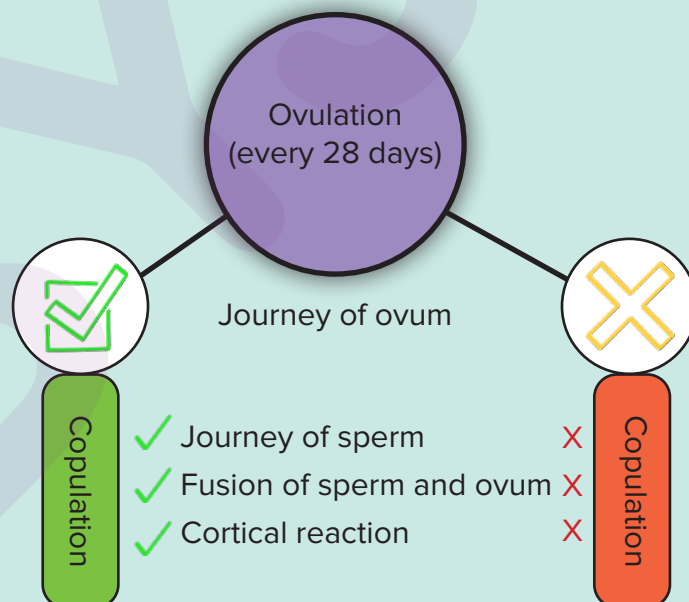
Female reproductive system



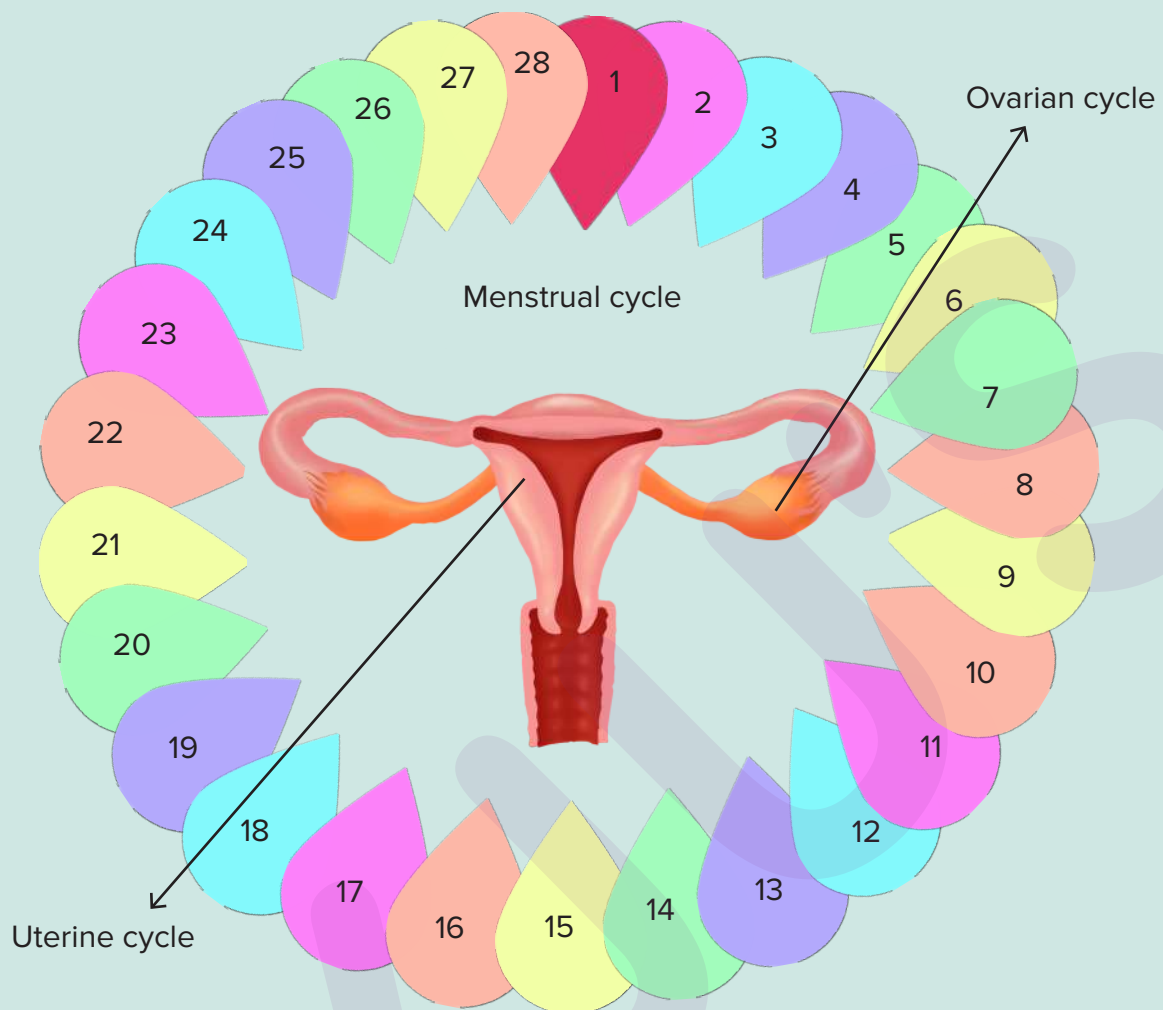
- Secondary oocyte is released from the ovary
- Carried out by fimbriae into fallopian tube
- Moved to ampulla region with the help of cilia

### Menstrual Cycle

- It is a cyclic process in females in which the ovum is released from the ovary every 28 days.
- However, ovum is not fertilised every time as copulation is not a regular process.



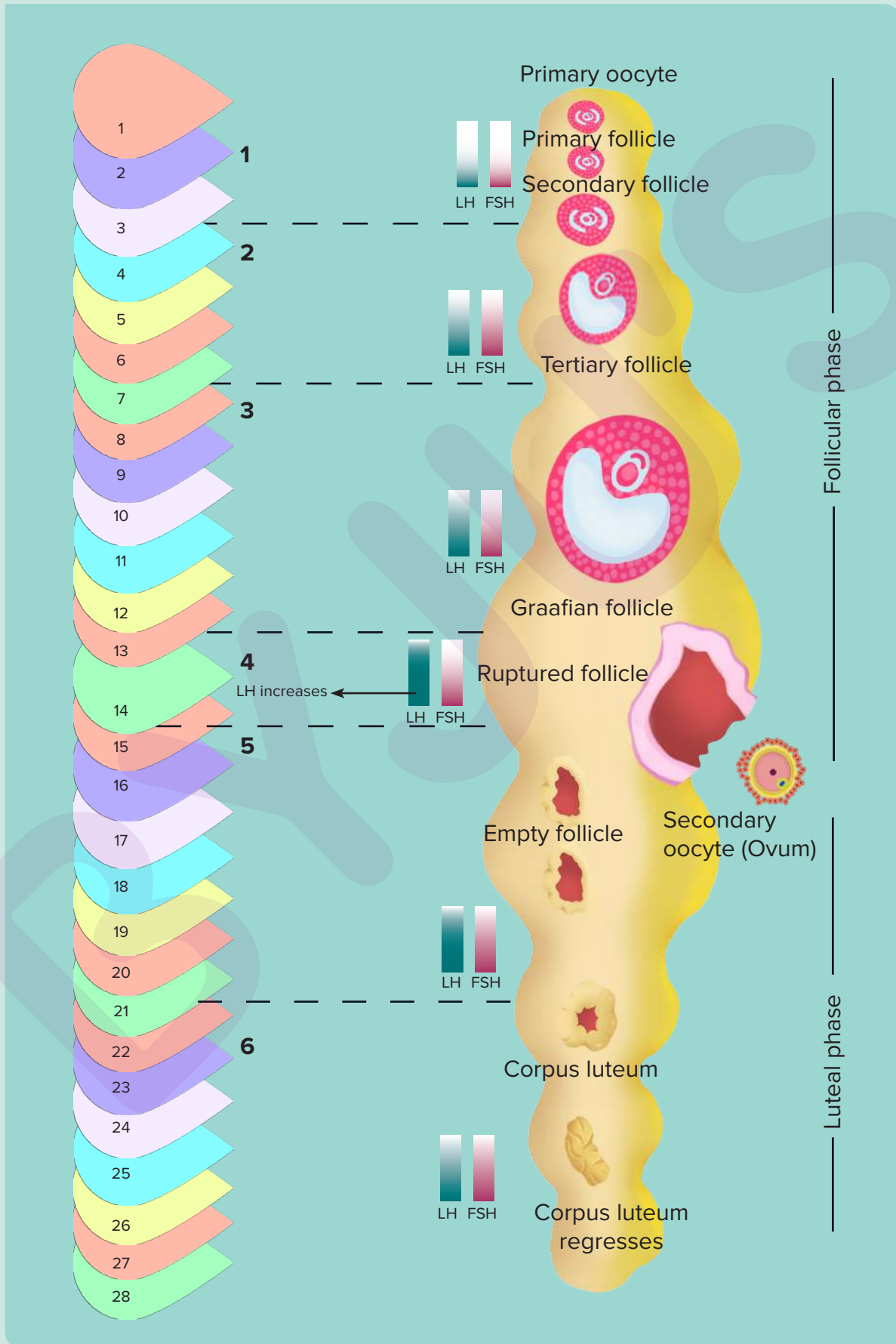
Menstrual cycle = Uterine cycle + Ovarian cycle



- **Menstruation:** It is the cyclic discharge of **blood** and **mucosal tissue** from the uterus through the vagina.
- In human females, menstruation is repeated every **28/29 days**. The cycle of events from one menstruation to the next is known as the menstrual cycle.



Ovarian cycle



**1**

- The secretion of **FSH** and **LH** is stimulated by **GnRH**.
- There is a stimulation of the **follicular growth** and the **oocyte development** inside the follicle.

**2**

- There is a gradual **increase** in the levels of FSH and LH during the first seven days.
- The **growth** and the **development** of the follicle and the oocyte continues.

**3**

- There is a formation of a mature **Graafian follicle** containing the **secondary oocyte**.

**4**

- A steep increase in the LH levels is known as **LH surge**. It leads to the rupture of the Graafian follicle to release the secondary oocyte (**ovulation**).

**5**

- After ovulation, there is a **reduction** in FSH and LH levels from the maximum.
- There is a formation of **corpus luteum** from the remnants of the follicle with the stimulation by LH.

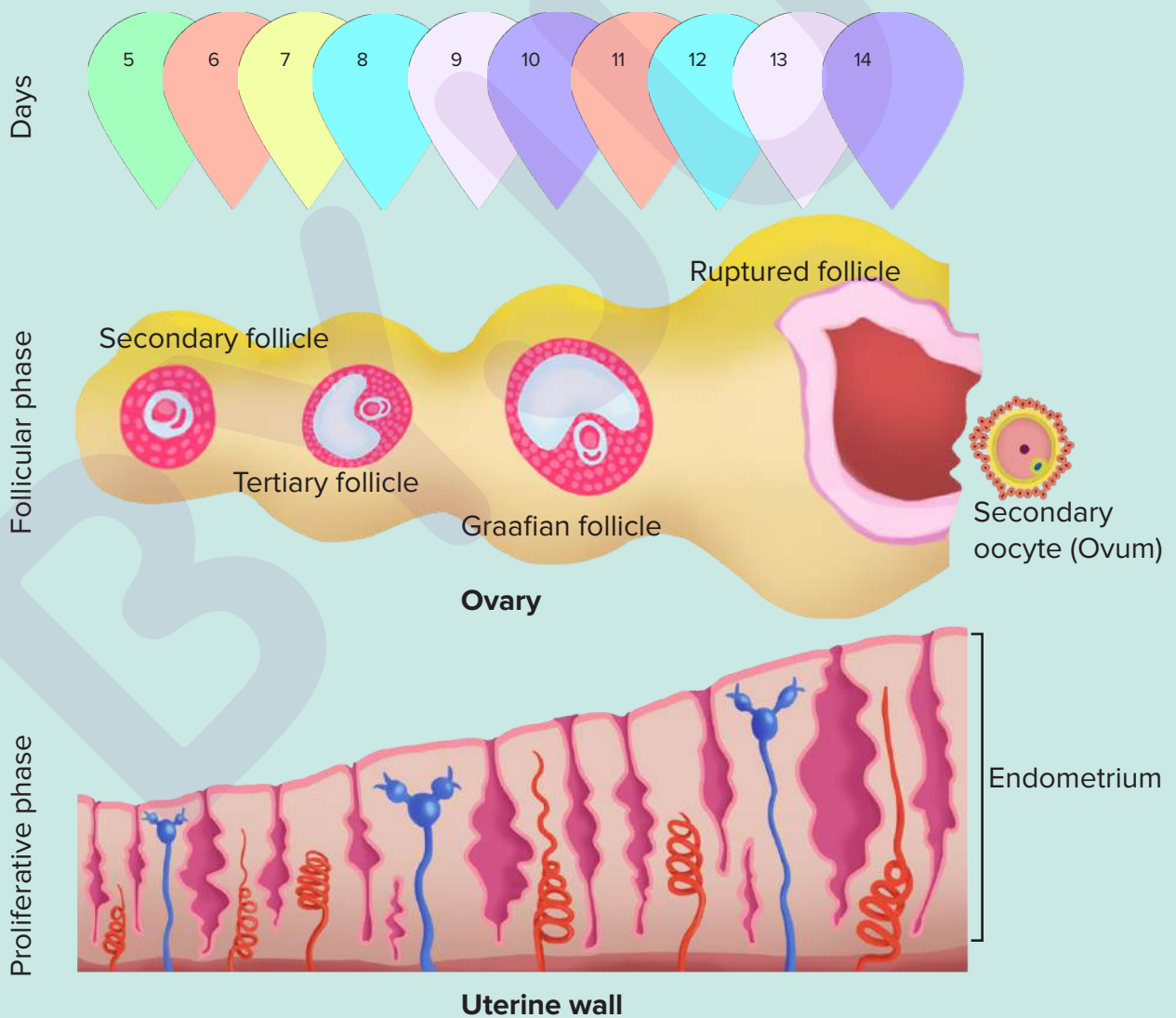
**6**

- There is a **decrease** in FSH and LH to the minimum level.
- There is **degeneration** of corpus luteum in the absence of fertilisation.

## Uterine cycle

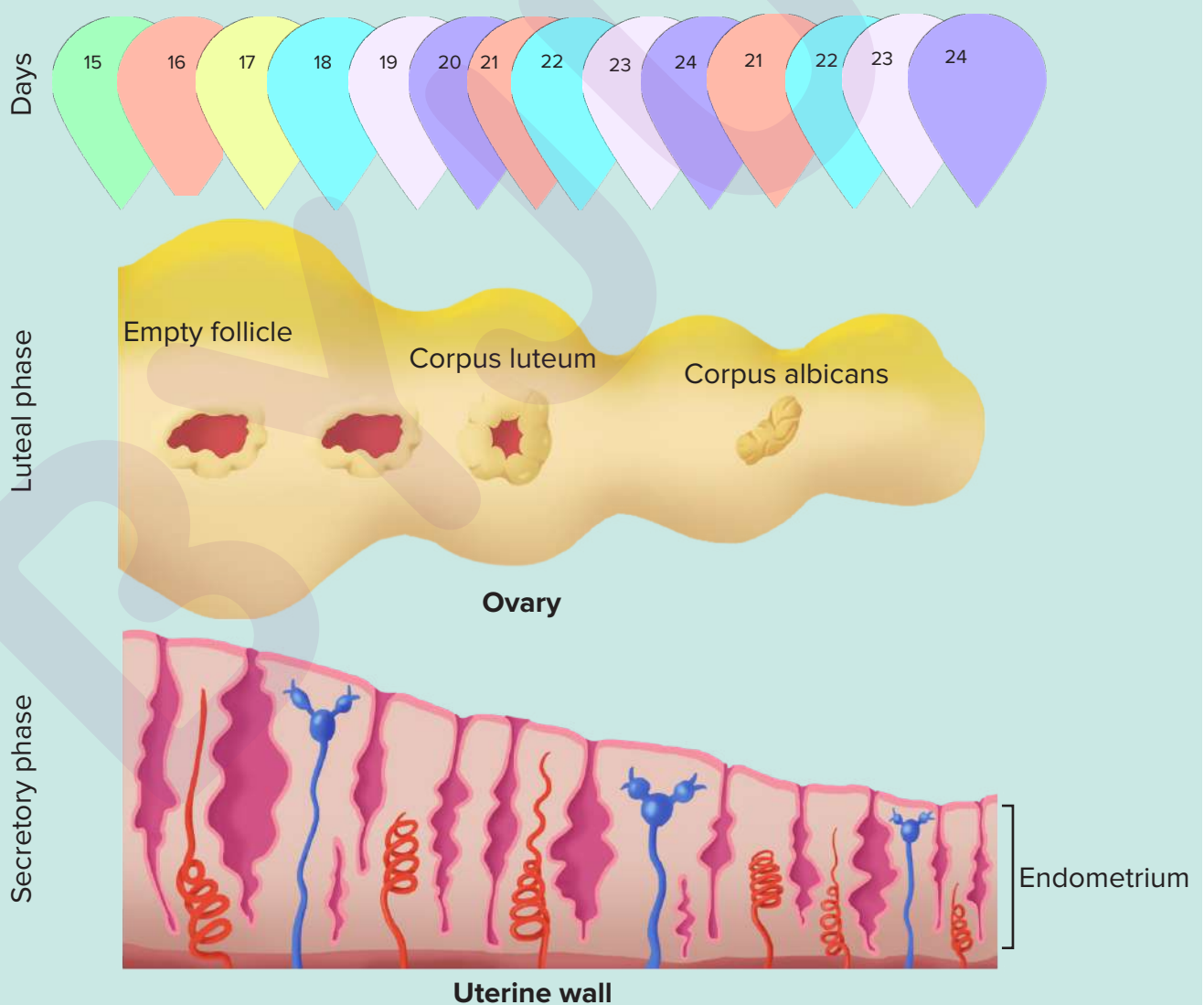
### Proliferative phase

- **Duration:** It starts from the end of the last menstruation and continues up to the 14th day of the menstrual cycle.
- **Hormonal levels:** There is a **rise in oestrogen** released from growing follicles stimulated by FSH.
- **Changes in uterus:**
  - The **proliferation of endometrium** stimulated by oestrogen takes place.
  - There is an increase in the uterine glands and the blood vessels with the **thickening of endometrium**.
  - Uterine preparation takes place for implantation.



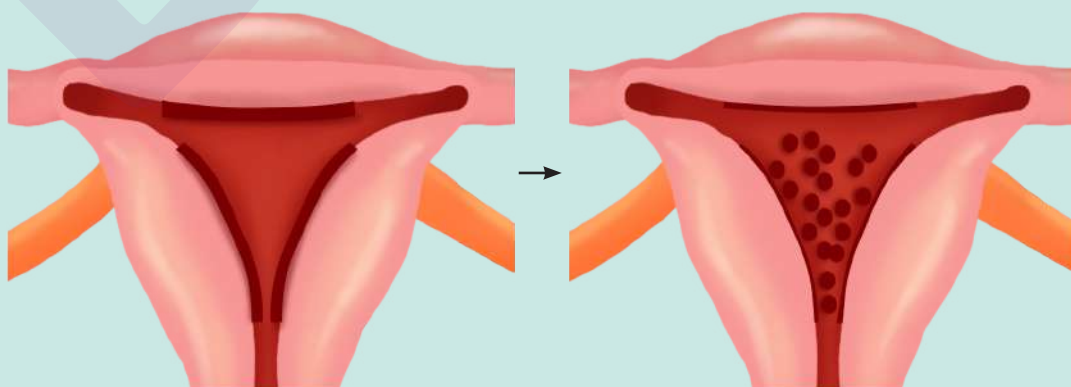
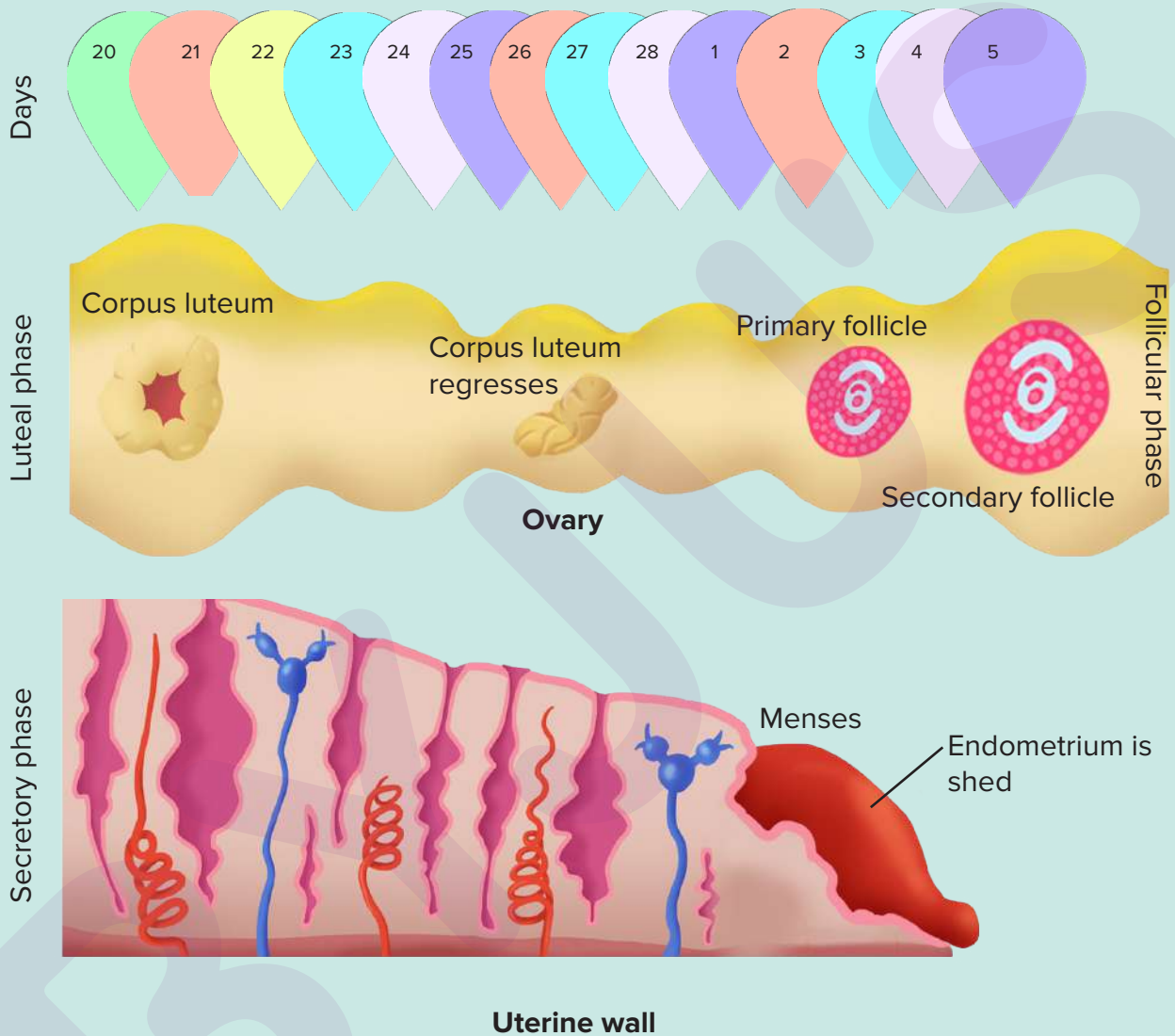
## Secretory phase

- **Duration:** It starts from the 15th day and continues up to the 28th day of the menstrual cycle and ends with menstruation.
- **Hormonal levels:**
  - There is an **increase in progesterone** secreted from corpus luteum and decrease in estrogen level till 24th day.
  - There is a **decrease in progesterone level after the 24th day** by degeneration of corpus luteum in the absence of fertilisation.
- **Changes in uterus:**
  - Maintenance of endometrium by large amounts of progesterone is required till the 24th day.
  - There is **disintegration of endometrium** after the decrease in progesterone that leads to menstruation at last.



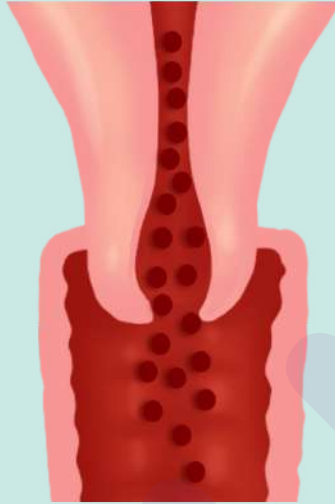
## Menstruation/Menstrual phase

- **Duration:** It takes place for **3-5 days** (1st-5th day of the menstrual cycle).
- There is **disintegration** of the endometrial lining of the uterus and its blood vessels.



**Disintegration of endometrium lining to form menstrual fluid**

- The formation of menstrual fluid takes place from the **breakdown of the endometrium** and its blood vessels, which come out through the vagina.
- Menstruation only occurs if the released **ovum is not fertilised**.



Menstrual fluid comes out through vagina



### Did you know?

Lack of menstruation may be an indicator of pregnancy, but it can also happen due to stress, medications, poor health conditions, etc.



Weight changes



Profound stress



Illness



Medications



Extreme exercise



Recently attained puberty

### Conditions that can cause lack of menstruation

## Menarche and Menopause

Menstruation does not happen throughout a woman's life.



**Birth**  
Pre-menarche



- There is no menstruation in a girl from her birth till menarche.



**Menarche**  
Age: 12-15 years



- The **onset of menstruation** in a female is known as **menarche**.
- It signals the onset of puberty.
- It marks the **beginning** of the **fertile period**.
- A girl acquires the ability to get pregnant.



**Menopause**  
Age: 45-50 years



- The **cessation of menstruation** and ovulation is known as **menopause**.
- It marks the **ending** of the **fertile period**.
- A girl loses the ability to get pregnant.
- There is a transition period between menarche and menopause.
- The menstrual cycle becomes **irregular**.
- Sometimes the menstruation is also marked by heavy bleeding known as **menorrhagia**.



### Did you know?

#### Menstruation in monkeys and apes

- Besides human beings, other close primates like monkeys and apes also menstruate. The reproductive cycle in the female primates (for example, monkeys, apes, and human beings) is known as the menstrual cycle.
- Sexual swellings, i.e., enlarged areas of external and internal genitalia of female primates, are observed during the menstrual cycle that attracts the male. The swelling increases during the follicular phase till ovulation and then decreases in the luteal phase.



Sexual swelling in Baboon

## Menstrual Hygiene

### Menstrual hygiene guidelines

- Taking bath and washing hands
- Keeping the pubic area clean and dry
- Using menstrual hygiene products
- Disposing used menstrual absorbents safely
- Taking enough rest and sleep

### Menstrual hygiene products

**Cloth pad** • Since it is a **reusable** pad made up of cloth, it is **eco-friendly**.

**Sanitary pad** • It is designed for **one-time use** only.  
• It needs to be discarded every **4-5 hours** after use.

**Tampon** • It is mostly for **one-time use** only.  
• It is **inserted into the vagina** during menstruation to absorb blood and vaginal secretions.

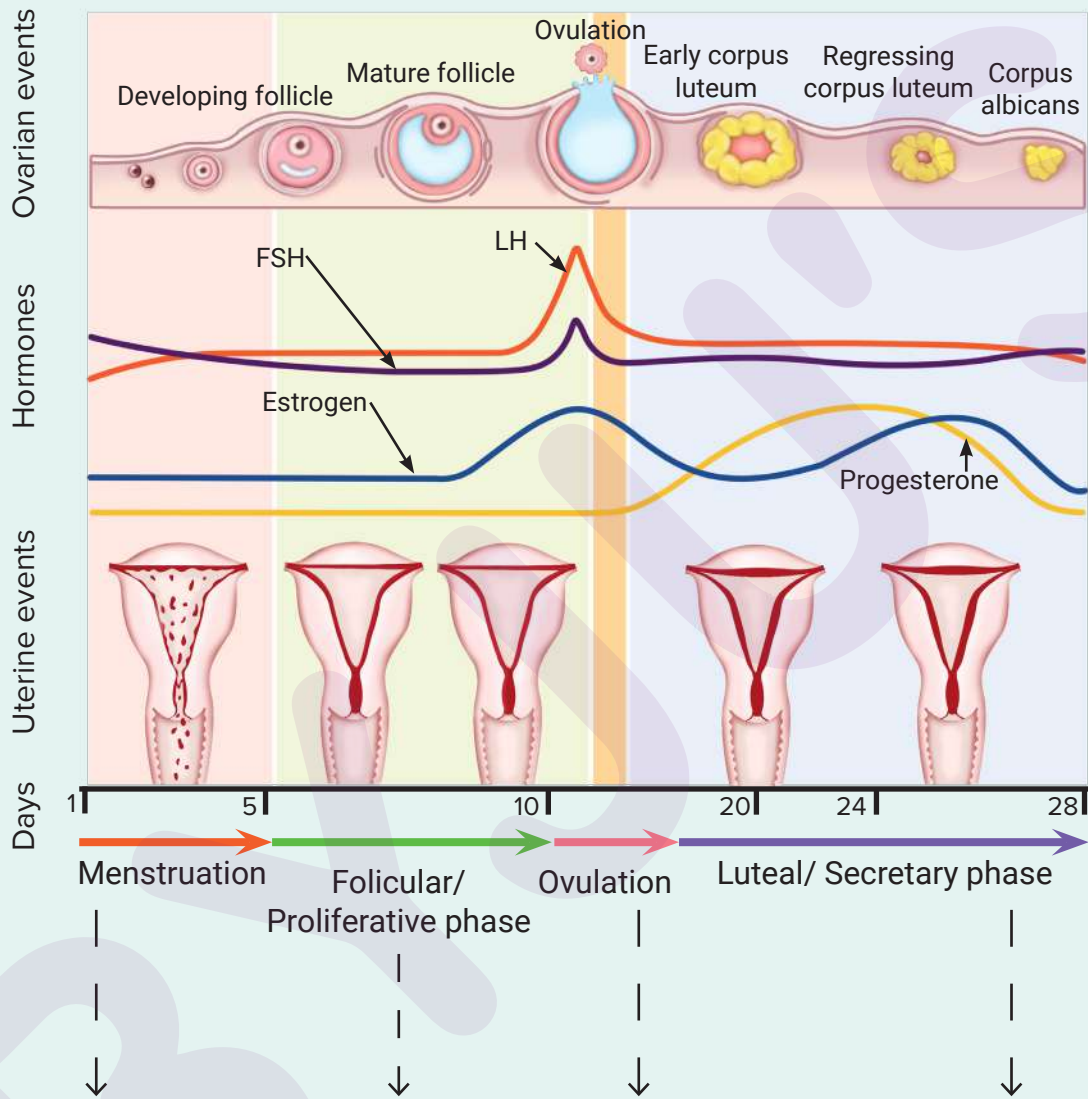
**Menstrual cup** • It is a **reusable** and **eco-friendly** cup made of medical grade silicone to collect menstrual blood inside the vagina.  
• It needs to be **washed** to drain out the blood after a few hours of use, depending on the flow.





## Summary Sheet

### Menstrual cycle = Uterine cycle + Ovarian cycle



- The formation of menstrual fluid takes place from the **breakdown of endometrium** and its blood vessels, which comes out through the vagina.
- The **growth of follicle** and **oocyte** takes place inside it with increasing FSH and LH levels.
- **Proliferation of endometrium** takes place with an increasing level of estrogen released from the growing follicle.
- It is the rupture of the Graafian follicle to release the **secondary oocyte** due to **LH surge**.
- The formation of **corpus luteum** is stimulated by LH, which releases progesterone to maintain the endometrium till the 24th day.
- The **degeneration** of corpus luteum takes place after the 24<sup>th</sup> day with decreasing levels of FSH and LH.
- The **disintegration** of endometrium takes place after the 24th day with decreasing levels of progesterone.

### Menarche

- Age: 12-15 years
- It is the onset of menstruation at puberty and the beginning of the fertile period.

### Menstrual hygiene

- General hygiene
- Balanced diet
- Use of menstrual hygiene products
- Proper discard of used products

### Reproductive phase

### Menopause

- Age: 45-50 years
- It is the cessation of menstruation and the end of the fertile period.

### Menstrual hygiene products

- Cloth pad
- Sanitary pad
- Tampon
- Menstrual cup