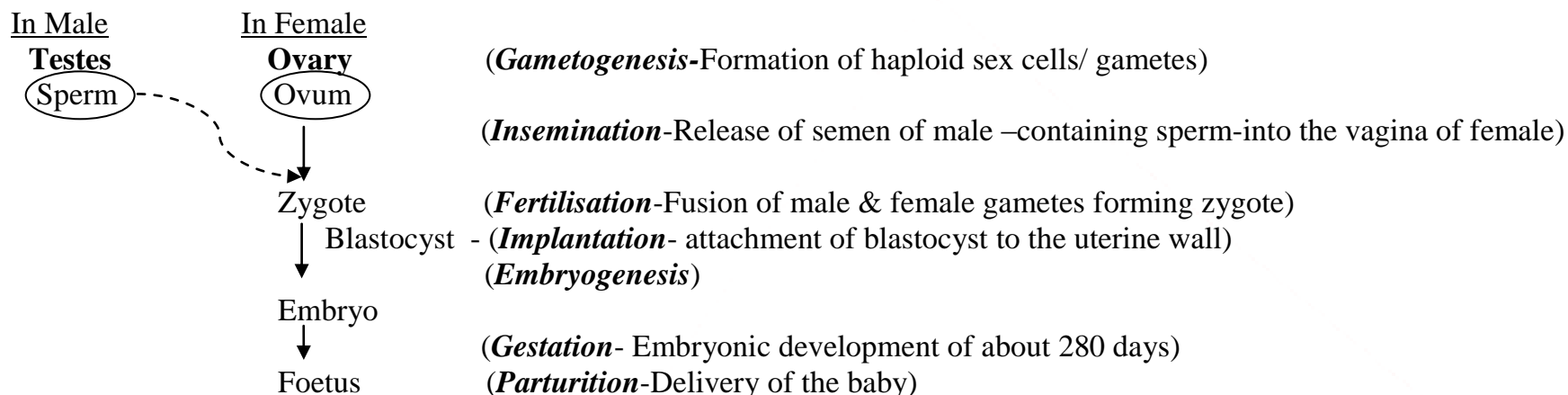


## 3. HUMAN REPRODUCTION

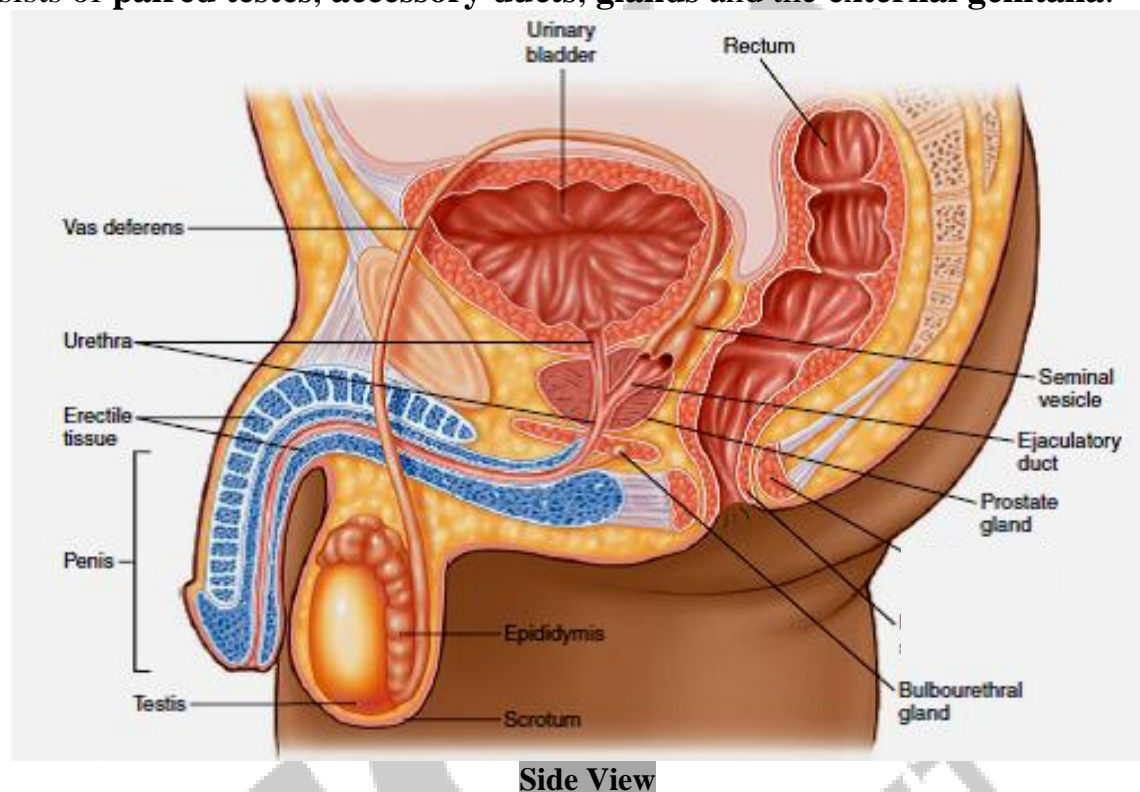
- Humans are sexually reproducing and viviparous

### Reproductive Events In Human



## THE MALE REPRODUCTIVE SYSTEM

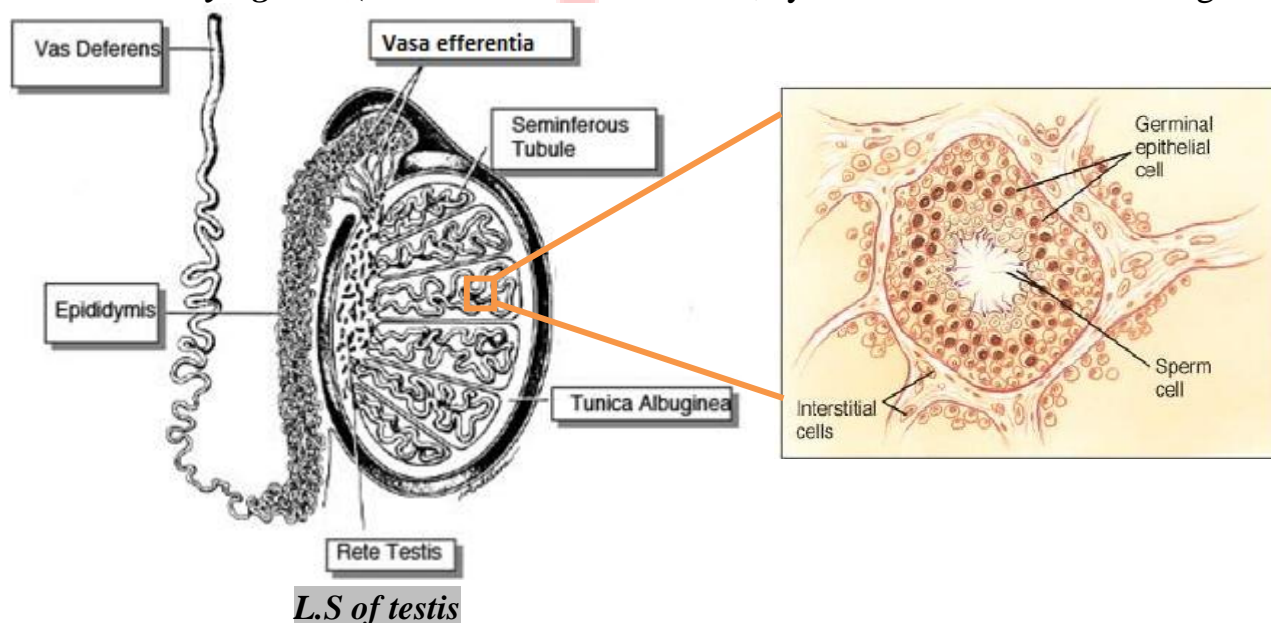
- ❖ It consists of **paired testes**, **accessory ducts**, **glands** and the **external genitalia**.



Side View

### Testes

- **1<sup>o</sup> sex organ** that produce **sperm** (male gamete) & **androgen** (sex hormone).
- Situated in **scrotum** (provide optimal temperature for spermatogenesis)
- Pinkish, oval in shape, length: 4-5 cm, width:2-3 cm, thick:2-4cm; covered by fibrous **tunicae**.
- Each testis has about 250 **testicular lobules** (compartments)
- Each lobule contains 1-3 highly coiled, 60cm long **seminiferous tubules** in which sperms are produced.
- Each seminiferous tubule is lined on its inside by two types of cells called **male germ cells** (*spermatogonia*) and **Sertoli cells**.
  - The *male germ cells* undergo meiotic divisions → sperm formation
  - *Sertoli cells* provide nutrition to the germ cells.
- The regions outside the seminiferous tubules (**interstitial spaces**), contain -
  - Small blood vessels
  - Interstitial cells or **Leydig cells**(-10% of testicular volume; synthesise and secrete androgens: 7-8mg/day)



L.S of testis

## Accessory ducts

- Include **rete testis**, **vasa efferentia**, **epididymis** and **vas deferens**
- Seminiferous tubules unite to form straight tubules
  - ↓
  - Open into **rete testis** (irregular cavities)
    - ↓
    - Vasa efferentia** (10-20 fine tubules; *conduct sperms out from the testes*)
      - ↓
      - Epididymis** (6m highly coiled tube; *store sperms temporarily*)
        - ↓
        - Vas deferens** (40cm long duct; ascends to the abdomen and loops over the urinary bladder)
          - ↓
          - Join with a duct from **seminal vesicle** to form **ejaculatory duct** (2cm)
            - ↓
            - Opens into **urethra** (receives the ducts of prostate & bulbourethral glands and passes through the penis)
              - ↓
              - Urethral meatus** (external opening).

## Accessory Glands

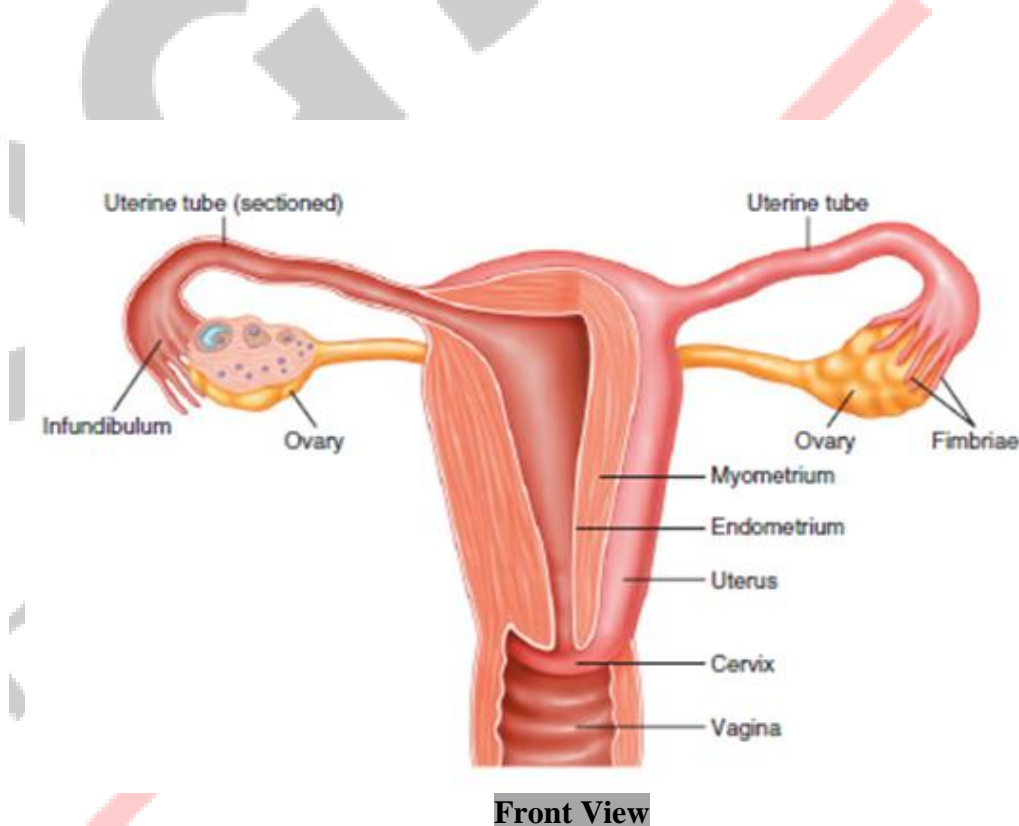
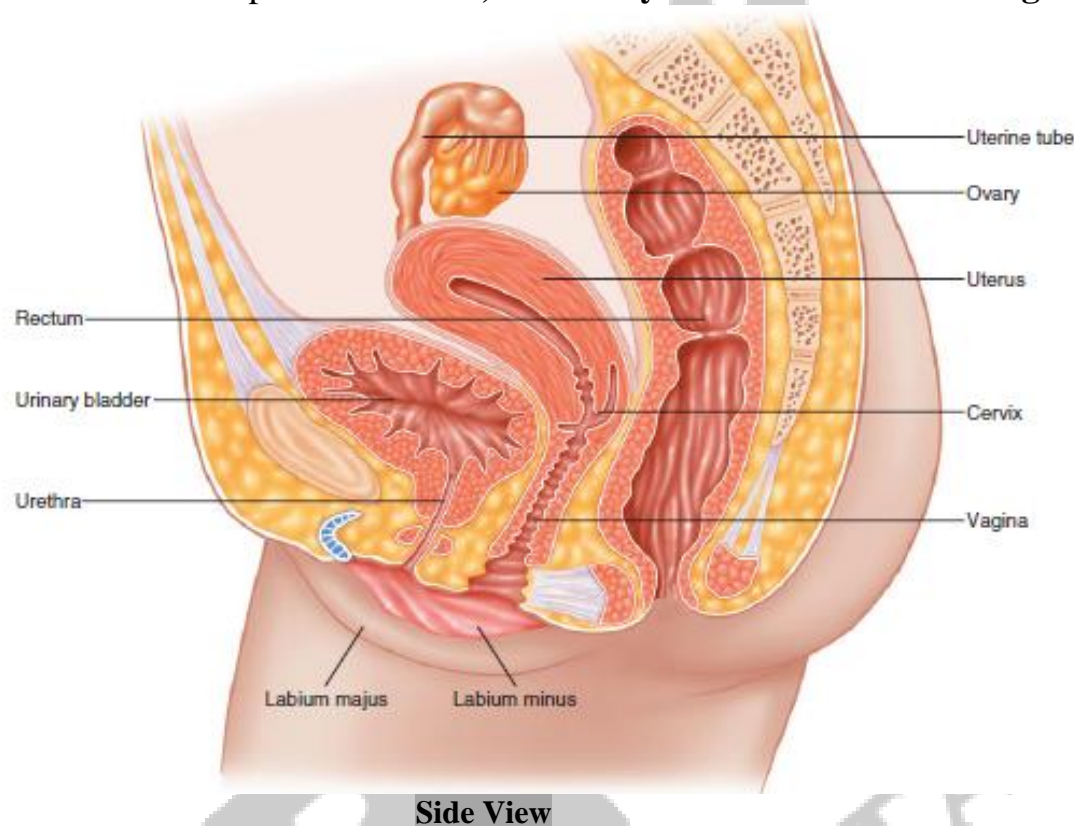
- Include
  1. Paired **seminal vesicles**
  2. A **prostate**
  3. Paired **bulbourethral glands**- The secretion helps in the lubrication of the penis.
- Secretions of these glands constitute the **seminal plasma** which is rich in **fructose** (provide energy to the sperm for swimming), **Ca<sup>+</sup>** (play imp. role in acrosomal reaction) and certain **enzymes**.

## External genitalia (Penis)

- It is the copulatory organ made up of spongy tissue which when filled with blood causes erection of penis.
- The enlarged end of penis called the **glans penis** is covered by a loose fold of skin called **foreskin**.

# THE FEMALE REPRODUCTIVE SYSTEM

- ❖ It consists a pair of **Ovaries**, **Accessory ducts** and the **external genitalia**.



## Ovaries

- ◆ **1<sup>o</sup> sex organs** that produce ovum (the female gamete) and several steroid hormones (ovarian hormones).
- ◆ Located one on each side of the lower abdomen; connected to the pelvic wall and uterus by ligaments.
- ◆ Each ovary is almond shaped; about 2- 4 cm in length, 2cm width & 1cm thick.
- ◆ Each ovary is covered by a thin epithelium which encloses the **ovarian stroma**. The stroma is divided into two zones –
  1. An outer **cortex** -
  2. An inner **medulla**- contains many rounded bodies **ovarian** or **Graaffian follicle** at various stages of development.

The oviducts (fallopian tubes), uterus and vagina constitute the **female accessory ducts**

## Oviducts

- ◆ Muscular tubes of 10-12 cm long which carry the ovum from ovary to the uterus. It is divided into 3:-
  - (i) The part closer to the ovary is the funnel-shaped **infundibulum**.  
The edges of the infundibulum possess finger-like projections called **fimbriae**, which help in collection of the ovum after ovulation.
  - (ii) The infundibulum leads to a wider part of the oviduct called **ampulla**.
  - (iii) The last part of the oviduct, **isthmus** has a narrow lumen and it joins the uterus.

## Uterus (womb)

- ◆ It is a large, inverted pear-shaped, elastic median sac specialized for the development of the embryo. Supported by ligaments attached to the pelvic wall.
- ◆ The wall of the uterus has 3 layers of tissue-
  1. External **Perimetrium** (thin membrane)
  2. Middle **Myometrium** (thick layer of smooth muscle) - exhibits strong contraction during delivery.
  3. Inner **Endometrium** (glandular layer)-undergoes cyclical changes during menstrual cycle
- ◆ Uterus opens into vagina through a narrow **cervix**. **Cervical canal** + vagina = **birth canal**



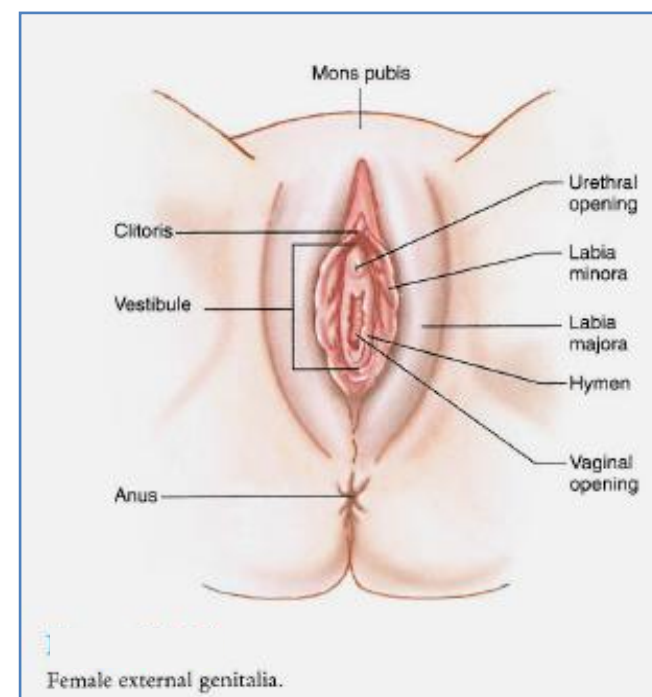
## Vagina

- It is a large, elastic, muscular tube about 7.5cm long.

## External genitalia (Vulva)

- Consists of mons pubis, labia majora, labia minora, hymen and clitoris
  - Mons pubis** is a cushion of fatty tissue covered by skin and pubic hair.
  - The **labia majora** are fleshy folds of tissue, which extend down from the mons pubis and surround the vaginal opening.
  - The **labia minora** are paired folds of tissue under the labia majora.
  - The **clitoris** is a tiny finger-like structure which lies above the urethral opening.
  - The opening of the vagina is often covered partially by a membrane called **hymen**.

→ The hymen is often torn during the first coitus (intercourse). *It can also be broken by a sudden fall or jolt, insertion of a vaginal tampon, active participation in some sports like horseback riding, cycling, etc. In some women the hymen persists even after coitus. So the presence or absence of hymen is not a reliable indicator of virginity.*



## MAMMARY GLAND (*Breasts*—not part of the reproductive system, but aids in child care)

- The mammary glands are paired structures that contain glandular and fatty tissue.
- Each **glandular tissue** is divided into 15-20 **mammary lobes** containing clusters of cells called **alveoli**. The cells of alveoli secrete milk, which is stored in the cavities (**lumens**).

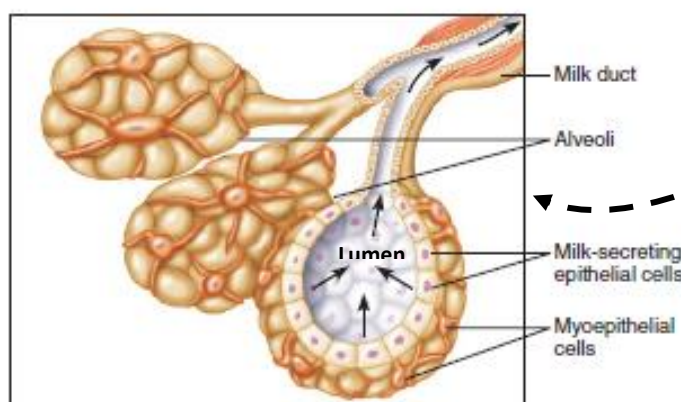
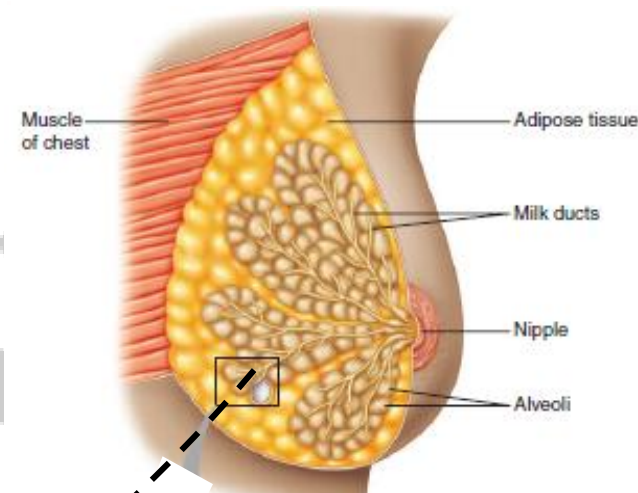
↓  
The alveoli open into **mammary tubules**.

↓  
The tubules of each lobe join to form a **mammary duct**.

↓  
Several mammary ducts join to form a wider **mammary ampulla**

↓  
This is connected to **lactiferous duct**

↓  
Ducts combines to form **nipple** through which milk is sucked out.



# GAMETOGENESIS

- The primary sex organs – the testis in the males and the ovaries in the females – produce gametes, i.e, **sperms** and **ovum** respectively.

## Spermatogenesis

- It occurs in 2 steps:-

### **Step 1. Formation of spermatids**

This step include following phases-

#### **(i) Multiplication Phase:-**

- The **spermatogonia** present on the inside wall of seminiferous tubules multiply by mitotic division and increase in numbers.

#### **(ii) Growth Phase:-**

- Spermatogonia grow and increase in size to form **1<sup>o</sup> spermatocytes** (diploid-46 chromosomes).

#### **(iii) Maturation Phase:-**

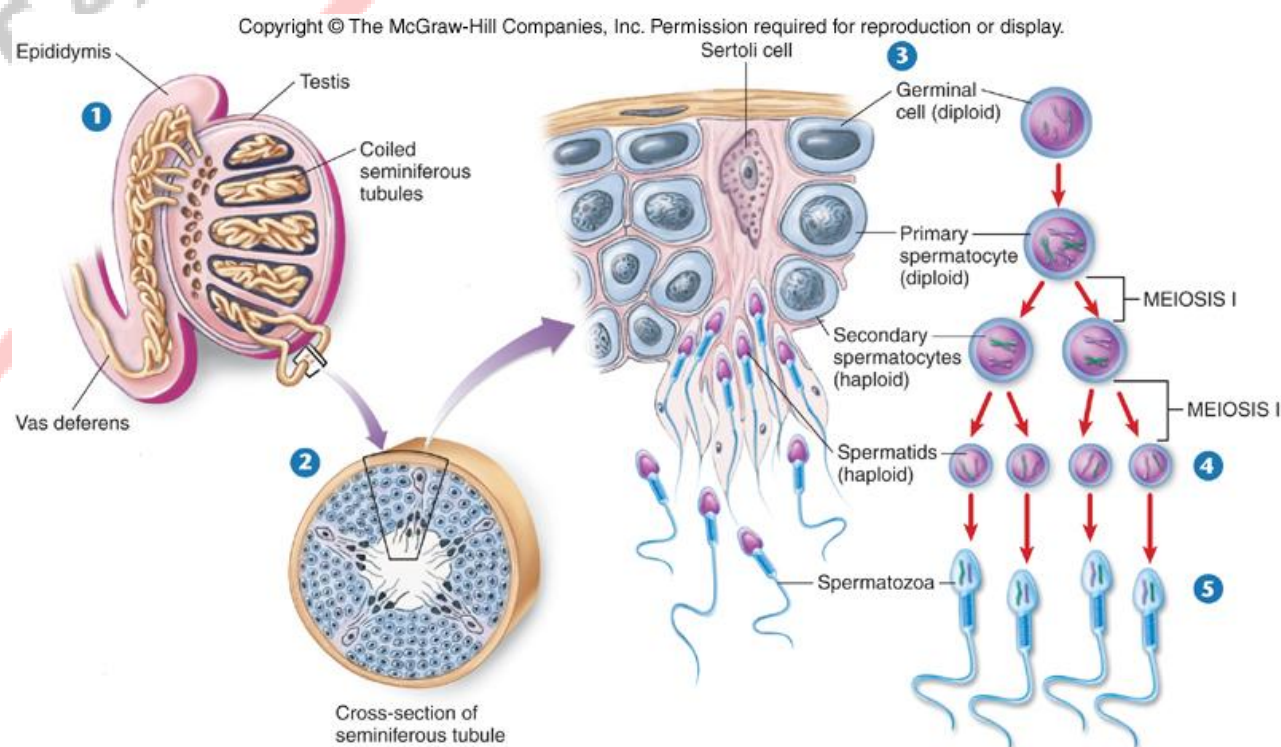
- Some of the **1<sup>o</sup> spermatocytes** periodically undergo **1<sup>st</sup> meiotic division** (reduction division) leading to formation of 2 equal **2<sup>o</sup> spermatocytes**, (haploid).
- The **2<sup>o</sup> spermatocytes** undergo the **2<sup>nd</sup> meiotic division** to produce 4 equal, haploid **spermatids**.

### **Step 2. Spermiogenesis**

- It is process of transformation of spermatids into **spermatozoa** (sperms).

**Changes occurred**- \*Transformation of nucleus into head, \*Acrosome formation, \* Losing cytoplasm, \*Formation of tail

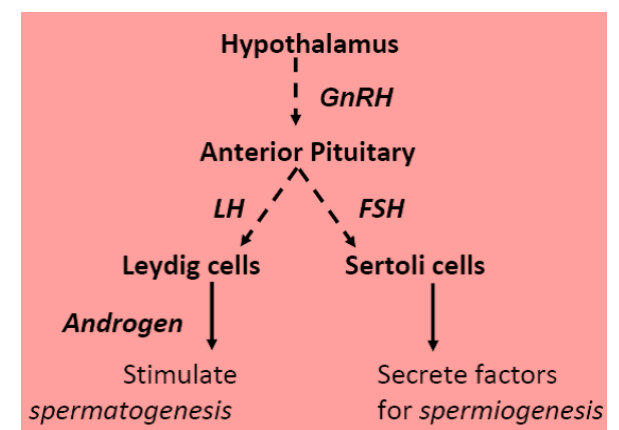
- After spermiogenesis, sperm heads become embedded in the **Sertoli cells**, and are finally released from the seminiferous tubules by the process called **spermiation**.





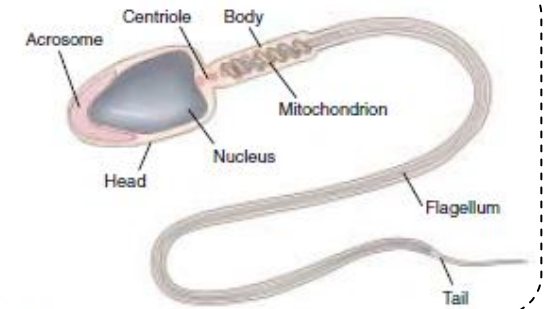
## Hormonal action on spermatogenesis

- Spermatogenesis starts at the age of puberty due to significant increase in the secretion of gonadotropin releasing hormone (GnRH).
- \*The increased levels of GnRH then acts at the anterior pituitary gland and stimulates secretion of two gonadotropins – luteinising hormone (LH) and follicle stimulating hormone (FSH).
- 1. **LH acts** at the Leydig cells and stimulates synthesis and secretion of androgens. **Androgens**, in turn, stimulate the process of spermatogenesis.
- 2. **FSH acts** on the Sertoli cells and stimulates secretion of some factors which help in the process of spermiogenesis.



### Structure of a sperm

- A mature sperm is 0.06mm long, flagellated cell.
  - A plasma membrane envelops the whole body of sperm.
- Sperm consists of-
- Head:** Oval shaped. Containing **nucleus** and capped by **acrosome** (contains **lytic enzymes**).
  - Middle piece:** Contain **mitochondria** which produce energy for the sperm motility.
  - Tail:** It helps the sperm moves in fluid medium by the **undulating movement**.



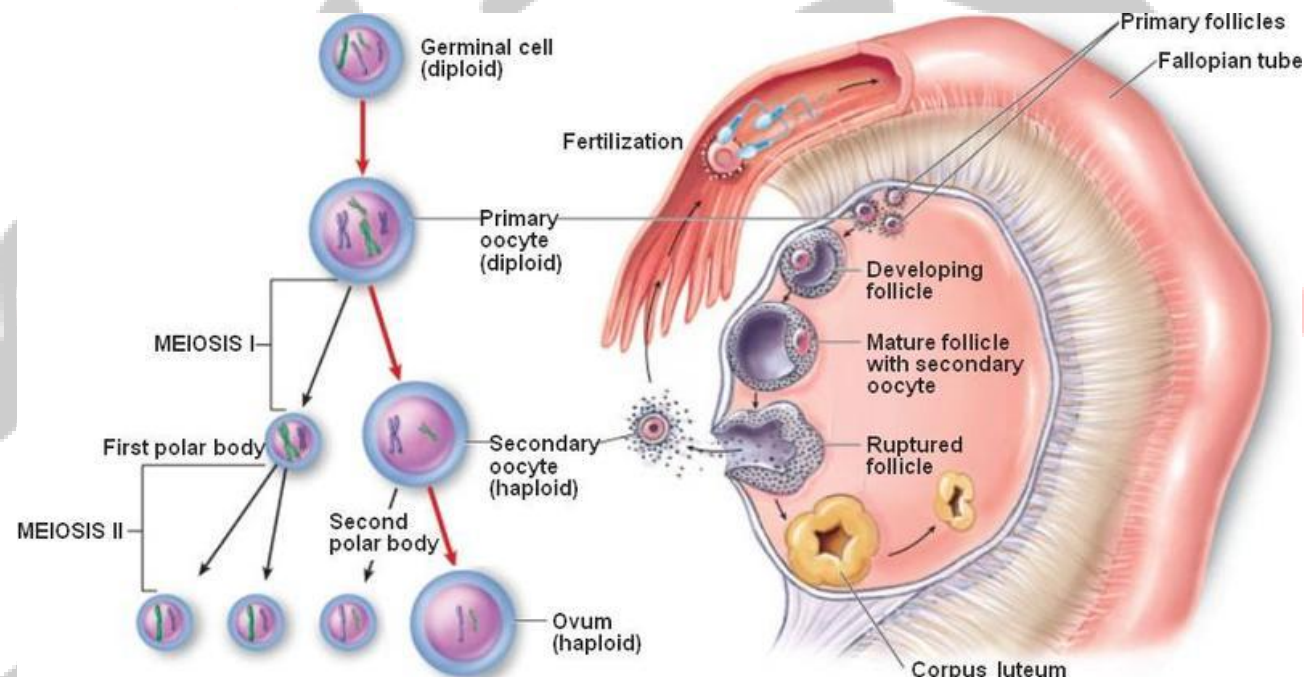
- The human male ejaculates about 200 to 300 million sperms during a coitus.
- For normal fertility, at least 60% sperms must have normal shape and size and at least 40 % of them must show vigorous motility.
- Semen**= *sperm* (10%) + seminal plasma

## Oogenesis

- ✓ This process include following phases-

### (i) Multiplication Phase:-

- At foetal stage, about 2 million gamete mother cells (**oogonia**) are formed within each ovary; no more oogonia are formed after birth.

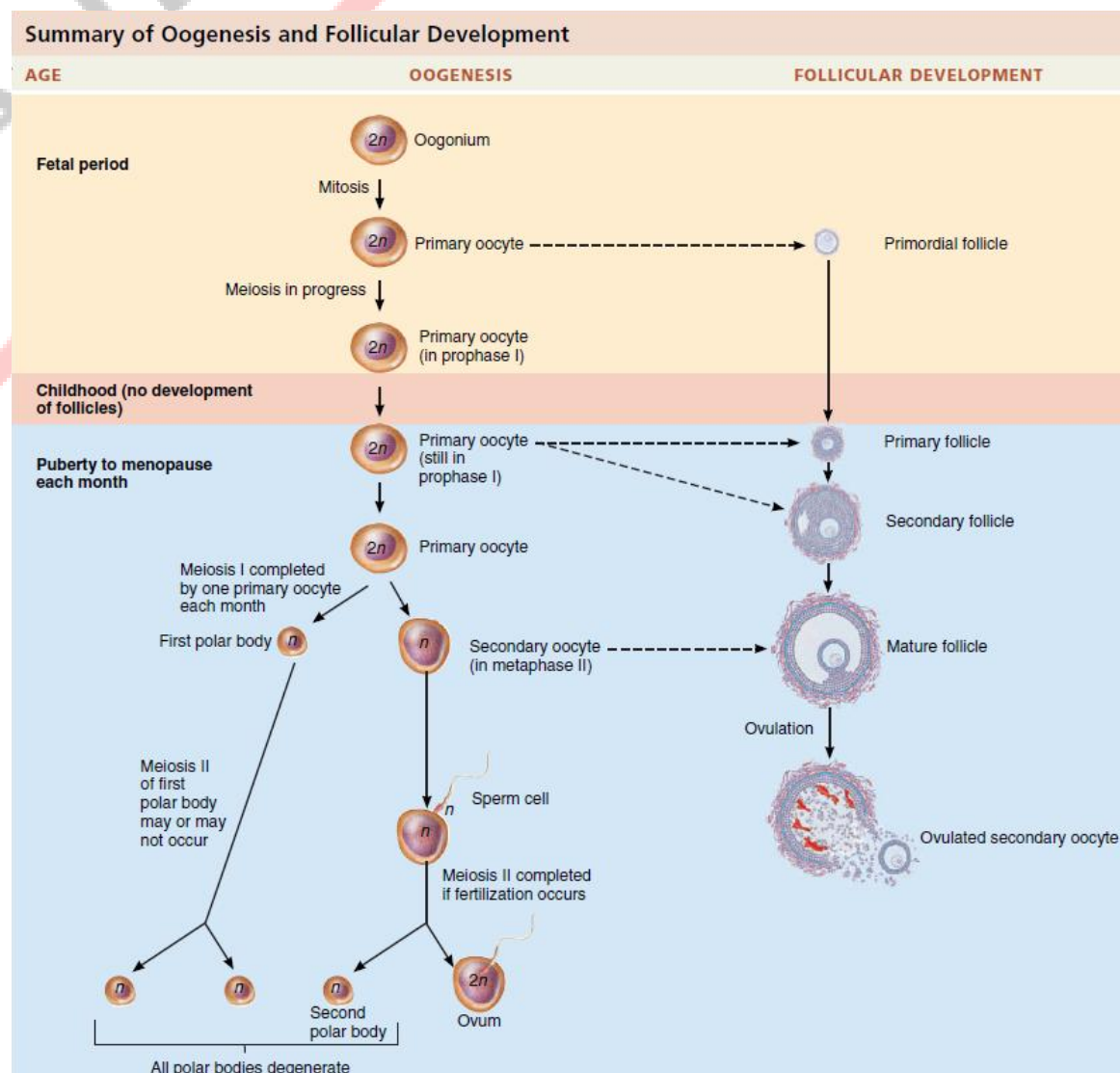


### (ii) Growth Phase:-

- Oogonia divide and enter into *prophase-I* of the meiotic division and get temporarily arrested at that stage, called **1<sup>o</sup> oocytes**.
- Each 1<sup>o</sup> oocyte then gets surrounded by a layer of **granulosa cells** and is called the **1<sup>o</sup> follicle**. A large number of these follicles degenerate during the phase from birth to puberty.
- Therefore, at puberty only 60,000-80,000 1<sup>o</sup> follicles are left in each ovary.
- The 1<sup>o</sup> follicles get surrounded by more layers of granulosa cells and a new theca and are called **2<sup>o</sup> follicles**.
- The 2<sup>o</sup> follicle soon transforms into a **3<sup>o</sup> follicle** which is characterised by a fluid filled cavity called **antrum**.
- Then, the **1<sup>o</sup> oocyte** within the 3<sup>o</sup> follicle grows in size.

### (iii) Maturation Phase:-

- 1<sup>o</sup> oocyte completes its *1<sup>st</sup> meiotic division* to form a large haploid **2<sup>o</sup> oocyte** and a tiny **first polar body**.
- The **3<sup>o</sup> follicle** changes into the mature **Graafian follicle**.
- The 2<sup>o</sup> oocyte forms a new membrane called **zona pellucid** surrounding it.
- The Graafian follicle now ruptures to release the 2<sup>o</sup> oocyte (ovum) from the ovary by the process called **ovulation**.



### Comparison between spermatogenesis and oogenesis

Spermatogenesis	Oogenesis
i. It occurs in the testis	i. In Ovary
ii. Gamete is called sperm	ii. Ovum
iii. Limited growth phase	iii. Elaborated
iv. Each 1 <sup>0</sup> spermatocyte gives 4 sperms	iv. Each 1 <sup>0</sup> oocyte gives only 1 ovum and 3 polar bodies
v. It begins at puberty and extends up to senility	v. It begins at embryonic stage and suspended at the time of birth. The remaining part takes place only after puberty.

## MENSTRUAL CYCLE

- It is the cyclic changes in the activity of ovaries and accessory ducts as well as hormones during the reproductive phase in a female body, with menstruation, repeated at an average interval of about 28/29 days
- The first menstruation begins at puberty and is called menarche.
- Menstrual cycle has the following phases:-

### I. Menstrual / Bleeding Phase: 1-5<sup>th</sup> day

- The cycle starts with menstrual flow and it lasts for 3-5 days.
- It is due to breakdown of endometrial lining of the uterus and its blood vessels which forms liquid that comes out through vagina.
- Menstruation only occurs if the released ovum is not fertilised.
- Lack of menstruation may be indicative of pregnancy. It may also be caused due to stress, poor health etc.

### II. Proliferative / Follicular Phase: 6-13<sup>th</sup> day

- The secretion of **FSH** increases gradually from pituitary.  
FSH stimulates:-
  - Development of 1<sup>0</sup> follicles into **Graafian follicles**. It secretes **Estrogen**.
- Estrogens stimulate:-
  - Proliferation of ruptured uterine endometrium**.
  - Secretion of **LH**.

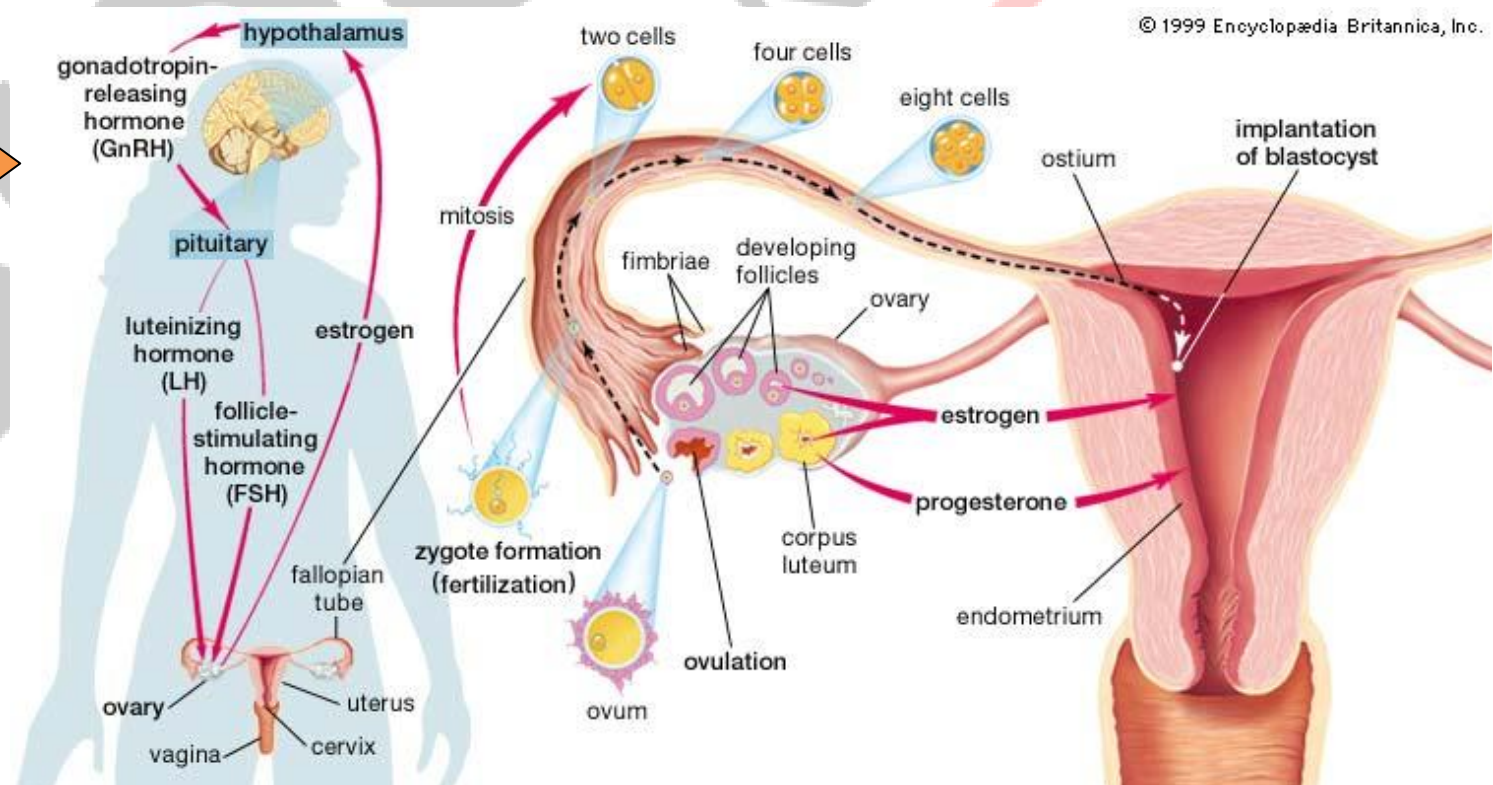
### III. Ovulatory Phase: 14<sup>th</sup> day

- Both LH and FSH attain a peak level.
- Rapid secretion of LH (**LH surge**) empty *Graafian follicle* to release ovum (**ovulation**).

### IV. Secretory / Luteal Phase: 15-28<sup>th</sup> day

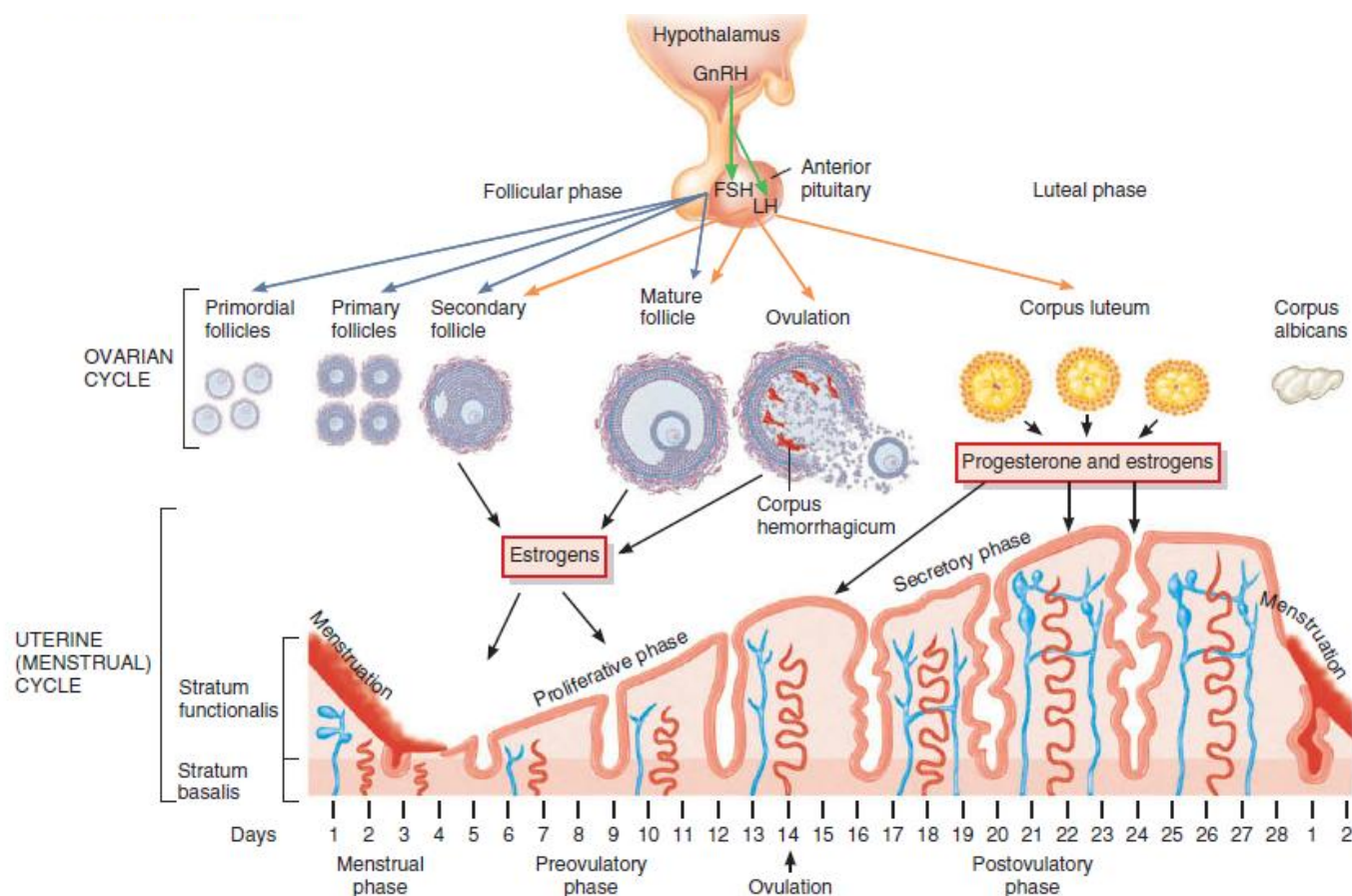
- After ovulation, **Graafian follicle** is transformed into a yellow glandular mass called **Corpus luteum**.
- It secretes large amount of **progesterone** which is essential for *maintenance of the endometrium*.  
Thus the uterus gets ready for implantation (of the fertilised ovum) and other events of pregnancy.
- If fertilization does not occur, corpus luteum degenerates. This causes disintegration of the endometrium leading to menstruation, marking a new cycle.

### Hormonal action on Menstrual Cycle



- During pregnancy all events of menstrual cycle stop and there is no menstruation.
- ➔ In human beings, menstrual cycles cease around 50 years of age; that is termed as menopause.





## FERTILISATION AND IMPLANTATION

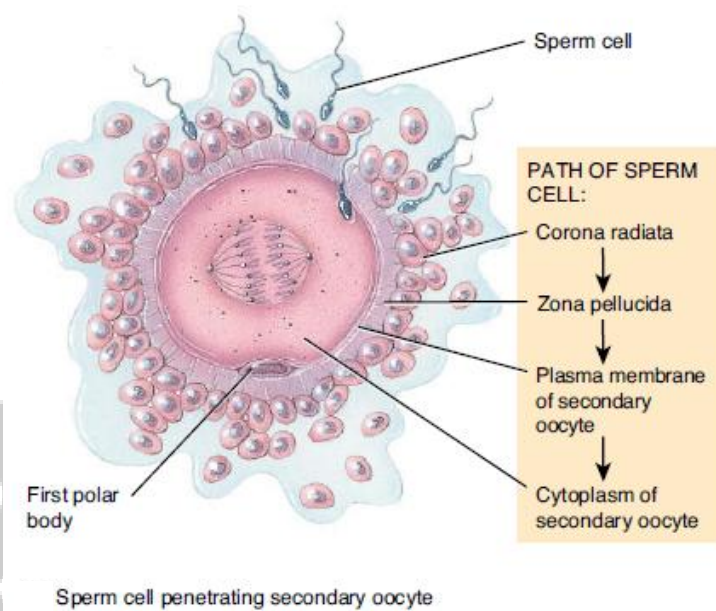
- During coitus, semen is released by the penis into the vagina (**insemination**).
- Fertilisation (**sperm + ovum** → **zygote**) can only occur if the ovum and sperms are transported simultaneously to the ampullary-isthmic junction. That is why; all copulations do not lead to fertilisation and pregnancy.

Sperms → vagina → cervical canal → uterus → isthmus

**Fertilization** ← Ampullary-isthmic Junction

Ovum (from ovary) → fimbriae → infundibulum → ampulla

- During fertilisation, a sperm comes in contact with the *zona pellucida* layer of the ovum and induces changes in the membrane that block the entry of additional sperms.
- Thus, it ensures that only one sperm can fertilise an ovum.

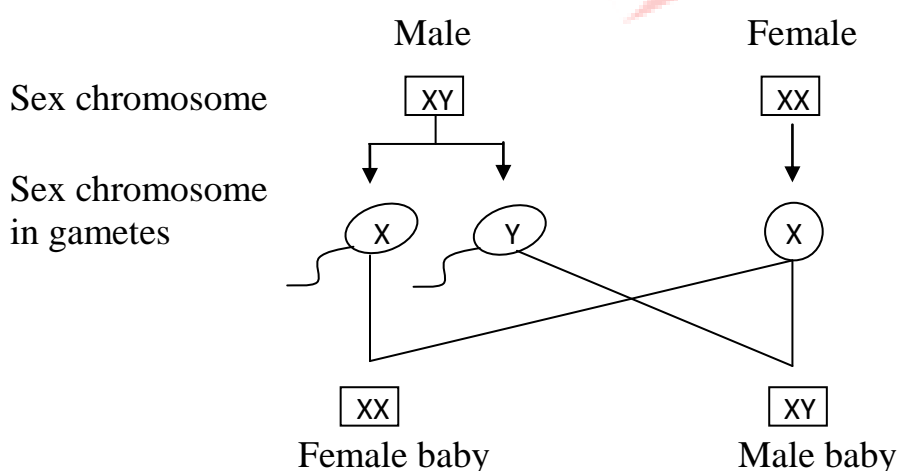


- The secretions of the acrosome help the sperm enter into the cytoplasm of the ovum through the zona pellucida and the plasma membrane.
- This induces the completion of the 2<sup>nd</sup> meiotic division of the secondary oocyte. This results in the formation of a second polar body and a haploid ovum (ootid).

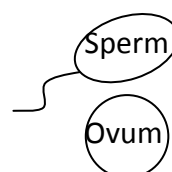
Soon the haploid nucleus of the sperms and that of the ovum fuse together to form a diploid zygote.

### SEX DETERMINATION

- The sex of the baby has been decided at the time of fertilisation.



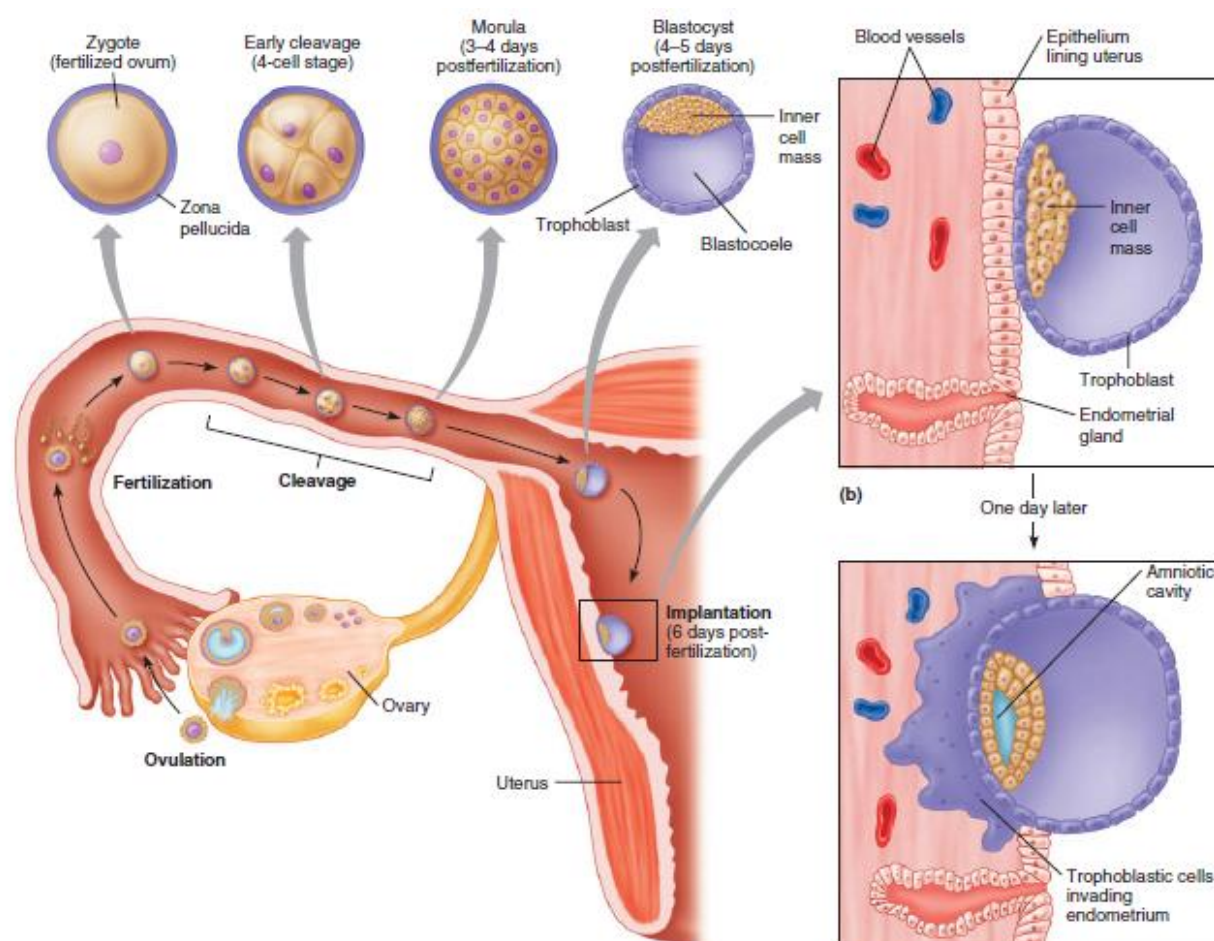
Indicators:-



Thus, the sex of the baby is determined by the father.



- ✚ The mitotic division (**cleavage**) starts as the zygote moves through the isthmus towards the uterus and forms 2, 4, 8, 16 daughter cells called **blastomeres**.



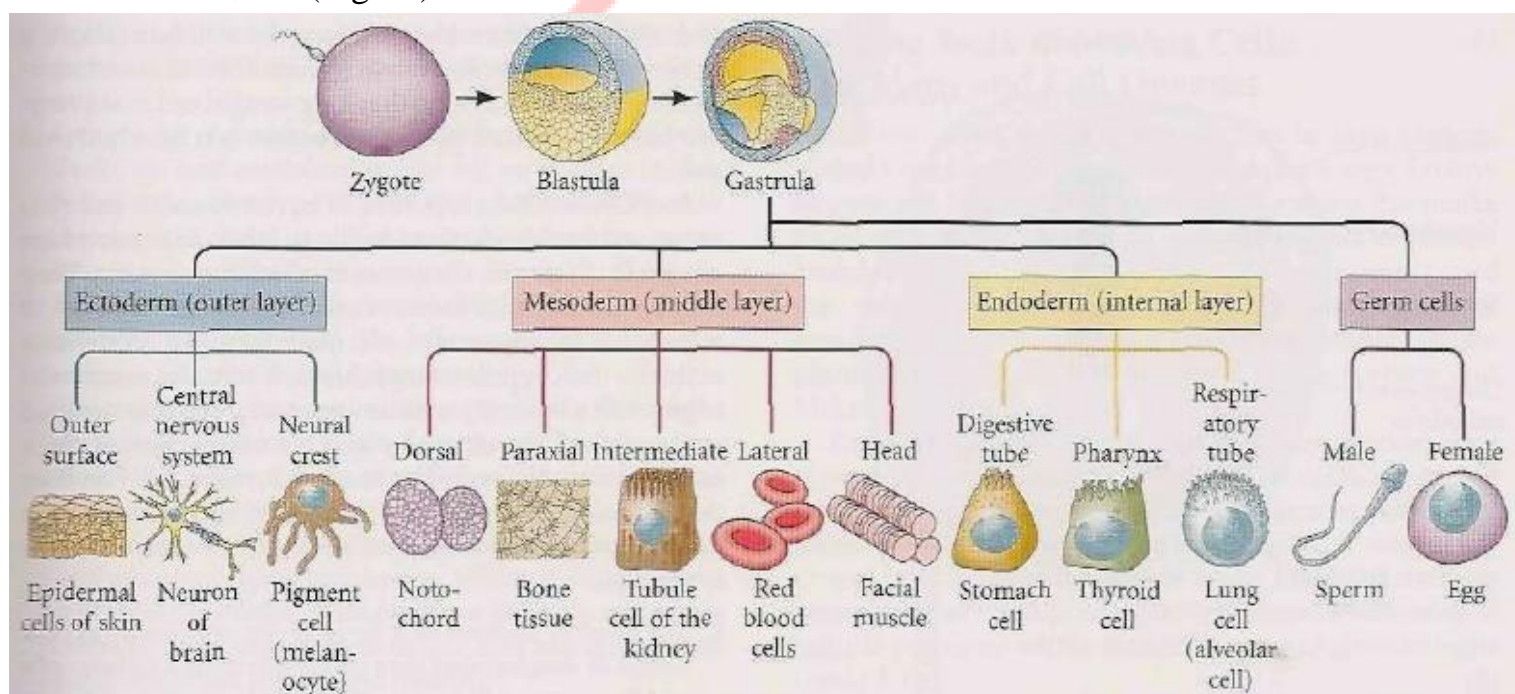
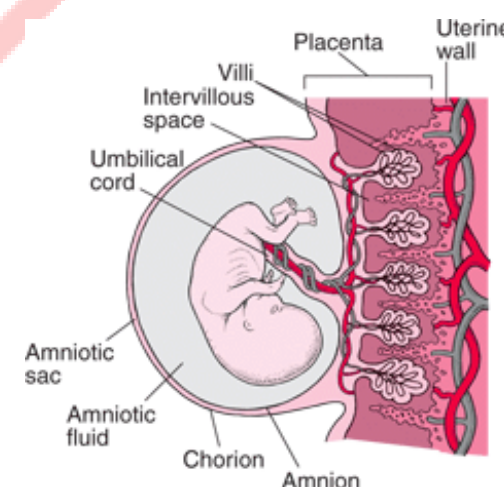
- ✚ The embryo with 8-16 blastomeres is called a **morula**
- ✚ The morula continues to divide and transforms into **blastocyst**. The blastomeres in the blastocyst are arranged into an outer layer (**trophoblast**) and an inner group of cells (**inner cell mass**) attached to trophoblast. The trophoblast layer then gets attached as finger-like projections (**chorionic villi**) to the endometrium and the inner cell mass give rise to the **embryo**.
- ✚ After attachment, the uterine cells divide rapidly and covers the blastocyst. As a result, the blastocyst becomes embedded in the endometrium of the uterus (**implantation**) and it leads to pregnancy.

## PREGNANCY AND EMBRYONIC DEVELOPMENT

- ◆ The chorionic villi and uterine tissue become inter digitated with each other and jointly form a structural and functional unit between developing embryo (foetus) and maternal body called **placenta**.
  - Placenta is connected to the embryo by an **umbilical cord**. It transports substances to and from the embryo.

### Functions of placenta:

- Supply O<sub>2</sub> and nutrients to the embryo
  - Remove CO<sub>2</sub> and waste materials produced by the embryo.
  - Acts as an endocrine gland by secreting **Human chorionic gonadotropin (hCG)**, **human placental lactogen (hPL)**, **oestrogens**, **progesterone**.
- ◆ In the later phase of pregnancy, a hormone called **relaxin** is also secreted by the ovary which helps in parturition by softening the connective tissue of the pubic symphysis.
- ◆ During pregnancy the levels of other hormones like estrogens, progestogens, cortisol, prolactin, thyroxine, etc., are increased several folds in the maternal blood. They support:-
  - The fetal growth
  - Metabolic changes in the mother
  - Maintenance of pregnancy.
- ◆ Immediately after implantation, the inner cell mass (embryo) differentiates into an outer **ectoderm**, middle **mesoderm** and an inner **endoderm**.  
These 3 layers give rise to all tissues (organs) in adults.





## Developmental stages of human embryo during pregnancy

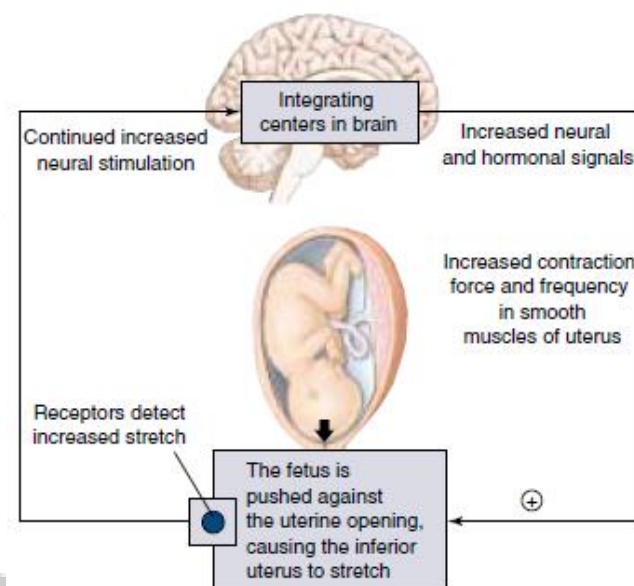
- ♦ The human pregnancy lasts 9 months (gestation period).
  - 1<sup>st</sup> month** - Heart is formed.
  - 2<sup>nd</sup> month** - Limbs and digits develops.
  - 3<sup>rd</sup> month** - Limbs and external genital organs well develops.
- (1<sup>st</sup> trimester)- Critical period and mother should be more careful.
- 5<sup>th</sup> month**- Shows movements and appear hair on the head.
- 6<sup>th</sup> month**- The body is covered with fine hair, eye-lids separate, and eyelashes are formed.
- (2<sup>nd</sup> trimester)
- 9<sup>th</sup> month**- The foetus is fully developed and is ready for delivery.
- (3<sup>rd</sup> trimester)

## PARTURITION AND LACTATION

- ☉ Vigorous contraction of the uterus at the end of pregnancy causes expulsion/delivery of the foetus (**parturition**).

### Neuroendocrine mechanism of parturition

- The signals for parturition originate from the fully developed foetus and the placenta which induce mild uterine contractions (**foetal ejection reflex**).
- This triggers release of oxytocin from the maternal pituitary.
- Oxytocin acts on the uterine muscle and causes stronger uterine contractions, which in turn stimulates further secretion of oxytocin.
- Contraction get stronger, which leads to expulsion of the baby out of the uterus through the birth canal.



Soon after the infant is delivered, the placenta is also expelled out of the uterus.



- ☉ The mammary glands of the female undergo differentiation during pregnancy and starts producing milk towards the end of pregnancy by the process called **lactation**.
  - This helps the mother in feeding the newborn.
  - The milk produced during the initial few days of lactation (**colostrum**) which contains several antibodies absolutely essential to develop resistance for the new-born babies.

