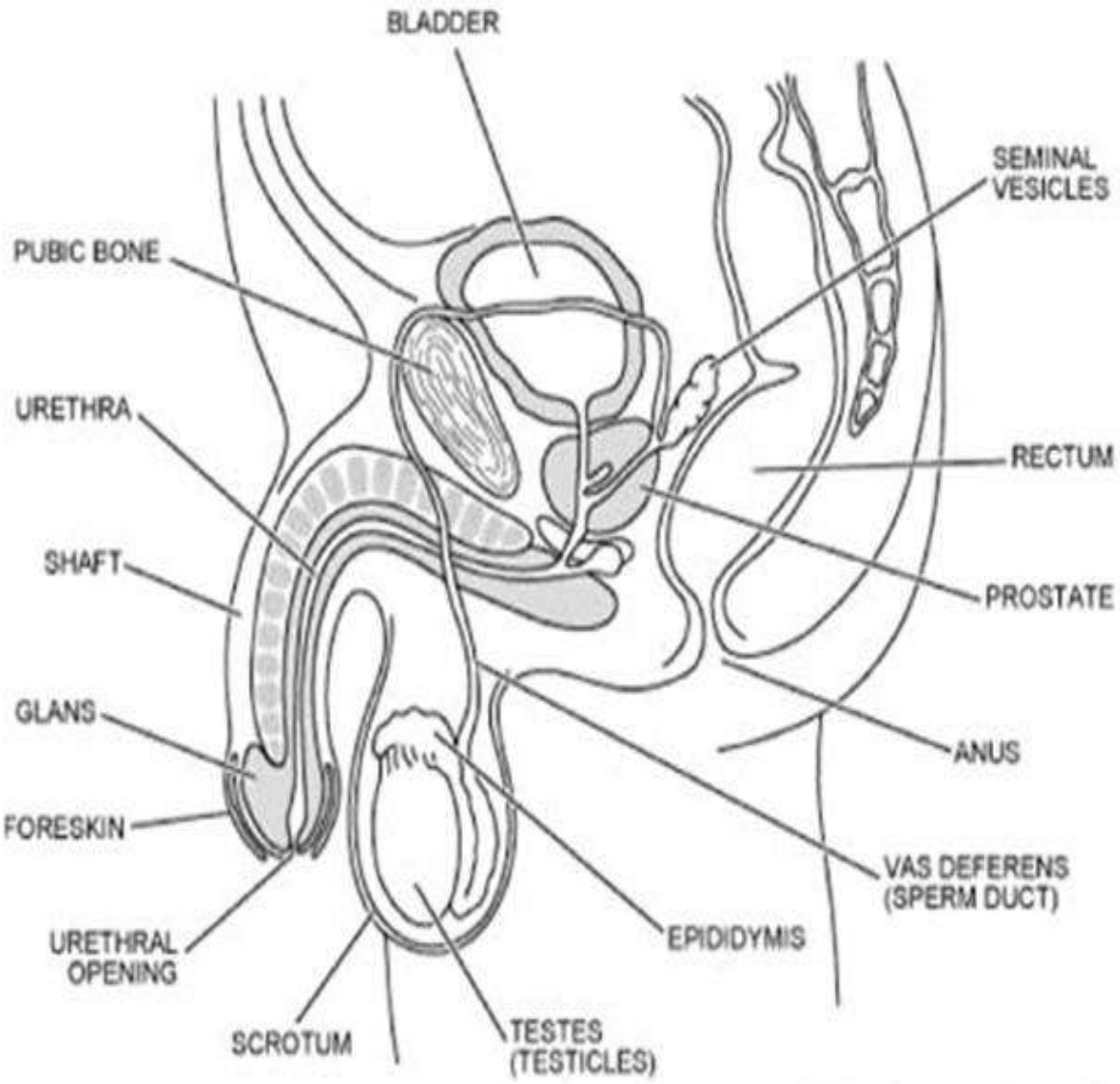
Human Reproduction

REPRODUCTIVE EVENTS

- Humans sexual reproduction, viviparous, unisexual.
- Each sex has pair of gonads, reproductive duct and accessory structures.
- Sex organs – Testis(paired) male , ovaries (paired) Gamete formation, hormones
- Puberty

1. Gametogenesis - formation of gametes (sperms/ ova)
2. Insemination -- transfer of sperms into the female genital tract
3. Fertilisation -- fusion of male and female gametes leading to formation of zygote
4. Implantation -- development of blastocyst and its attachment to the uterine wall
5. Gestation -- embryonic development (from conception to birth)
6. Parturition-- delivery of the baby (child birth)

Male reproductive system



THE MALE REPRODUCTIVE SYSTEM

- Located in pelvis region
- The Male reproductive system includes:

a) A pair of testes.
b) Accessory ducts.
c) Accessory glands.
d) External genitalia

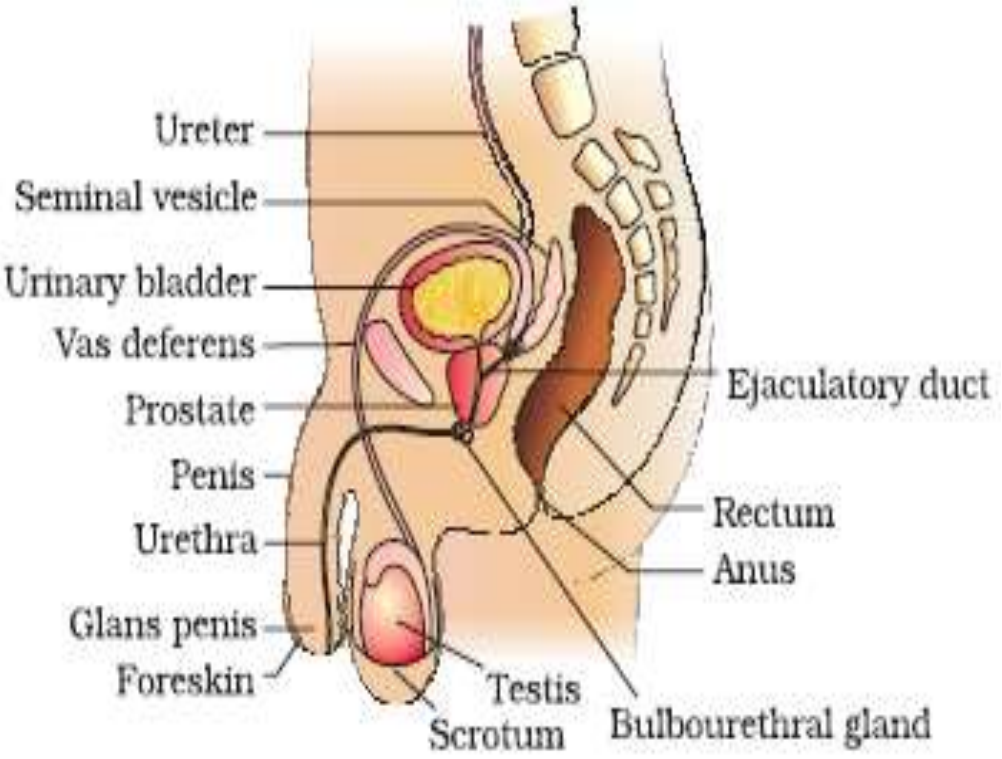
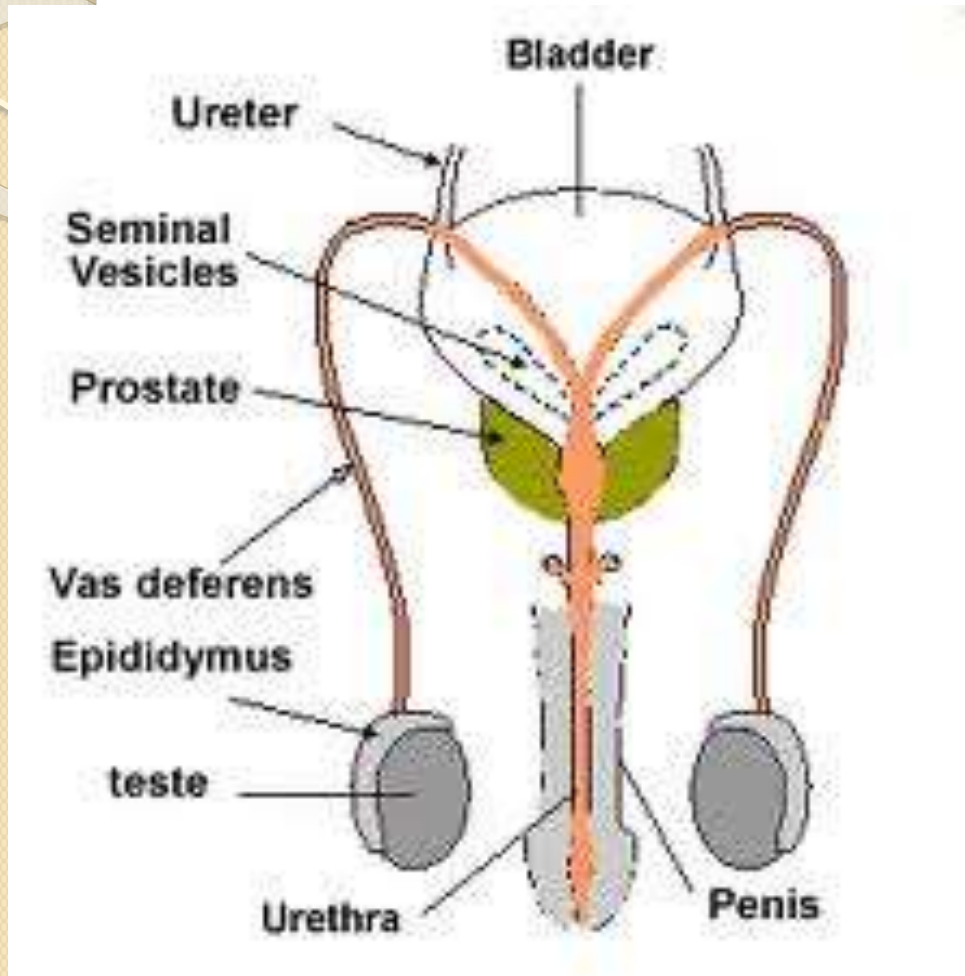


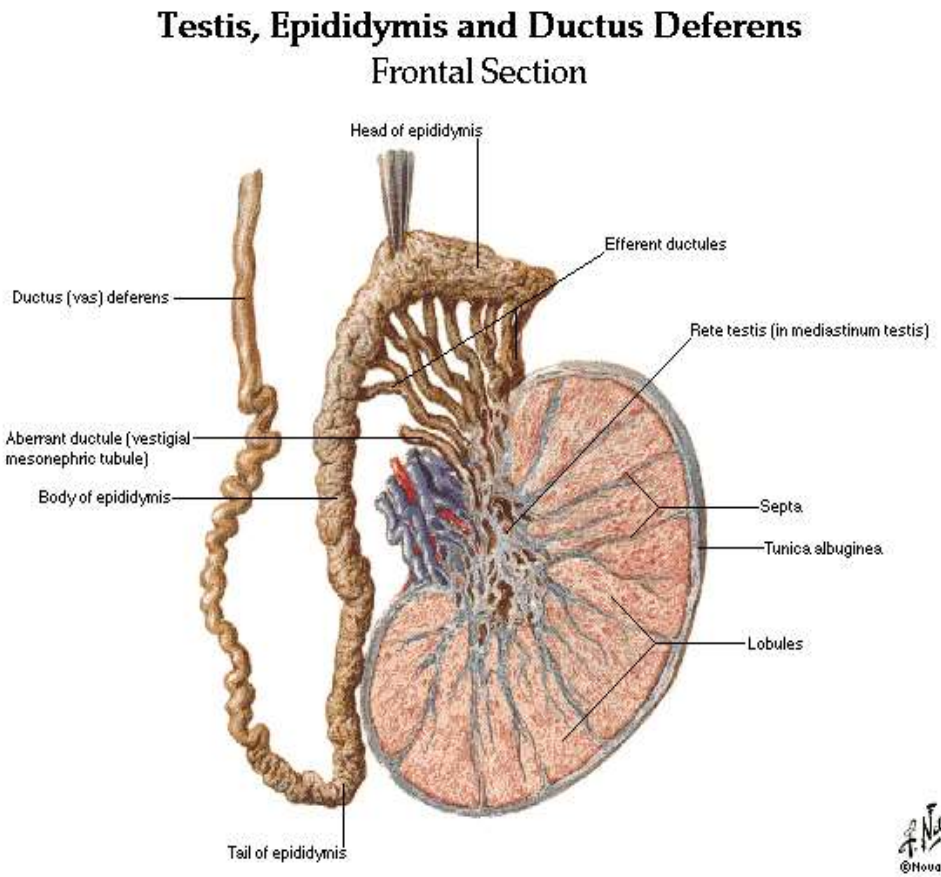
Figure 3.1(a) Diagrammatic sectional view of male pelvis showing reproductive system



- a pair of **testes (** in scrotum**)**
- **Accessory ducts, glands (**rete testis, vasa efferentia epididymis, vas deferens
- **External genitalia**.

(Penis)

TESTIS

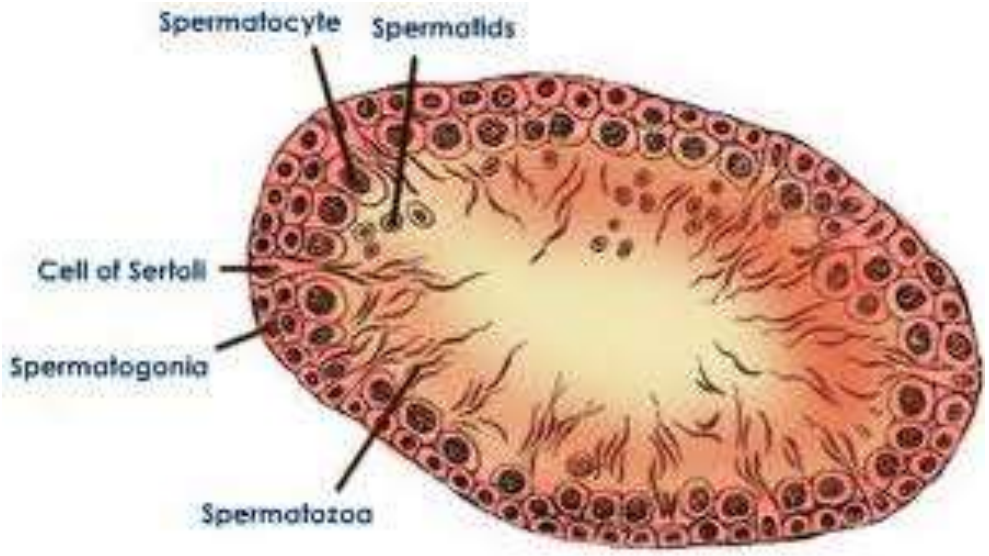


- Paired male gonads- sperm, hormones
- oval in shape, length- 4 to 5 cm, a width 2 to 3 cm
- situated outside the abdominal cavity within a pouch called **scrotum**.
- Scrotum - low temp. of the testes (2–2.5 °C lower than the normal internal body temperature) – spermatogenesis
- testis is covered by a dense covering **capsule tunica albuginea –** inside as **septae**
- In each testis -250 compartments

called **testicular lobules**

- Each lobule -1-3 convoluted (coiled) **seminiferous tubule**

SEMINIFEROUS TUBULE - SPERM PRODUCTION



- lined on its inside by two types of cells

a) **Male germ cells** (*spermatogonia*) - meiotic divisions - sperm formation

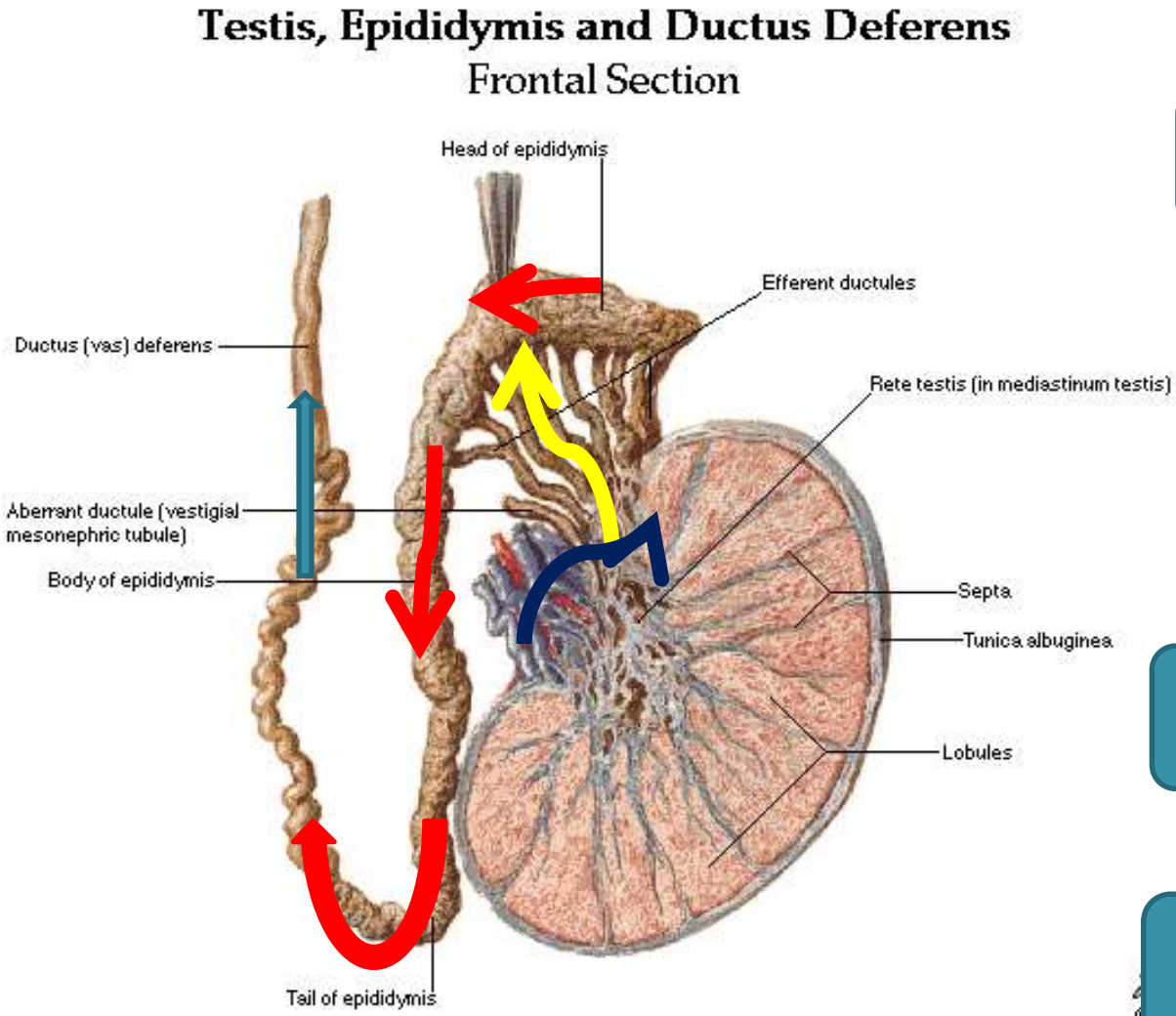
b) **Sertoli cells** (supporting cells)

-- provide nutrition to the germ cell

- regions outside the seminiferous tubules called **Interstitial spaces,** contain small blood vessels & **interstitial cells/ Leydig cells**
- **Leydig cells -** synthesise & secrete male hormone **Androgen (testosterone)**
- Other immunologically competent cells are also present

ACCESSORY DUCTS

rete testis vasa efferentia epididymis, vas deferens



Seminiferous tubule

↓

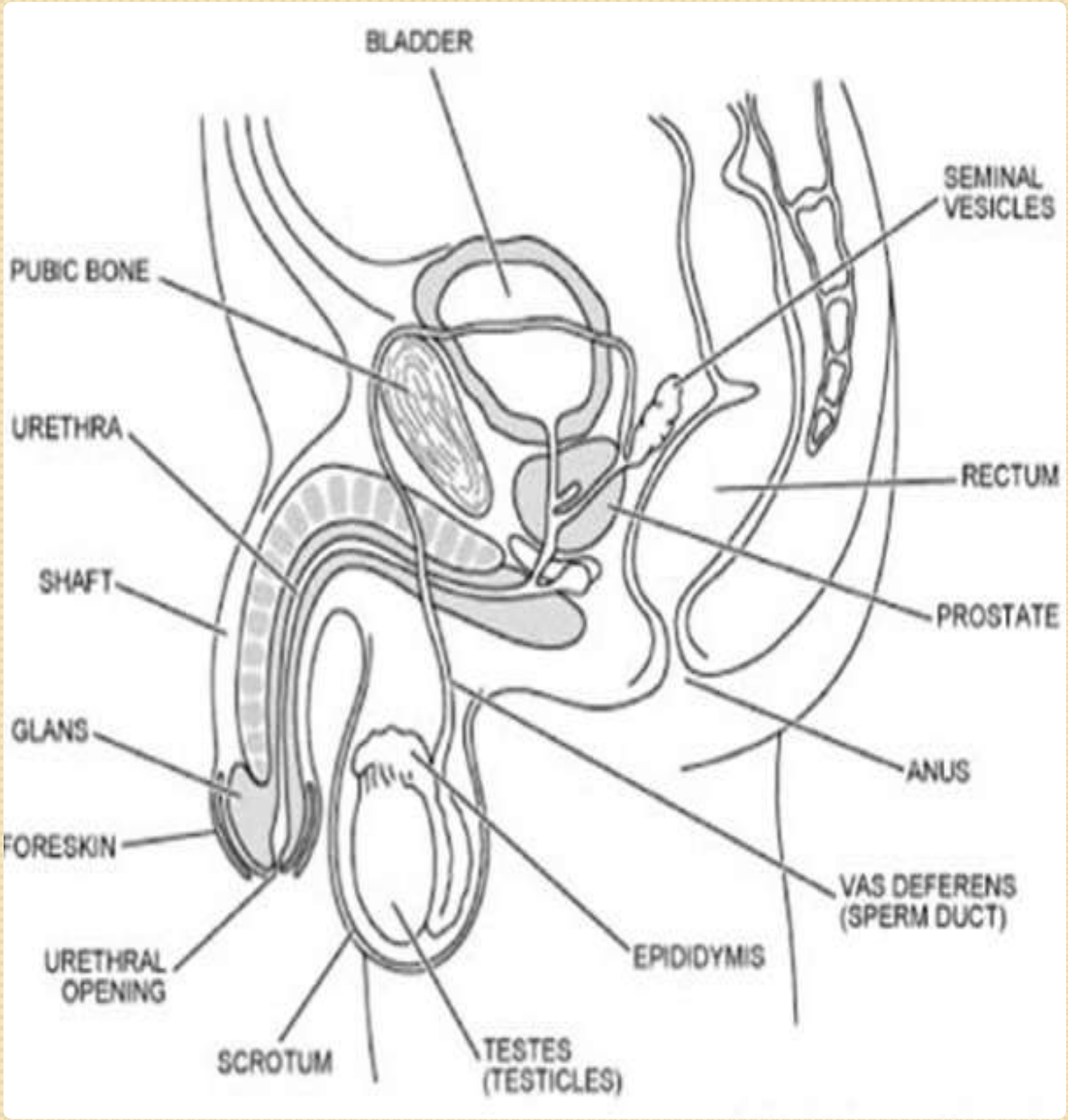
Vasa efferentia through rete testis

↓

Epididymis (posterior surface of testis)

↓

Vas deferens- ascend to abdomen & loop over urinary bladder



- Vas deferens receives duct- seminal vesicle
- Opens into urethra as **Ejaculatory duct**
- ***Function-*** *Stores & transports sperms from testis to urethra*
- Urethra- originates from urinary bladder, extends through penis to external opening- **urethral meatus**

EXTERNAL GENITALIA- PENIS

- External copulatory organ – external genitalia
- Made of special tissue- erection to facilitate insemination
- Enlarge distal end **glans penis** covered by loose skin called **fore skin**

ACCESSORY GLANDS

1. **Seminal vesicles** (paired)
2. A **Prostate gland**
3. **Bulbourethral** glands (paired)

- **Seminal plasma-** secretion of all the accessory glands.
- Rich in fructose, calcium and certain enzymes.
- Helps in lubrication

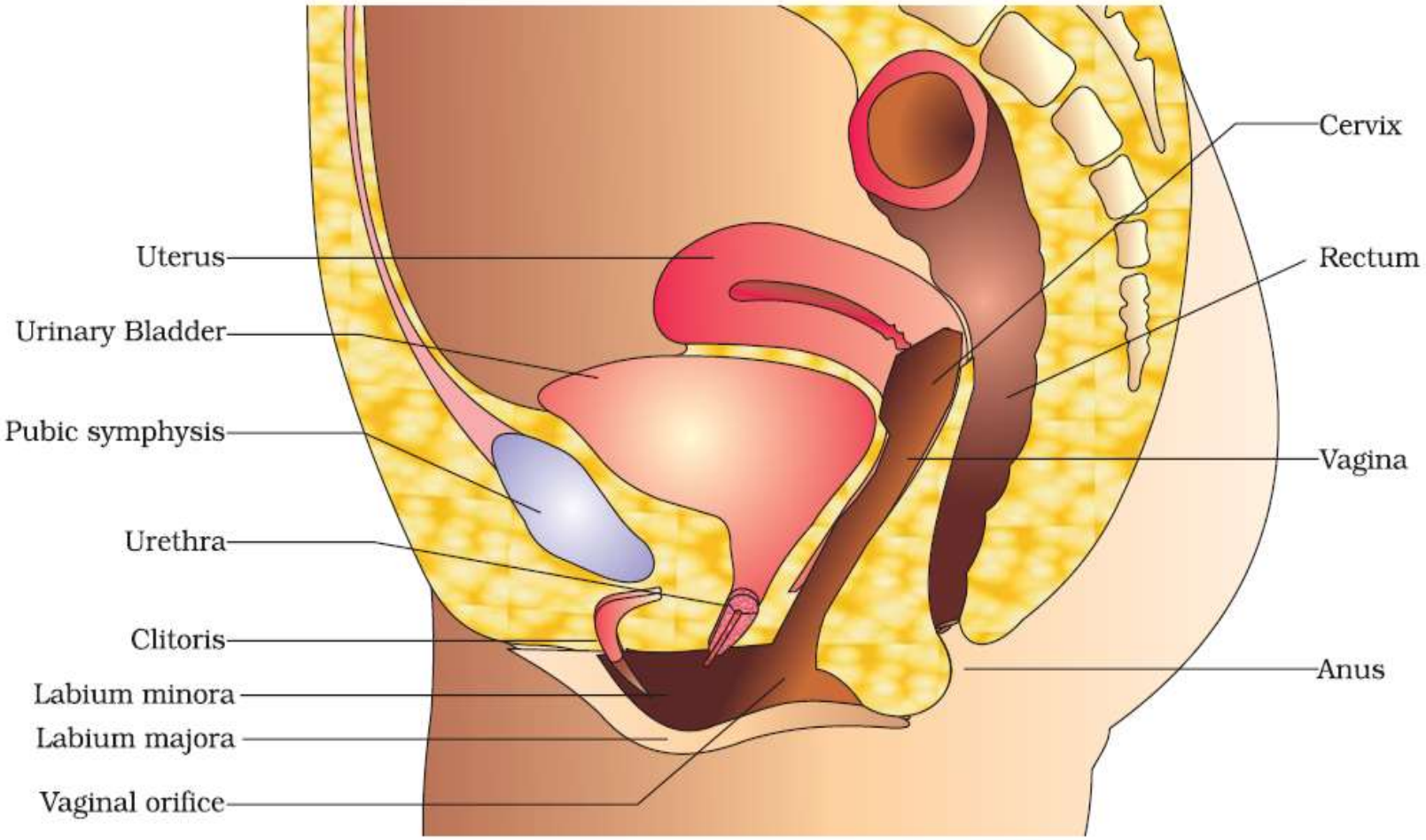
FEMALE REPRODUCTIVE SYSTEM

The female reproduction system is located in the pelvic region.

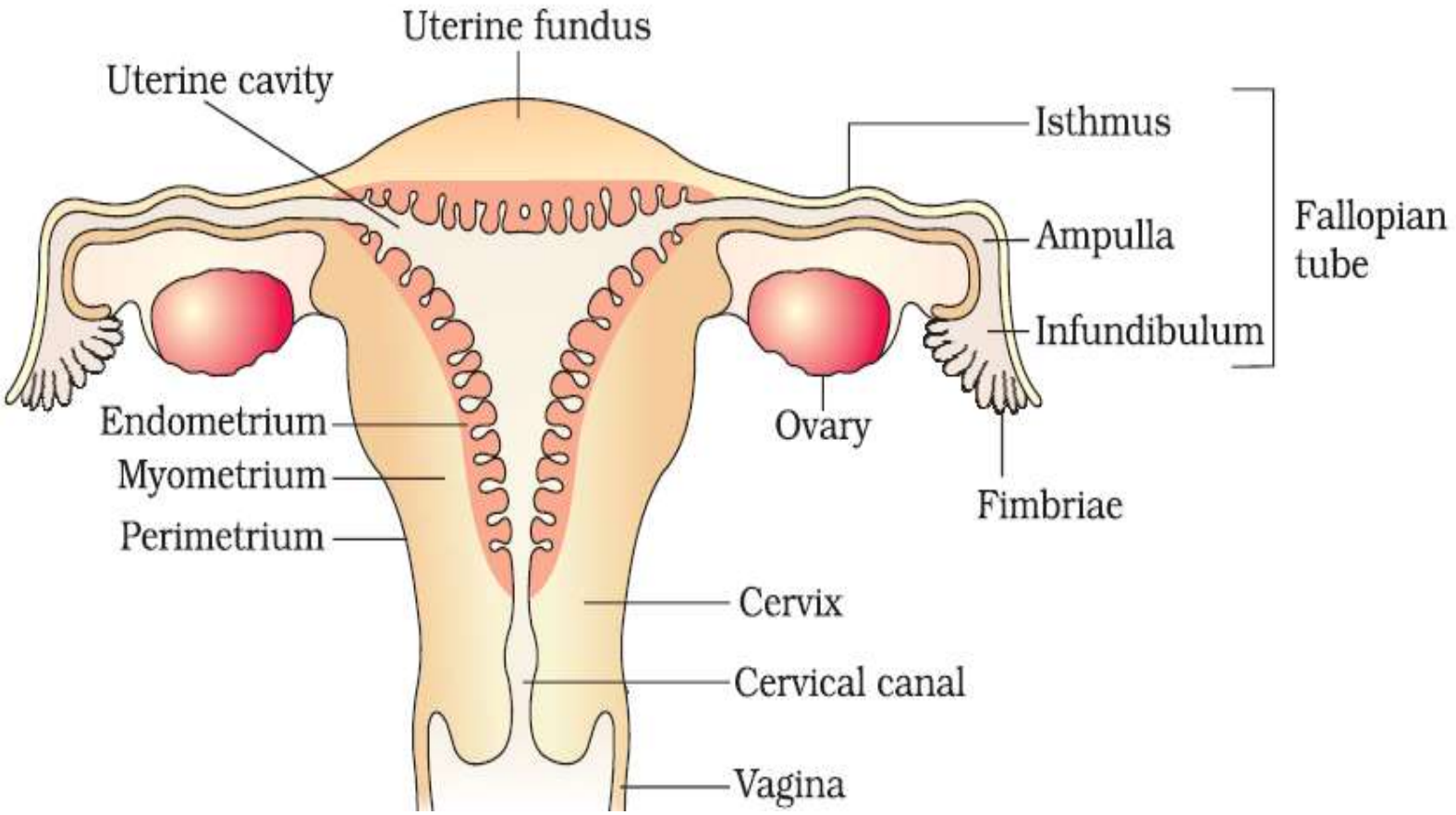
It includes:

1. A pair of ovaries
2. A pair of oviduct.
3. Uterus
4. Cervix
5. Vagina
6. External genitalia.

- **oviducts, uterus, vagina -** accessory ducts
- a pair of the **mammary glands (nourishment of offspring)**
- All parts are integrated structurally and functionally to support the processes of ovulation, fertilisation, pregnancy, birth and child care.



Sectional view through pelvis

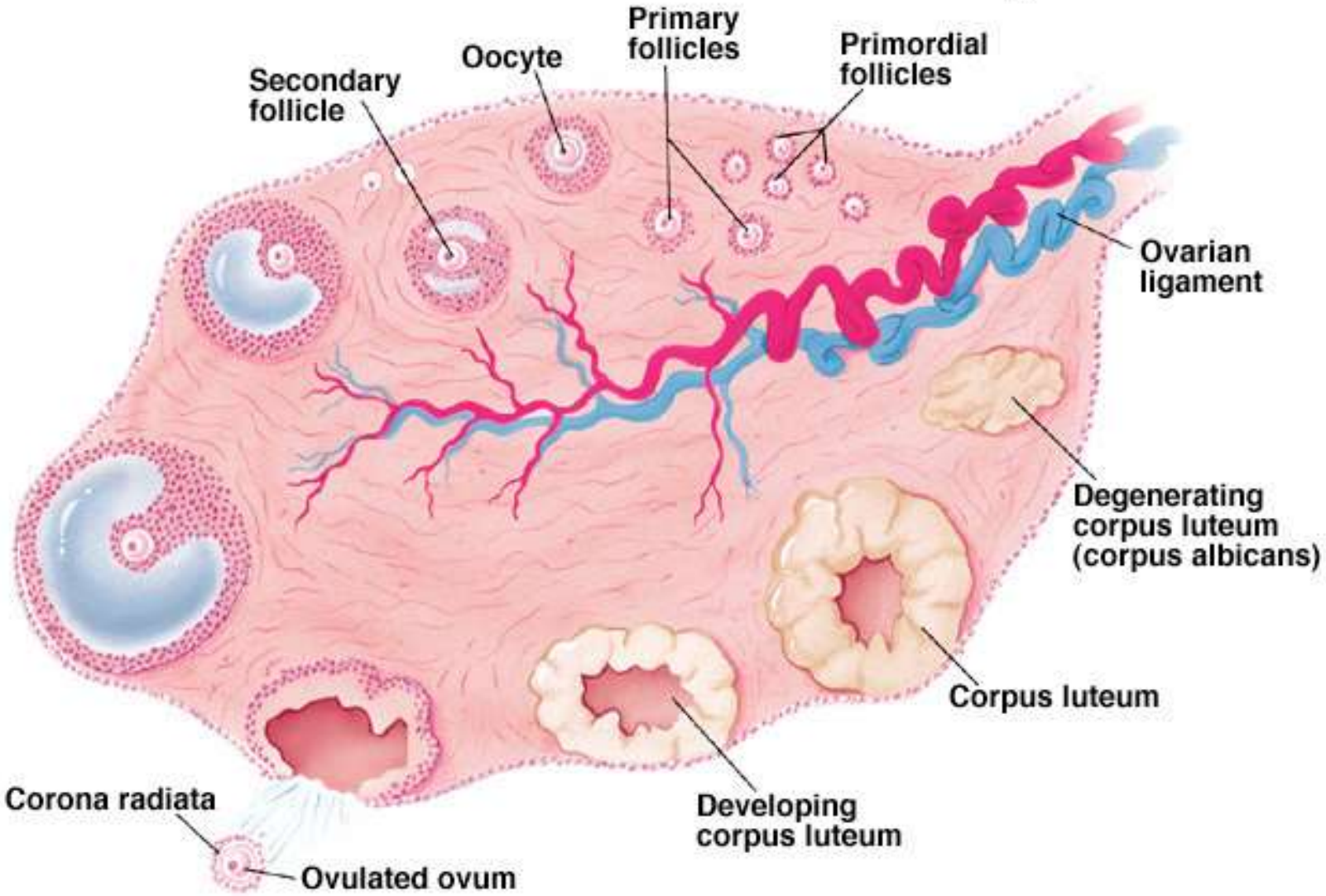


Sectional View of Female Reproductive System

FEMALE GONAD: OVARIES

- Ovaries are the primary female sex organs that produce the female gamete (ovum).
- It also produces several female steroid hormones- **estrogen** & **progesterone**
- The ovaries located in the lower abdomen.
- Each ovary is about 2-4 cm in length. These are Connected to the pelvic wall and uterus by ligaments.
- Each ovary is covered by thin epithelium which enclose ovarian stroma
- Ovarian Stroma, 2 zones- A peripheral cortex & an inner medulla.
- At the peripheral cortex follicles are present & in medulla blood vessels & ovarian ligaments are present

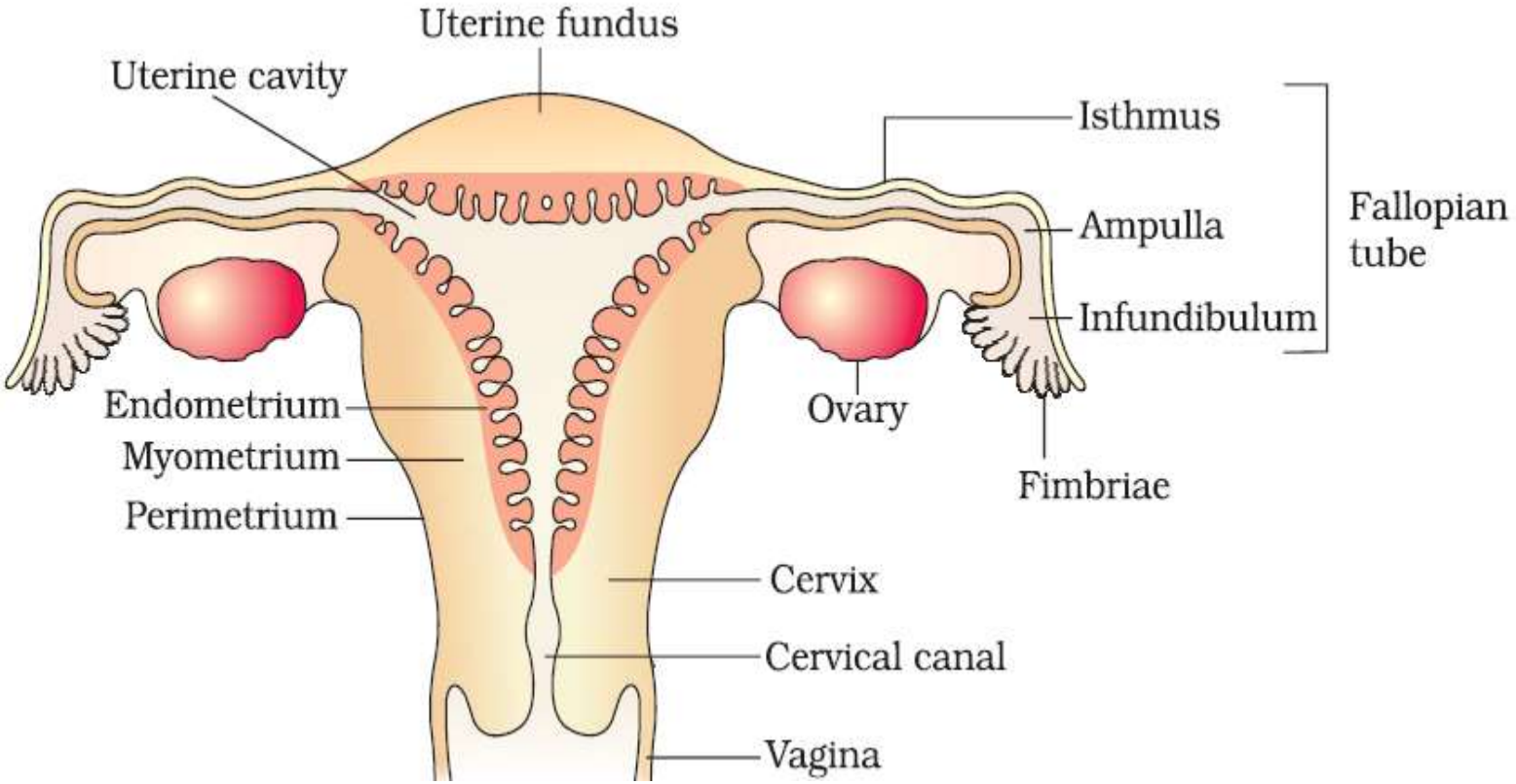
Structure of an Ovary



T.S OF OVARIES:

- Developing follicles in different Stages
- Primary follicle develops into Graafian follicle with mature ovum,
- One matures around 14th day of menstrual cycle and ruptures to release the oocyte – Ovulation
- After release – follicle filled with blood clot and then yellow cells – called corpus luteum (progesterone)

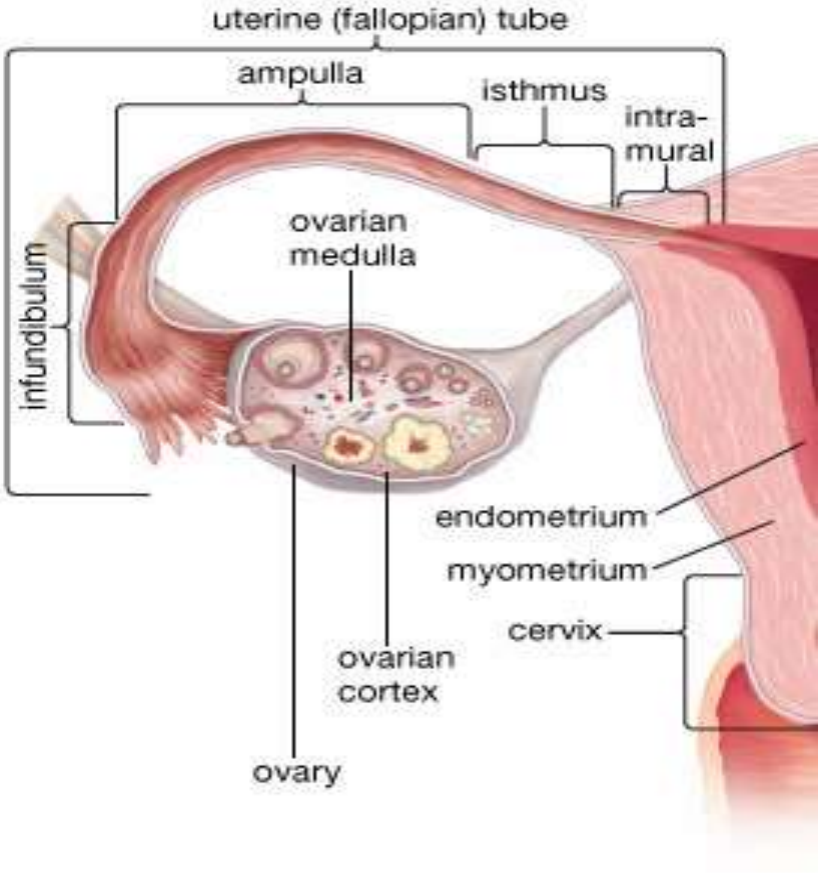
- Oviducts(fallopian tubes), uterus & vagina- Accessory ducts



Sectional view of Female reproductive system

ACCESSORY DUCTS - OVIDUCT, UTERUS, VAGINA

- **<u>Oviduct / Fallopian tube</u>-** 10-12 cm length, from periphery of each ovary to uterus
- Part closer to ovary funnel shaped **infundibulum –** edge finger like projections **Fimbriae** (collects of ovum after ovulation), wider part oviduct- **ampulla**, **Isthmus** has narrow lumen and joins uterus



Uterus /Womb & vagina

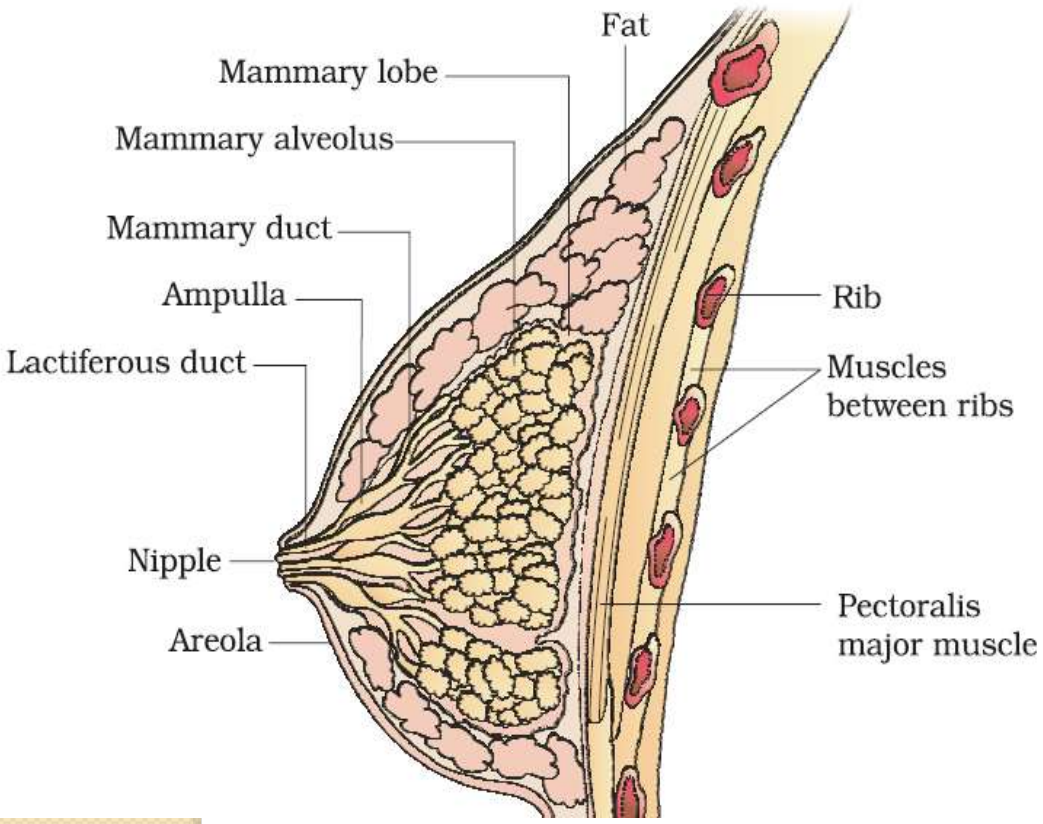
- Single uterus -present in lower abdomen region also called womb.
- hallow inverted pear shaped, attached to pelvic wall by ligaments
- Inside the uterus fertilized ovum grows and develops in to embryo.
- Opens into vagina through narrow cervix (cavity- **cervical canal)**
- Cervical canal along with Vagina- **Birth Canal**
- The wall of the uterus has three layers of tissues

1. ***Perimetrium***: external thin membranous.
2. ***Myometrium***: middle thick layer of smooth muscles; strong contraction during delivery
3. ***Endometrium:*** inner glandular layer, lines uterine cavity; cyclical changes during menstrual cycle.

EXTERNAL GENITALIA

- Mons pubis, labia majora, labia minora, hymen, clitoris
- **Mons pubis** a pad of fatty tissue covered with hair
- **labia majora -** fleshy folds of tissue, surround the vaginal opening.
- **labia minora –** paired folds of tissue under labia majora
- **Clitoris-** tiny finger structure, lies at the upper junction of two labia majora
- **Hymen -** just inside the opening of the vagina, often torn during the first coitus (intercourse)
- the presence or absence of hymen is not a reliable indicator of virginity

MAMMARY GLANDS



- Paired, Glandular tissue, variable amount fats
- Glandular tissue – divided into 15-20 **mammary lobes** containing cluster of cells – alveoli
- Alveoli secrete milk- stored in lumen (alveoli)
- Alveoli opens mammary tubules
- Tubules of each lobe join – **mammary duct**
- Many ducts join to form mammary ampulla- which is connected **lactiferous duct,** through which milk sucked out

GAMETOGENESIS

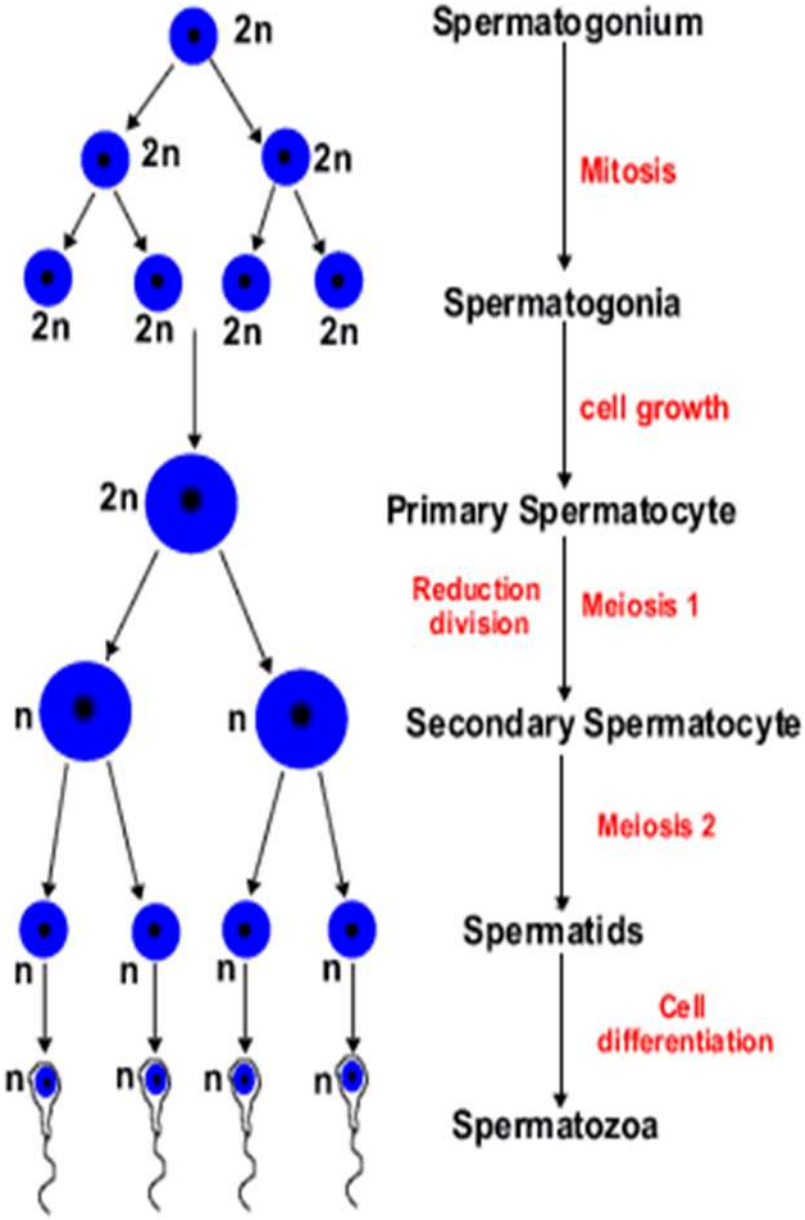
- The process of formation of haploid gametes from diploid germ cells in the gonad is called gametogenesis.
- Takes place- primary sex organ (testis & ovary) & produce **sperm** & **ovum**
- Male – Spermatogenesis (Spermatogonia) & begins at puberty
- Female- Oogenesis (Oogonia) & starts at embryonic stage

SPERMATOGENESIS:

- The process of formation of haploid male gamete sperm in seminiferous tubules of testis is called spermatogenesis.
- The inner wall of the seminiferous tubule contains two types of cells as germ cells (spermatogonia cells) and sertoli cells.
- germ cells divides and develops into sperms, sertoli cell nourishes the developing sperms.
- The spermatogenesis takes place in two stages as **Spermatidogenesis** and **Spermiogenesis**

Spermatidogenesis: It is the process of formation of spermatids. It involves 3 sub stages

1. **Multiplication phase:** The spermatogonia (Spermatogonium) undergoes repeated mitotic division and forms large number of diploid spermatogonia cells (46 chromosomes).
2. **Growth phase:** The spermatogonial cells grow in size by increasing cytoplasm and matures to form **primary spermatocytes**

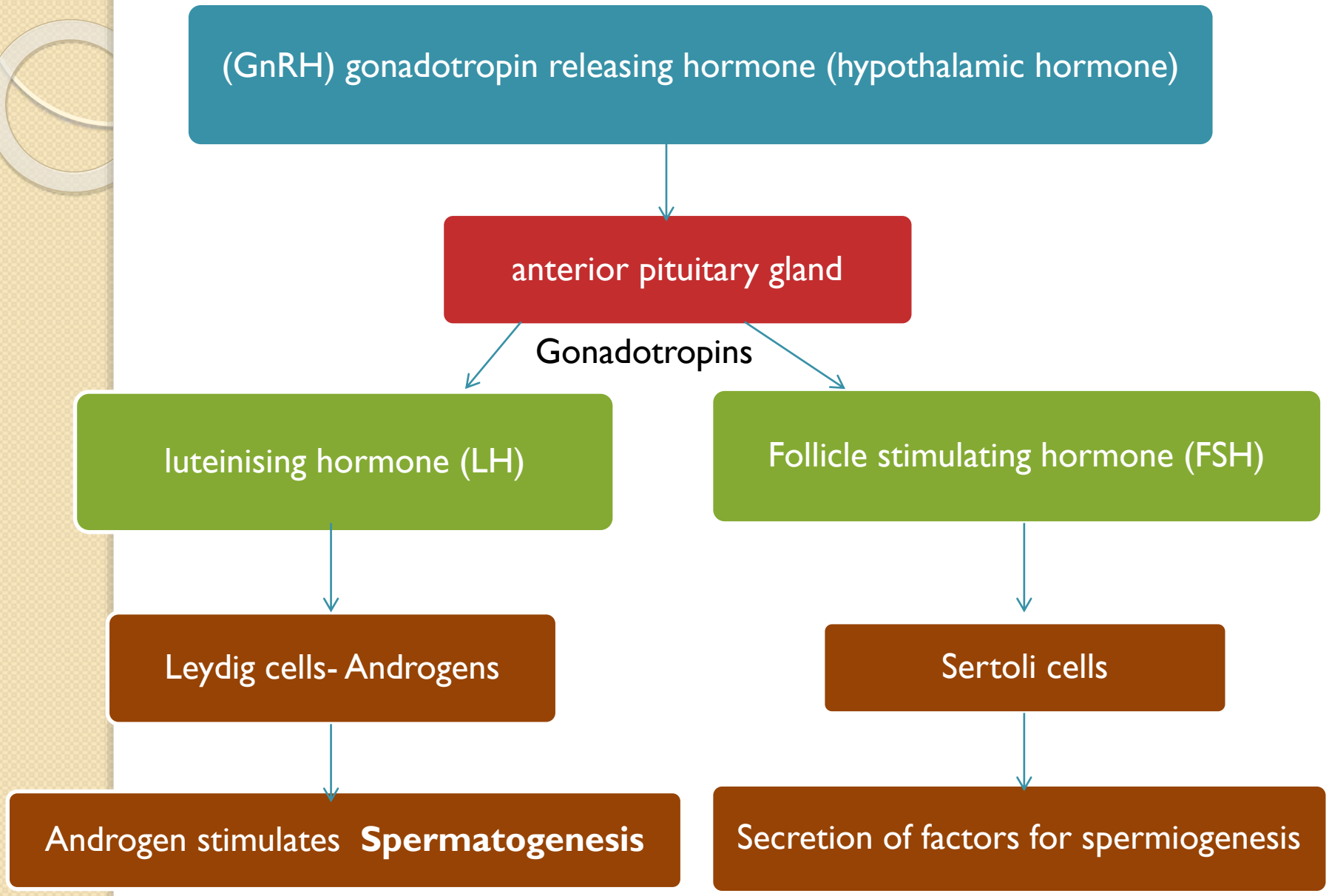


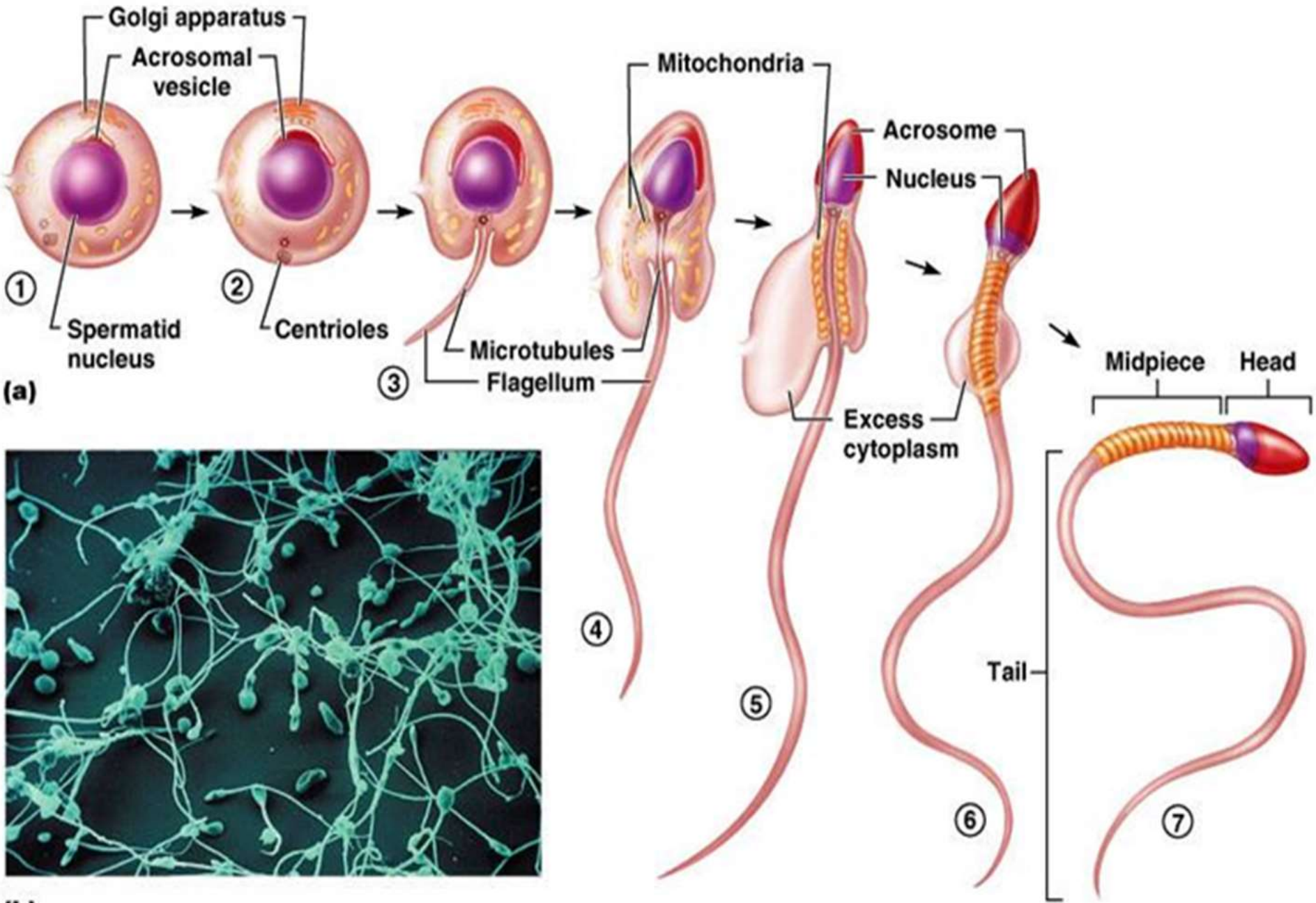
3. **Maturation phase:** The diploid primary spermatocyte undergoes first meiosis resulting in the formation of two equal haploid cells called **secondary spermatocyte** (23 chromosomes)**.** This later undergoes second meiotic division to produce four equal haploid **spermatids**.

Spermiogenesis: inactive non-motile spermatids are transformed into active motile spermatozoa (sperms)

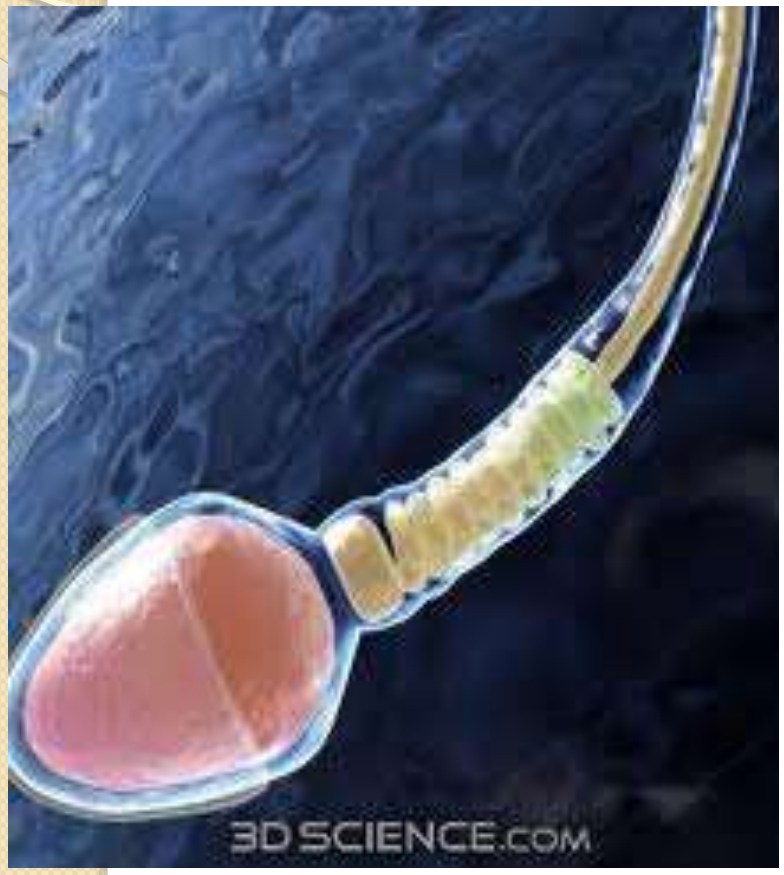
- After spermiogenesis sperm head- embedded in Sertoli cells & release from seminiferous tubules- **Spermiation**

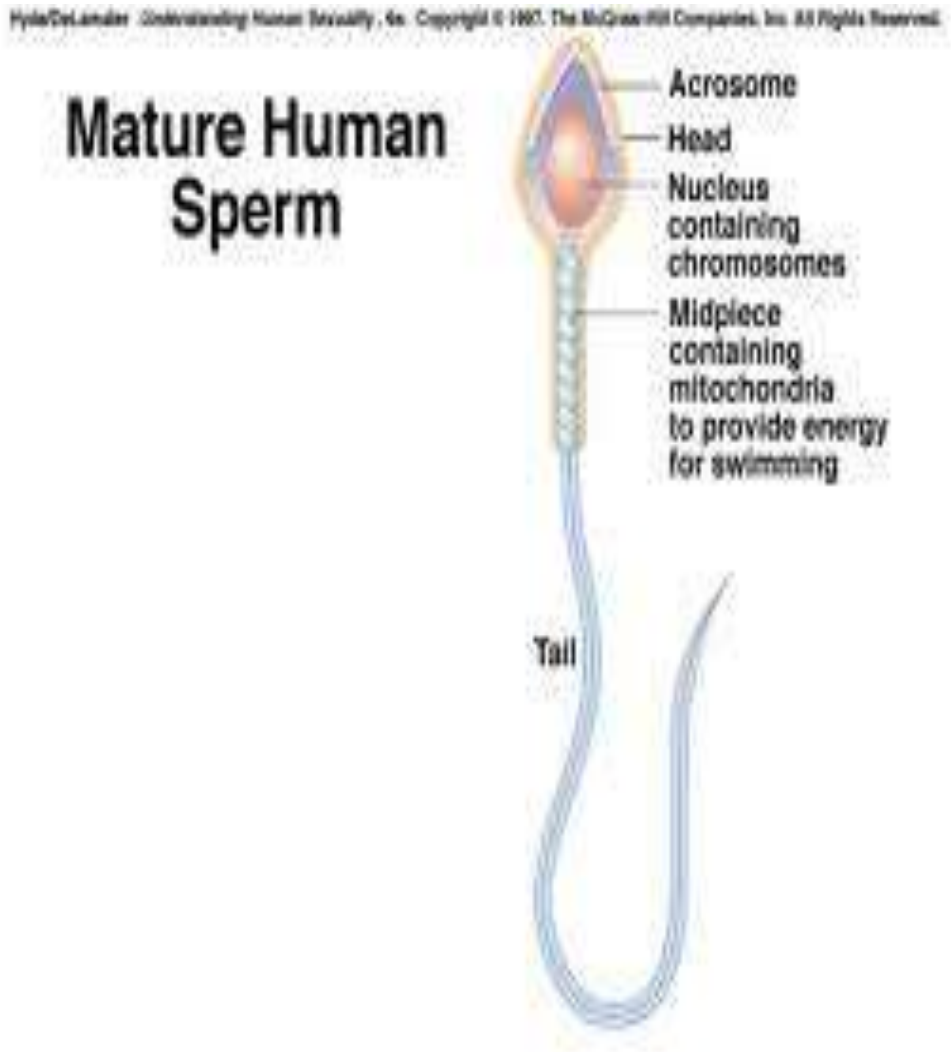
SPERMATOGENESIS AND HORMONES





STRUCTURE OF SPERM





SPERM STRUCTURE

- Plasma membrane envelops entire body.

Part of sperm	Details
Head	• Elongated haploid nucleus • Anterior cap like acrosome • Acrosome has hydrolytic enzymes (hyaluronidase). It is derived from Golgi complex during division – fertilization of ovum
Neck	Connecting head and middle piece
Middle part	• Many mitochondria (produce energy for the movement of tail – motility)
Tail	• Long slender • Vibration

- 200-300 million sperms – one ejaculation 60% must have normal shape , size and 40% motility

OOGENESIS

The process of formation of haploid ovum from diploid oogonia cells in the ovary is called oogenesis. This begins at begins at embryonic development.

Oogonia

- Gamete mother cell (2n)
- At birth many million in fetal ovary

Primary oocyte

- Propahse –I of meiotic division.
- Temporary arrested in this stage

Primary follicle

- Primary oocyte+ granulosa cells
- May follicles degenerate from birth to puberty
- 60,000 to 80,000 in each ovary (puberty)

Secondary follicles

- Primary follicles surrounded by more granulosa cells & theca

Tertiary follicles

- Secondary follicles – fluid filled cavity – antrum
- Theca layer – theca interna (vascular) & theca externa(fibrous)
- T. interna- 10-15 layers follicle cells (membrane granulosa)
- Primary Oocyte (2n) within follicle- size increases & first meiotic division – unequal large haploid secondary oocyte+ 1st polar body

Secondary oocyte

- Retain nutrient rich cytoplasm of primary oocyte
- Tertiary follicles into Graffian follicle
- Secondary oocyte (ovum)- zona pellucida (membrane)
- Graffian follicle ruptures & releases ovum

DEVELOPMENT OF FOLLICLES

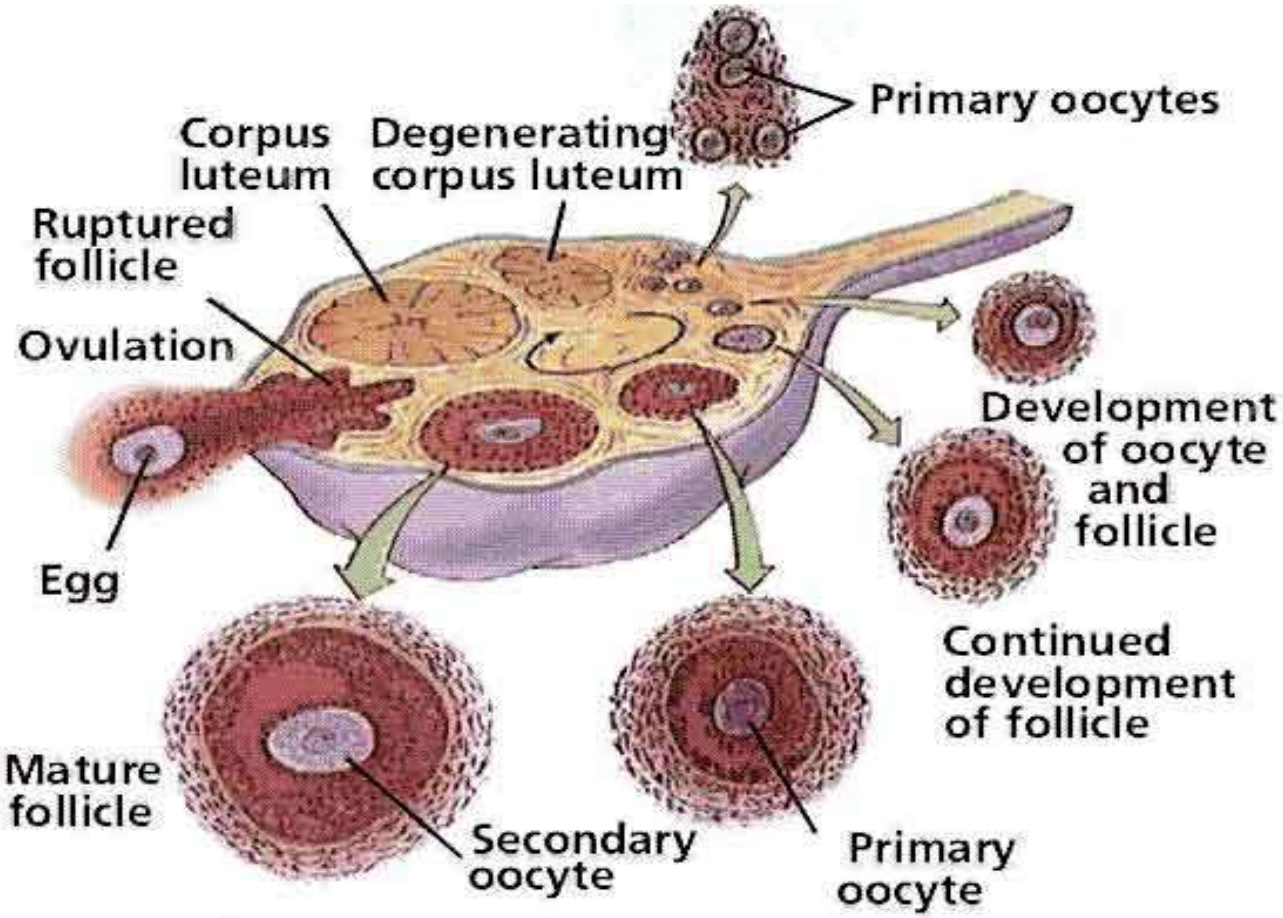
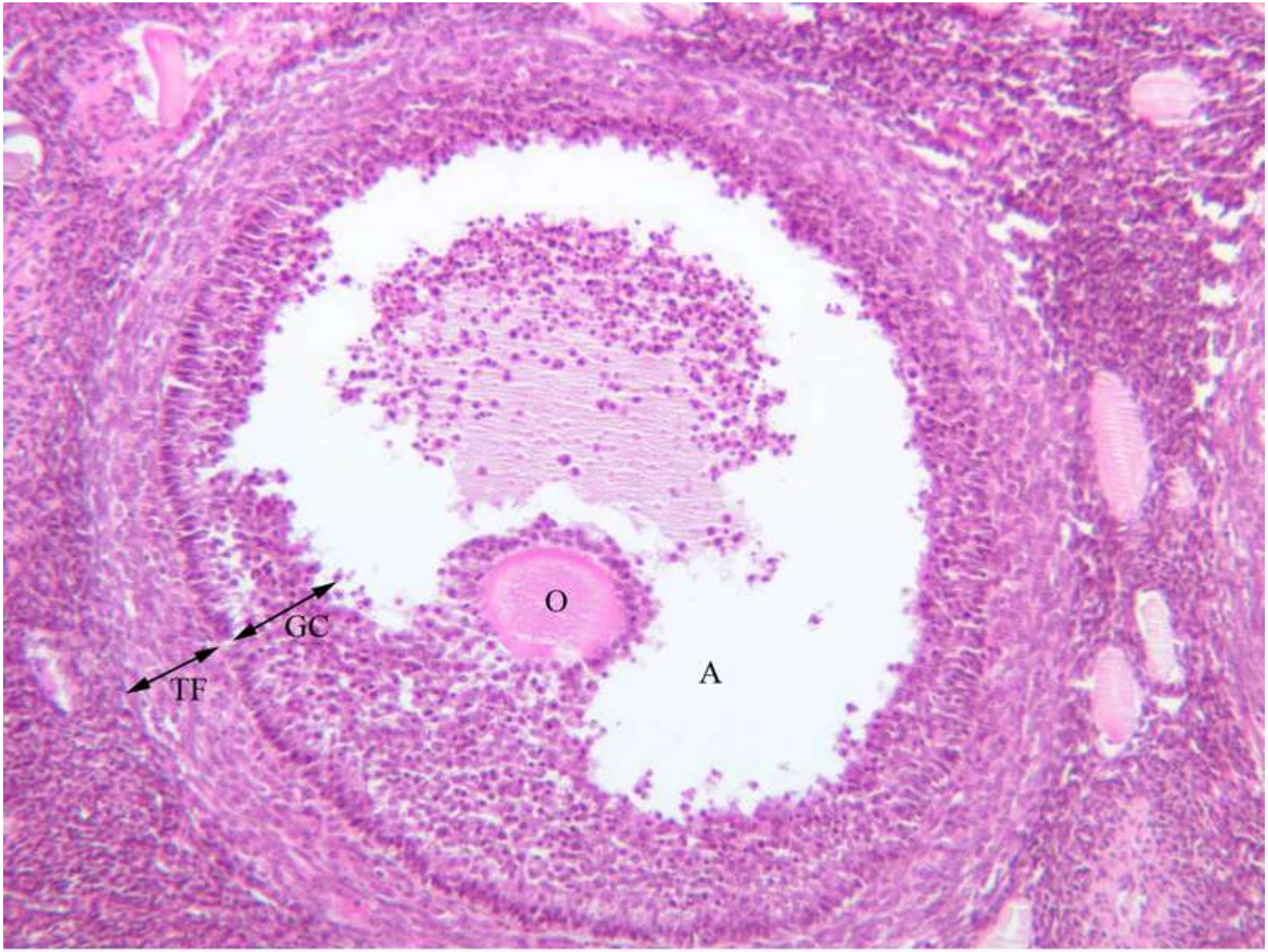


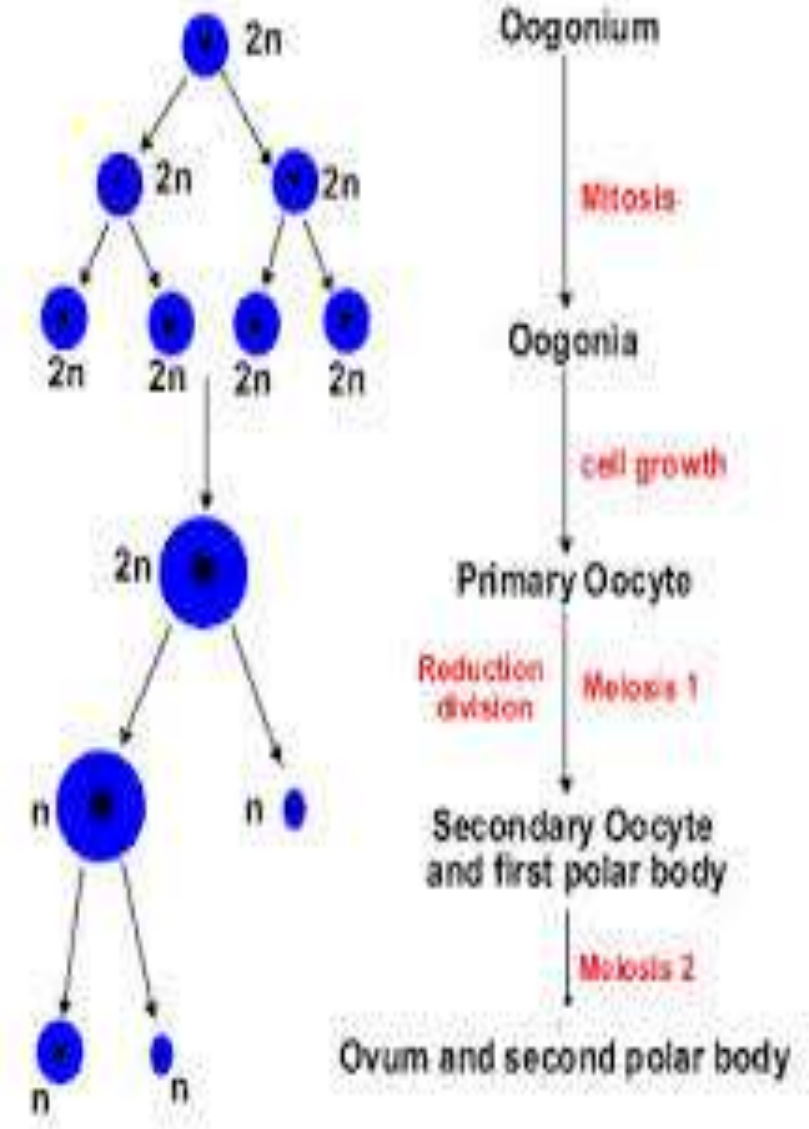
DIAGRAM OF A MATURE FOLLICLE



O - oocyte A - antrum GC - stratum granulosum TF - theca folliculi

OOGENESIS.

- The process of formation of haploid female gamete ovum in the follicles of ovary is called ***oogenesis.***
- Oogenesis starts during embryonic stage.
- Germinal epithelium of ovary divides mitotically to produce millions of gamete mother cell or oogonia.
- No oogonia formed or added after birth.
- Oogonia enters into meiosis-I. It proceeds Prophase-I , get suspended and forms primary Oocytes.
- during puberty, the primary oocyte restarts its first meiotic division.

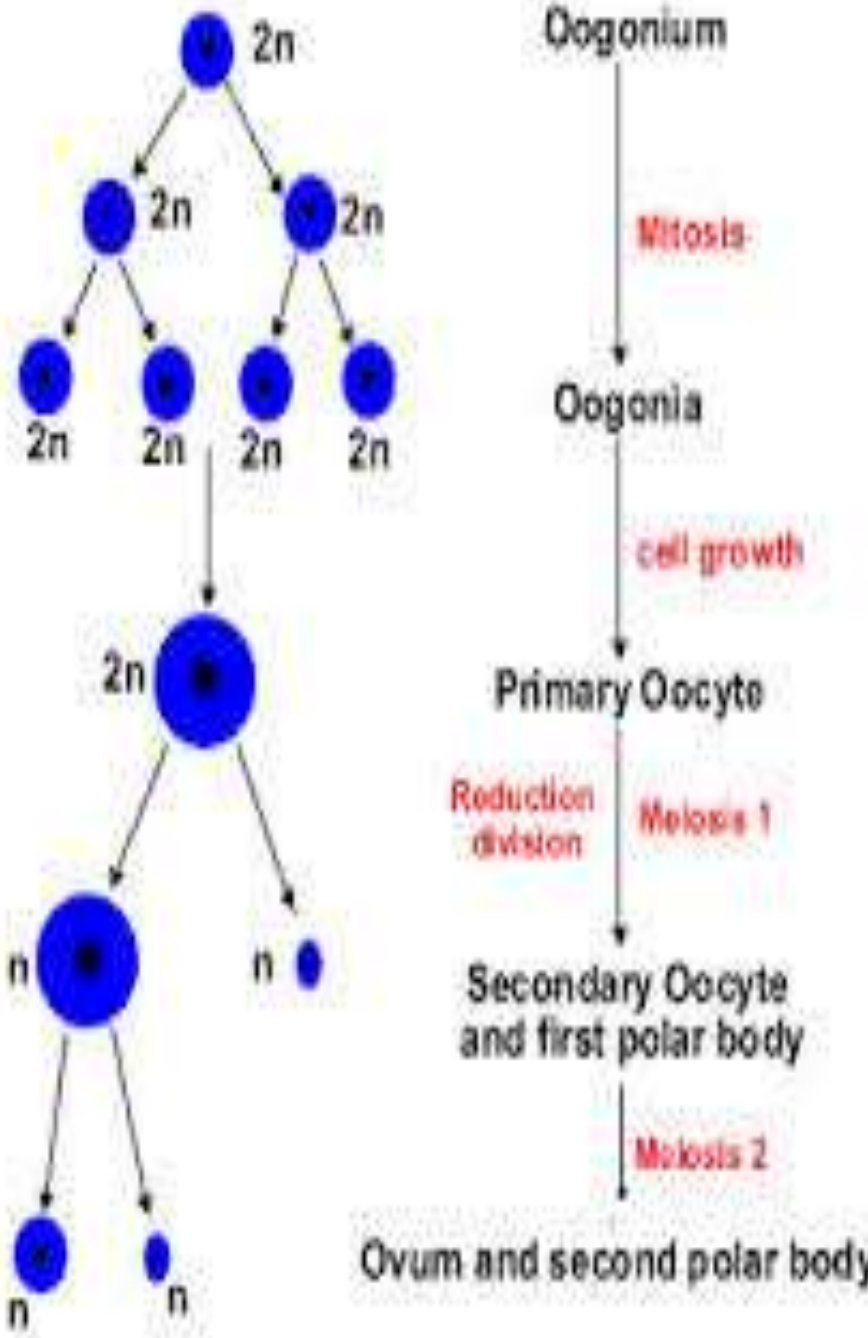


- Oogenesis takes place by three stages as follows.

1. Multiplicative Phase
2. Growth phase
3. Maturation phase

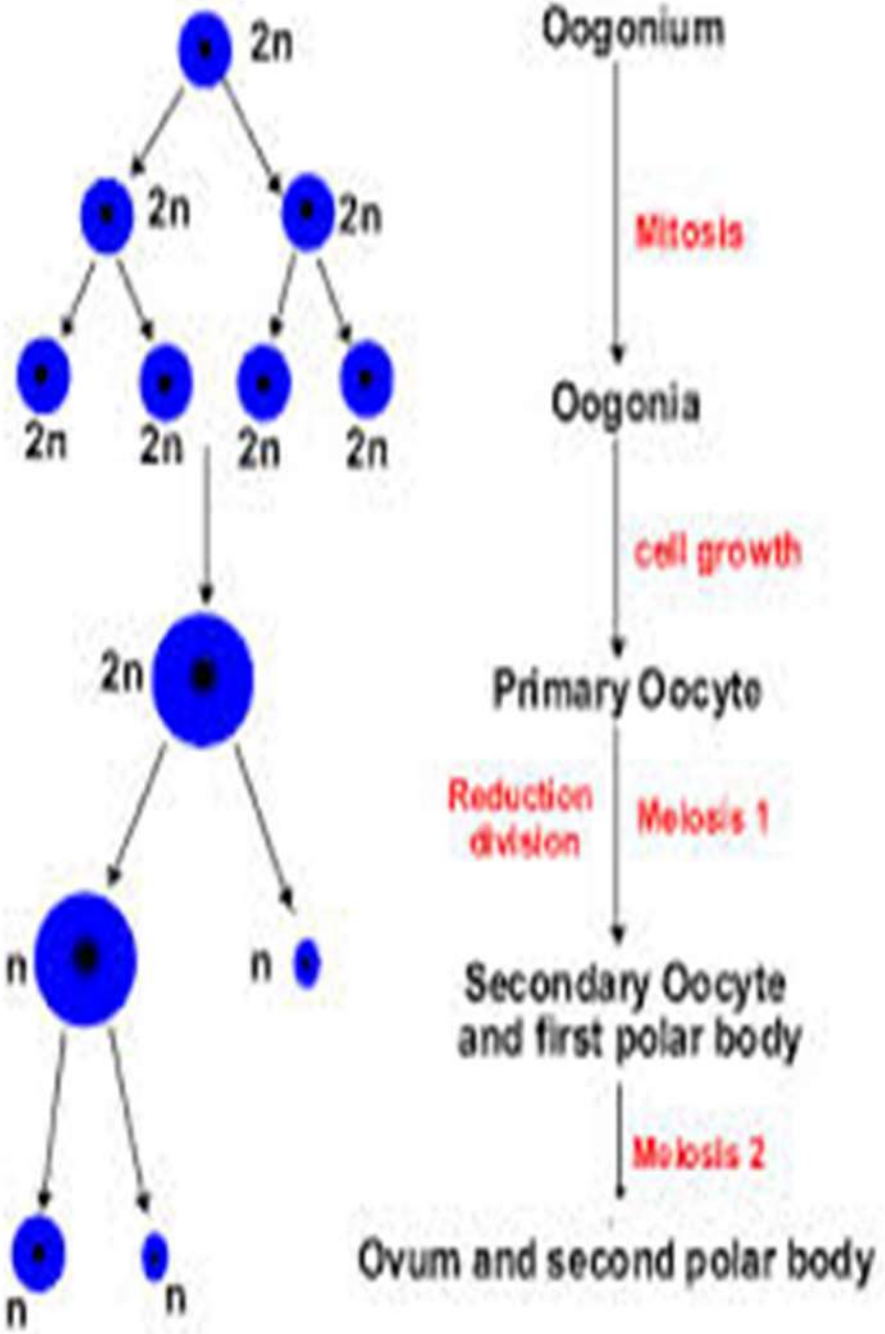
1. Multiplication phase:

- Certain primary germ cells (large size & nuclei) of germinal epithelium lining ovary, undergo rapid mitotic division.
- It result in formation of group of diploid egg mother cell, **oogonia.**
- Each group of cells forms a rounded mass called egg nest.



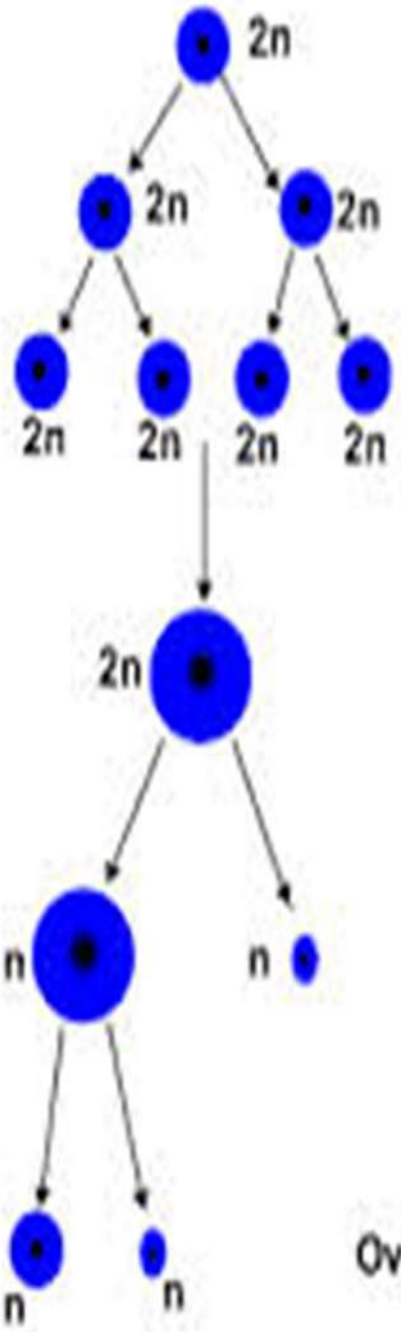
2. Growth phase:

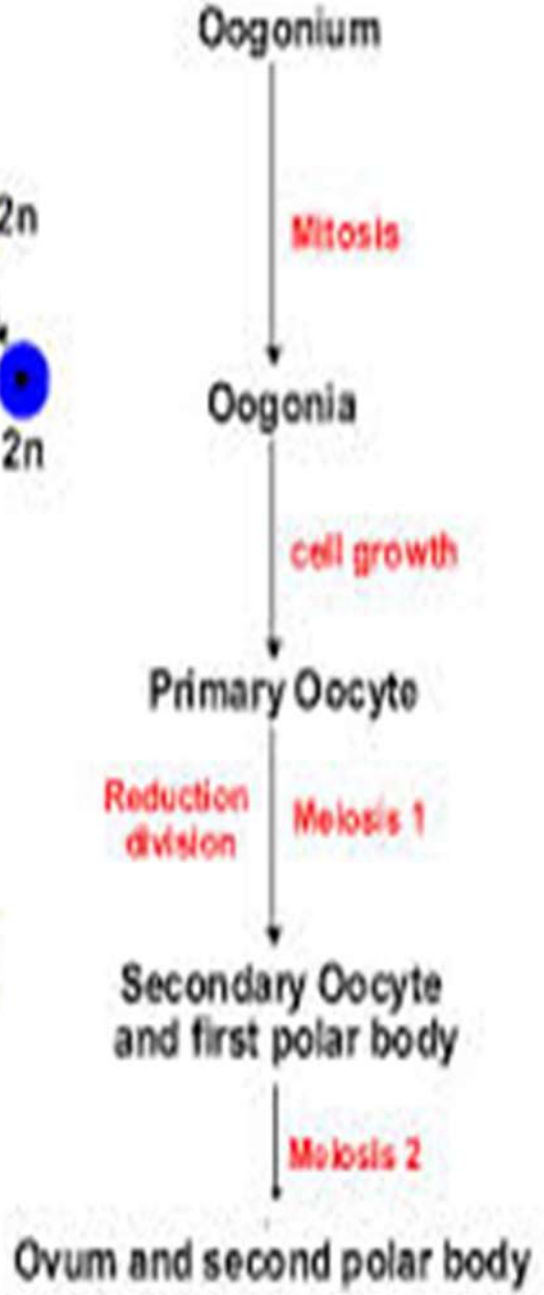
- Long duration (12- 13 years)
- One of the diploid oogonia undergoes growth increasing in cytoplasm and accumulation of yolk & transform to enlarged oogonia called primary oocyte (2n)
- Other oogonia form single layered follicular epithelium- P. follicle
- P. follicle surrounded by more granulosal cell- Sec. follicle
- Sec. follicle- fluid filled antral cavity- Antrium- Ter. Follicle
- Ter. Follicle- Graffian follicle



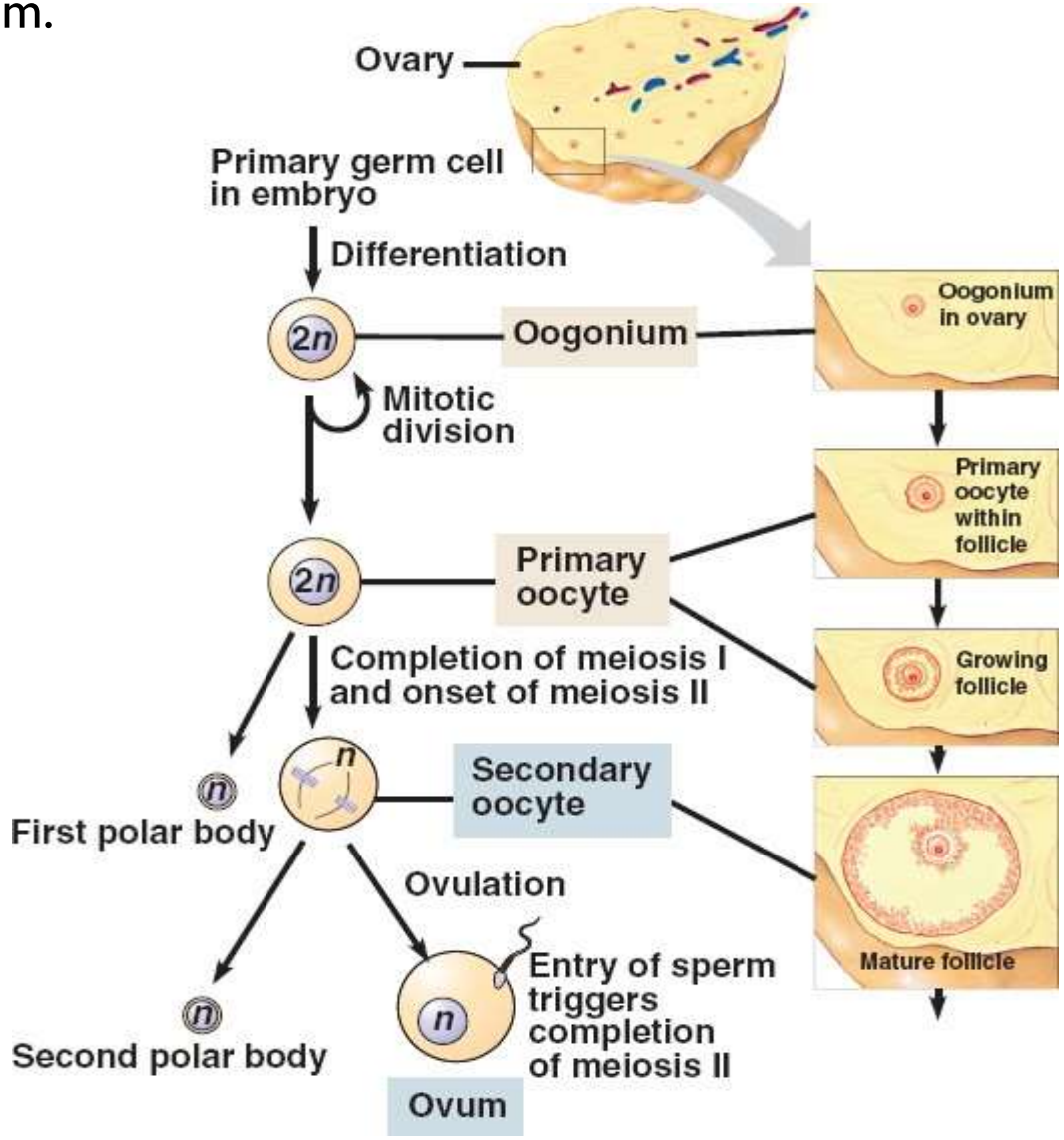
3. Maturation phase:

- A fully-grown primary oocyte (2n) undergoes I meiotic division results in the formation of two unequal sized haploid cells.
- The large secondary oocyte (n) and a small polocyte (polar body).
- The secondary oocyte undergoes II meiotic division to form a large ootid/ ovum and a small 2nd polar body.
- Sec. oocyte forms new membrane- Zona pellucida- Graffian follicle
- The 1st polar body also undergoes equal division to produce two cells.





- Thus during oogenesis four cells are produced. Among them one is functional ootid and three are non-functional polar bodies. The ootid with very little change becomes an ovum.



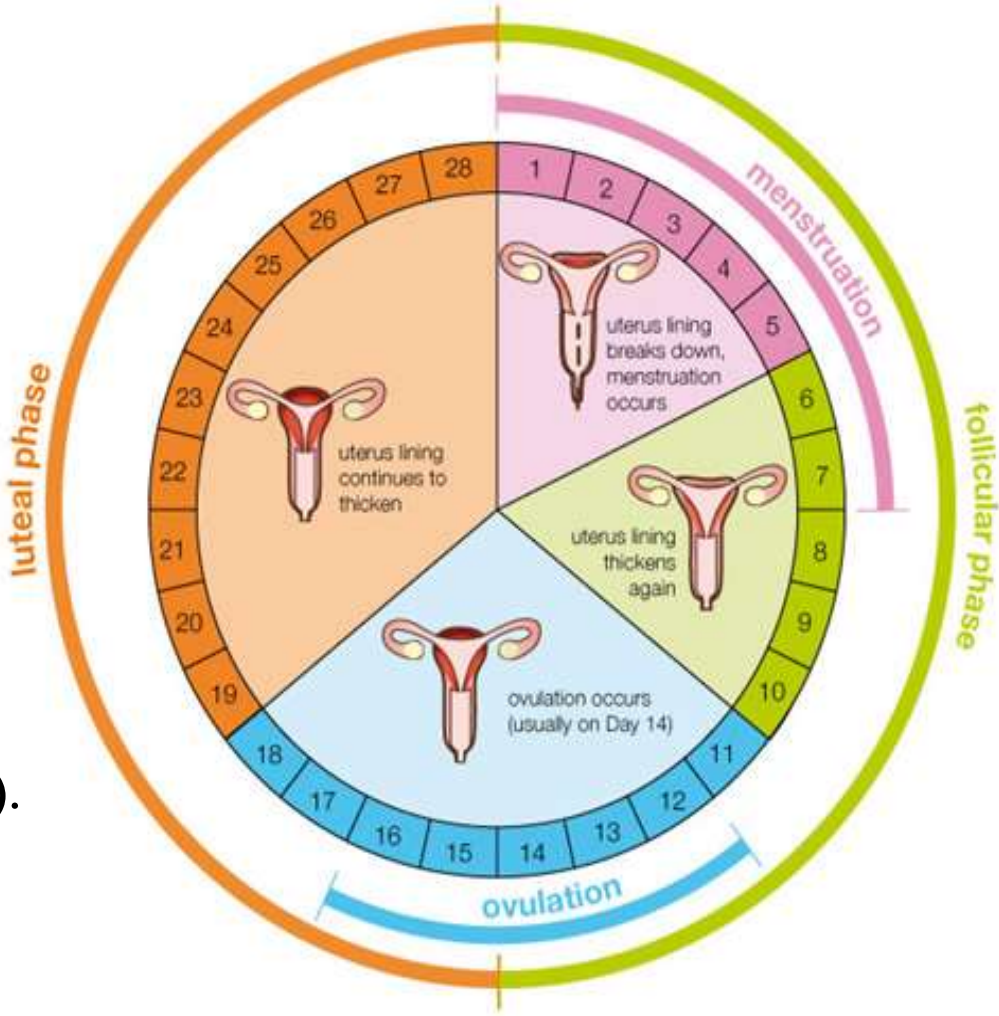
MENSTRUAL CYCLE:

- Reproductive cycle of female primates is called menstrual cycle.
- Menstruation is the term given to the periodic discharge of blood, tissue, fluid and mucus from the reproductive organs of sexually mature females. The flow usually lasts from 3 - 6 days each month and is caused by a sudden reduction in the hormones estrogen and progesterone.
- The menstrual cycle begins when a female reaches the age of puberty. The first menstruation begins at puberty is called ***Menarche***.
- During the menstrual cycle the uterus endometrium prepares itself for implantation of a fertilized egg. If fertilization does not occur the uterus lining is shed from the body.
- Menstrual cycle repeated at an average interval of 28 days.
- One ovum is released in the middle usually 14th day of each menstrual cycle.

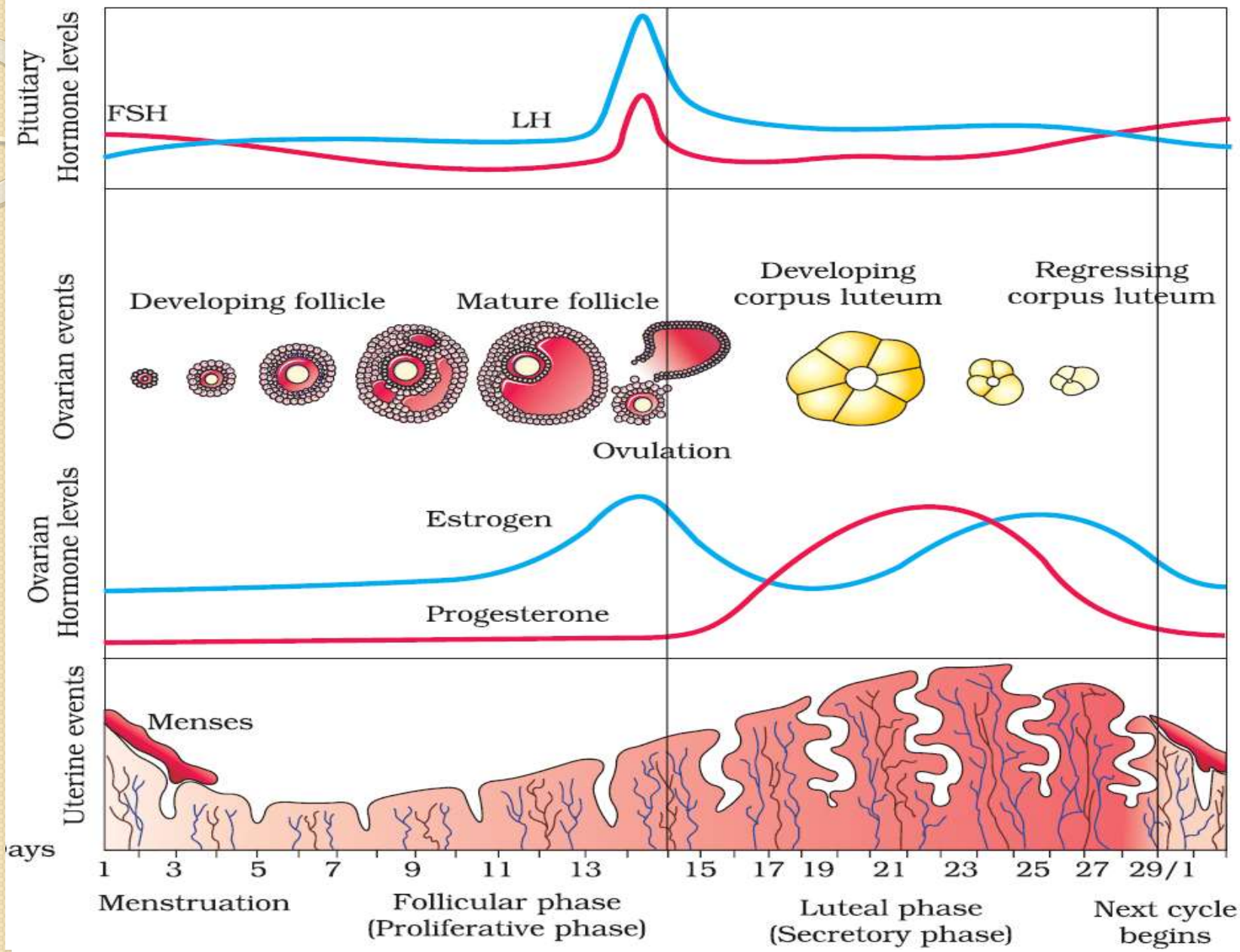
Menstrual cycle has following phases:

The cycle can be divided into four phases:

1. Menstrual phase (bleeding period).
2. Follicular (before the egg is released).
3. Ovulatory (egg is released)
4. Luteal (after release of the egg).

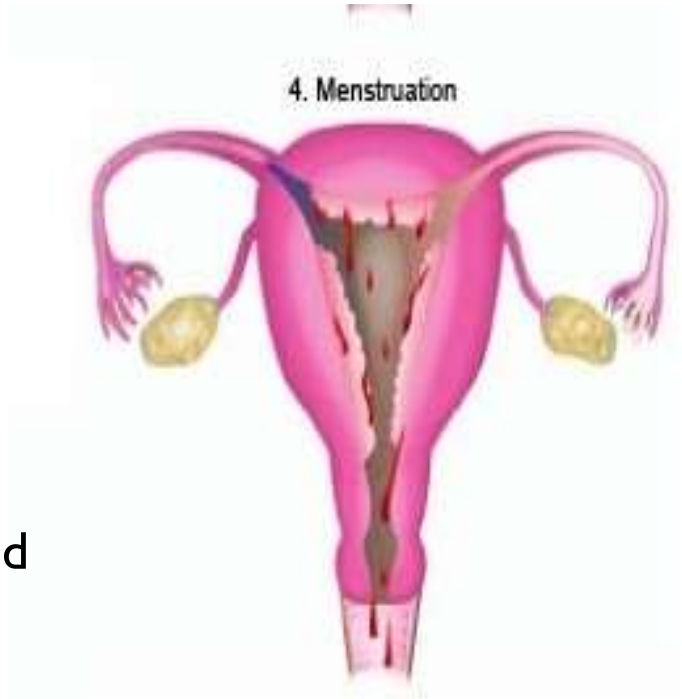


MENSTRUAL CYCLE



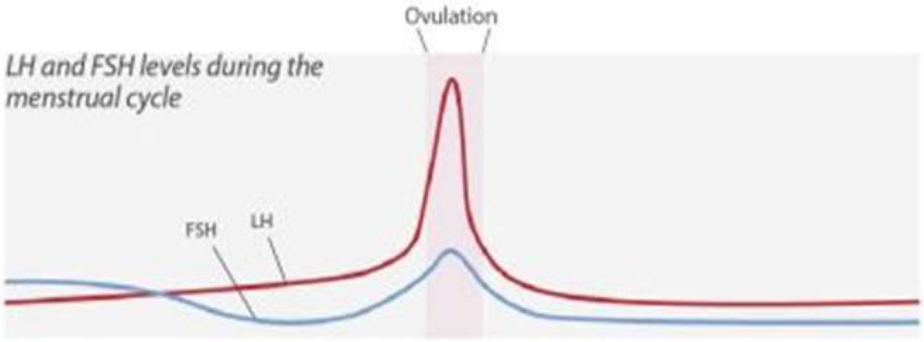
1. Menstrual phase (bleeding period).

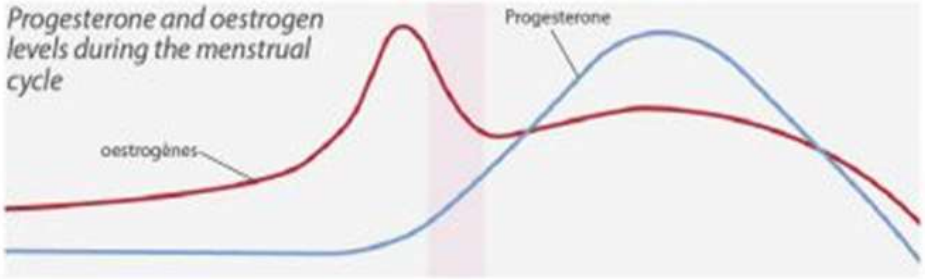
- It is the 1st phase of menstrual cycle lasts for 3-5 days.
- Breakdown of endometrial lining and blood vessel occurs. It leads to bleeding comes out through vagina.
- It occurs only when ovum released and fertilization does not occurs.
- Lack of menstruation is the indication of pregnancy.

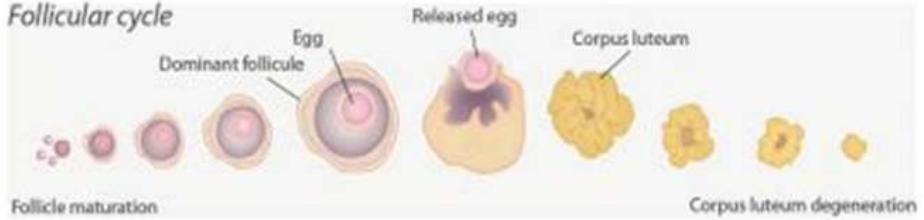


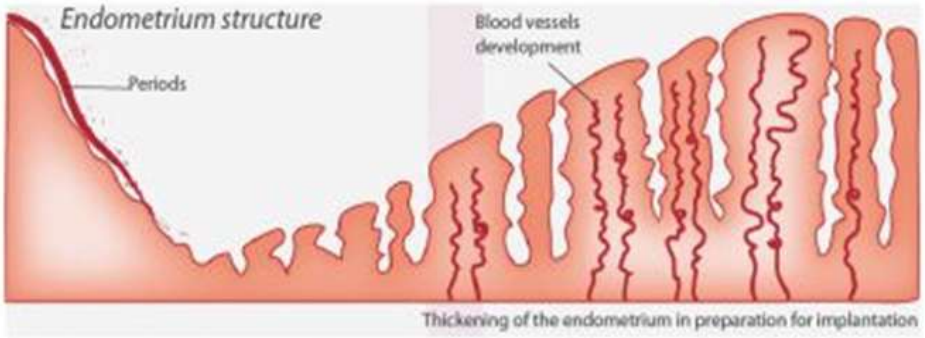
2. Follicular phase/ Proliferative phase:

- 1- 14 days
- Menstrual phase followed by follicular phase.
- P. follicle grows- G. follicle & endometrium regenerates- *proliferation*
- Gonadotropins (Pituitary)- **FSH & LH**, increases & stimulate follicular development. This in turn increases **estrogen** secretion from growing follicles.
- LH & FSH attains peak in middle of cycle (14th day)
- Rapid secretion of LH- **LH Surge** induces G. follicle to rupture & release ovum (**ovulation)- Corpus luteum**









3. Luteal phase/Secretory Phase:

- This phase begins after ovulation.
- Ruptured Graafian follicle transformed into corpus luteum. It produces large amount of **progesterone-** essential to maintain & proliferate endometrium
- Endometrium- necessary for implantation of fertilized egg/ ovum & does not shed during pregnancy
- If fertilization occurs corpus luteum grows further and pregnancy continues. Menstrual cycle stops up.
- In absence of fertilization, G. follicle transforms to yellow bodied Corpus luteum
- **Progesterone** level decreases. C. luteum degenerates to **Corpus albican**
- Decrease in Progesterone leads to menstruation

- Menstrual cycles ceases at 50 years- **Menopause**
- Cyclic menstruation is indicator of normal reproductive phase & extends between menarche & menopause

FERTILIZATION AND IMPLANTATION

- During copulation (coitus) semen is released by the penis into the vagina is called ***insemination***.
- The motile sperms swim rapidly, pass through the cervix, enter into the uterus and finally reach the junction of the isthmus and ampulla (ampullary-isthmic junction) of the fallopian tube
- Fertilisation - if the ovum and sperms are transported simultaneously to the ampullary isthmic junction.
- The process of fusion of a sperm with an ovum is called **Fertilisation**.

- Sperm contacts with zona pellucida of ovum & induces changes in membrane that blocks entry of other sperm
- Acrosome of sperm secretes lytic enzymes (hyaluronidase) helps in penetration into the ovum cytoplasm through zona pellucida & plasma membrane
  - Meiotic division of secondary oocyte after sperm enters plasma membrane of the ovum.
  - Second meiotic division – second polar body and ovum / ootid
  - Nucleus of Ovum + Sperm = **Zygote**
  - Sex of baby decided this stage

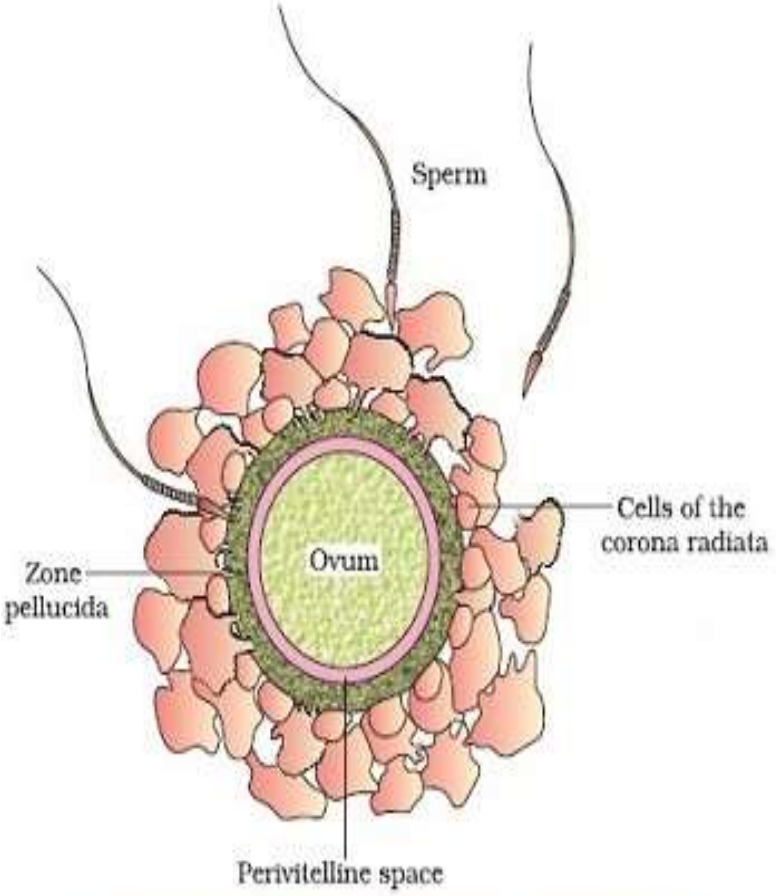
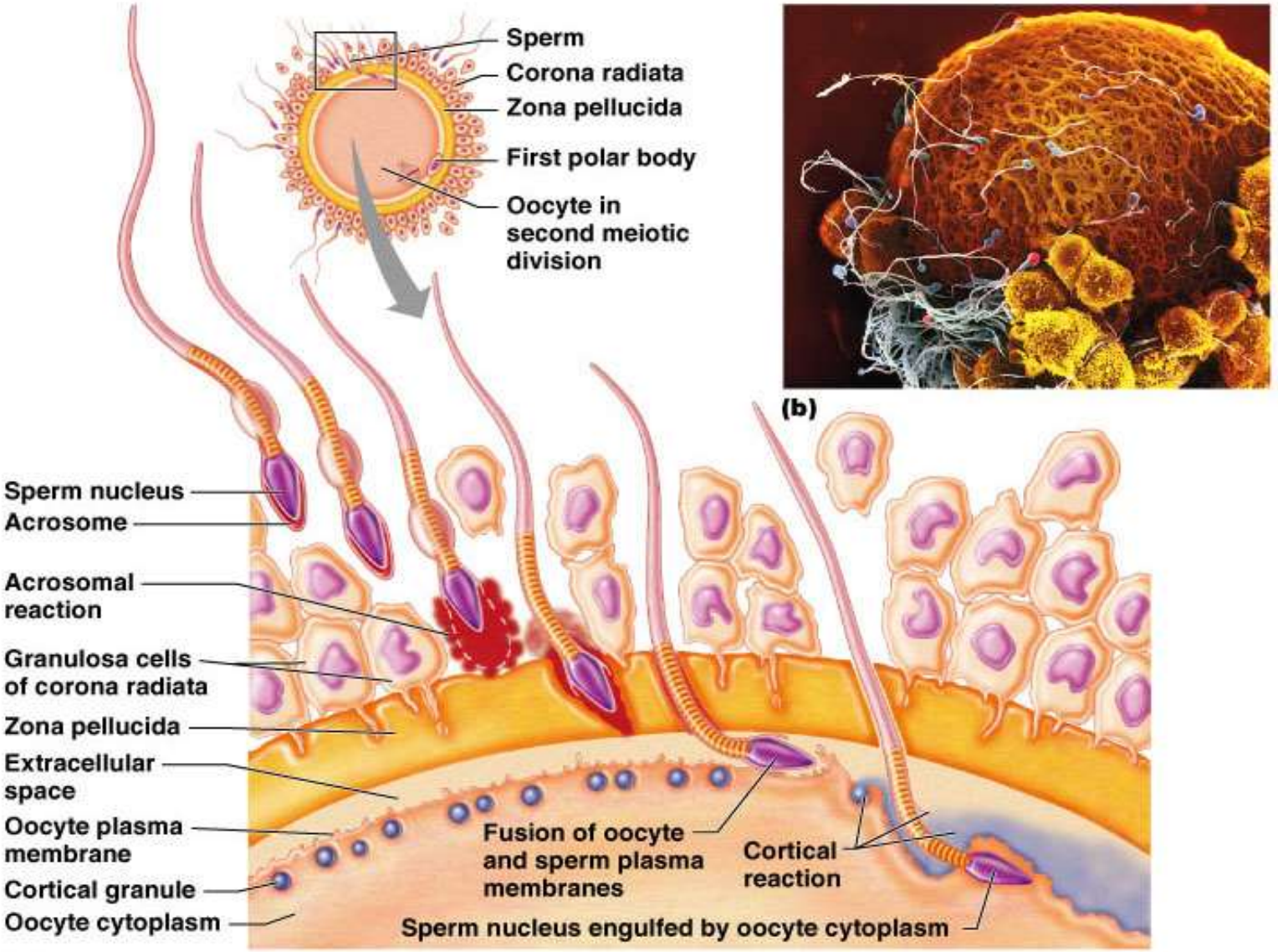
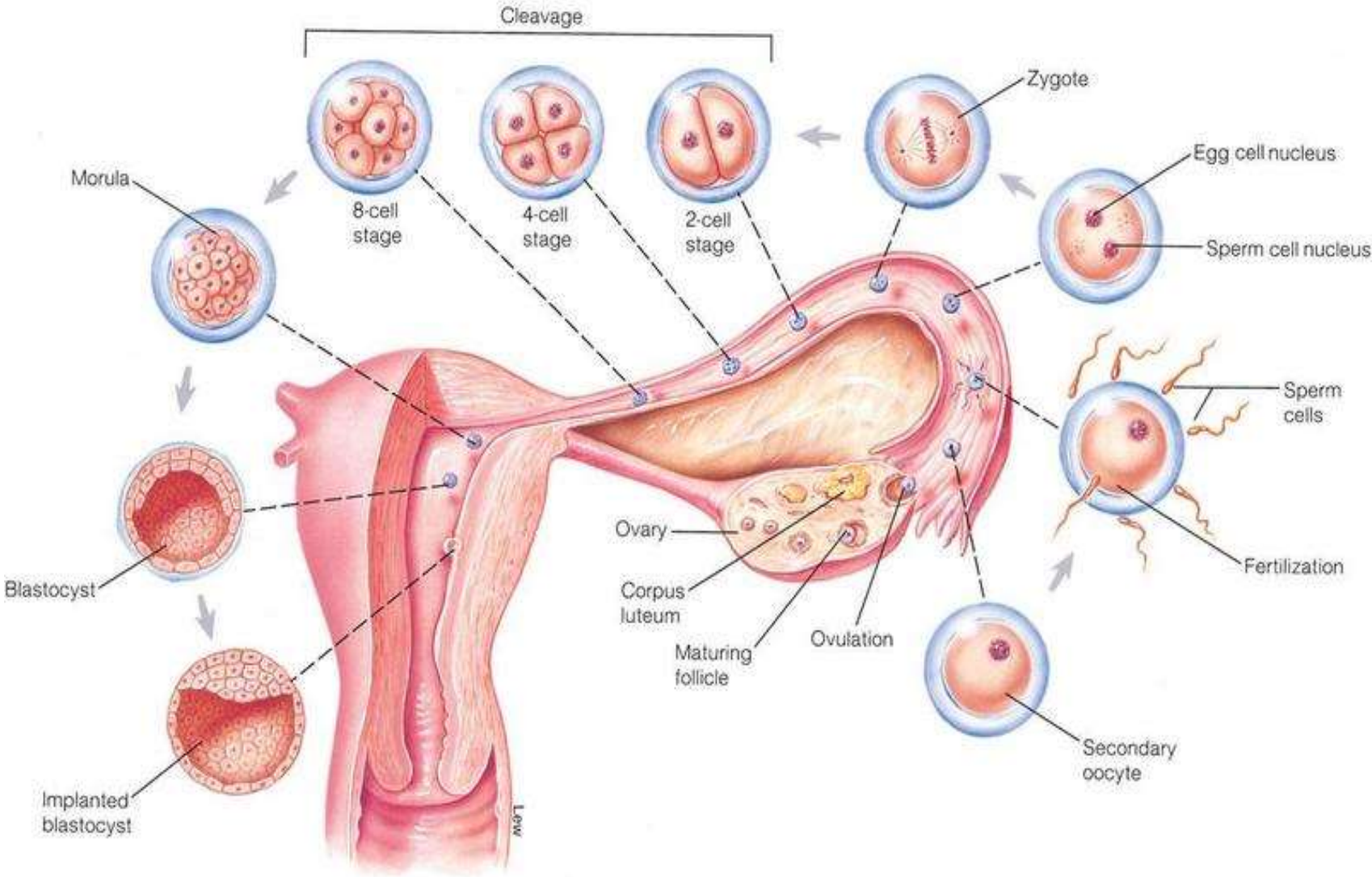


Figure 10. Ovum surrounded by few sperms

Fusion of Sperm and Ovum



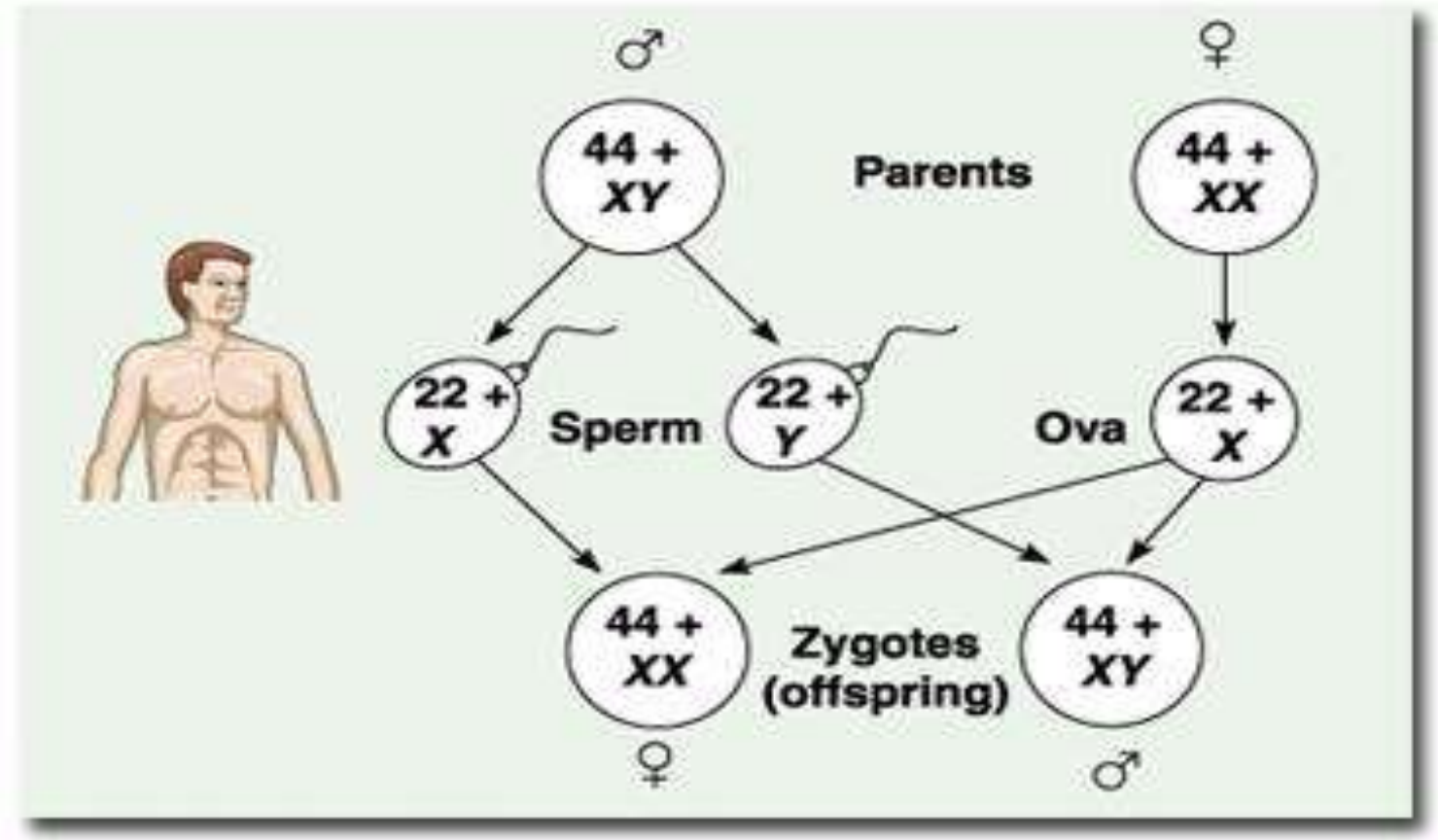
Fertilization and passage of growing embryo through Fallopian tube



SEX DETERMINATION:

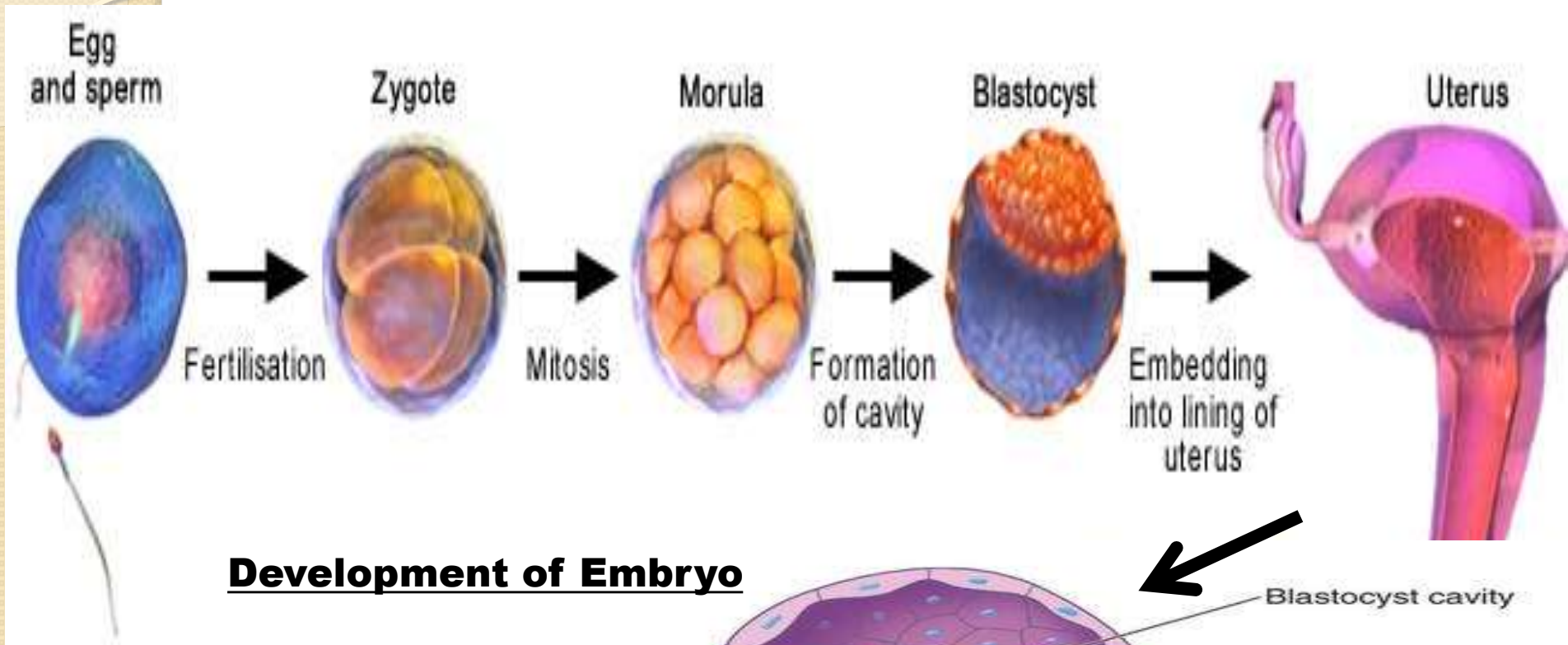
- Sex of a baby is determined during fertilization and in the zygote.
- Sex is determined by the sex-chromosomes present in zygote.
- Human contain 2 sets of chromosome- autosome & sex chromosome.
- Sex chromosome present in human female is XX and male XY.
- All the female gametes (ova) produced has 22 autosome and only 'X' chromosome.
- Sperms produced by male, 50% has 22 autosome with 'X' and 50 % has 22 autosome with 'Y' chromosome.

- The fusion of sperm with Y chromosome with ovum (X) results in male baby- XY & fusion of sperm with X chromosome with ovum (X) results in female baby.(XX).
- Zygote carrying XX chromosomes develop into female and with XY chromosome develops into male.

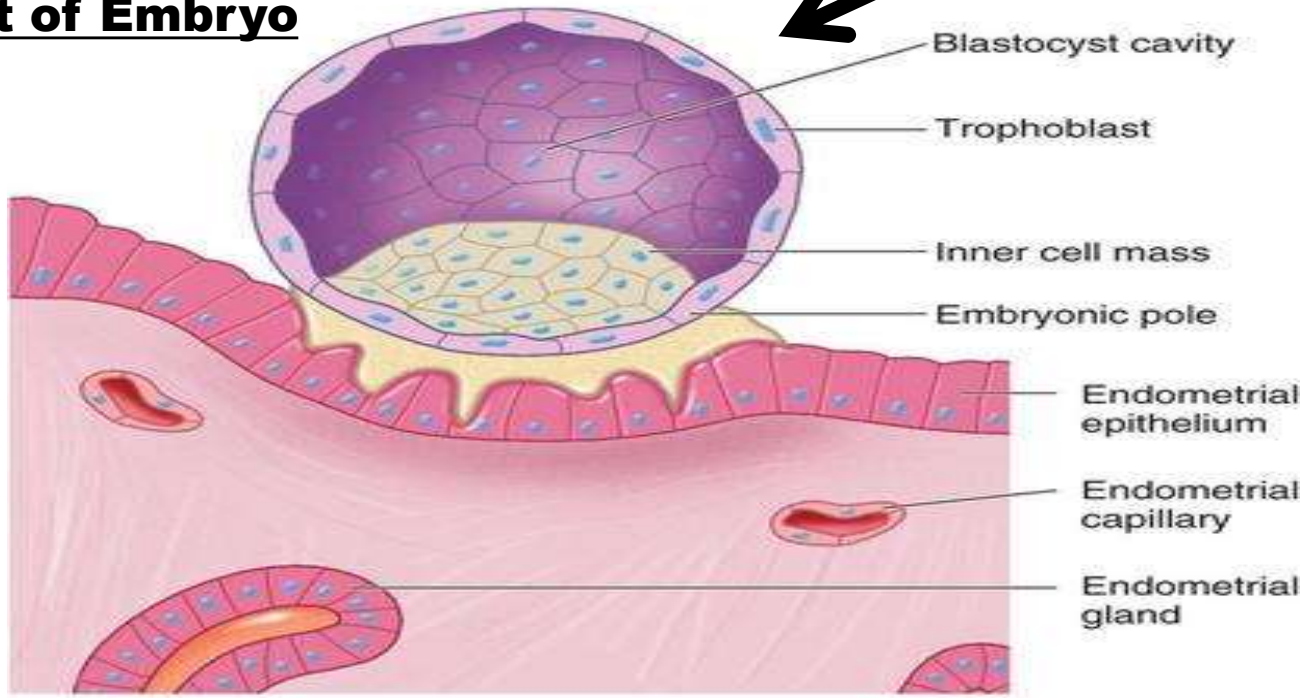


CLEAVAGE

- Zygote from isthmus (oviduct) to uterus– mitotic division, first cleavage in first 36 hrs
- 2,4,8,16 daughter cells- blastomeres
- Embryo with 8 – 16 blastomeres – **Morula**
- Morula – division continues – hollow ball called **Blastocyst.**
- The blastomeres in blastocyst arranged into two layers. An outer layer called trophoblast and an inner cells called inner cell mass.
- Trophoblast cells attaches to the endometrium. It helps in implantation and development of placenta.
- Inner cell mass gets differentiated into the embryo.
- The complete attachment of Blastocyst to the uterine endometrium is called **implantation.**



Development of Embryo



PREGNANCY & EMBRYONIC DEVELOPMENT

- **Chorionic villi –** finger like projections on trophoblast
- Villi surrounded by maternal blood, uterine tissues
- Villi & uterine tissue- interdigitated – structural & functional unit between foetus (embryo) & maternal body- **Placenta**
- Inner cell mass – ectoderm, mesoderm, endoderm - different organs

Function of Placenta:

1. Helps in **nutrition** of the embryo & transports nutrients like amino acids, sugars, vitamins form maternal blood to foetal blood
2. **Respiration** of embryo- exchange of O_2 & CO_2 through diffusion from foetal blood to maternal blood vice versa
3. **Excretion** – nitrogenous waste like urea into maternal blood
4. **Endocrine gland-** estrogen, progesterone, human chronic gonadotropin (hCG) & human placental lactogen (hPL)
5. **Antibodies-** diphtheria, small pox, measles etc., pass to foetus from maternal blood
6. Stores **glycogen** till liver formation
7. **Effective barrier-** toxic chemicals & germs

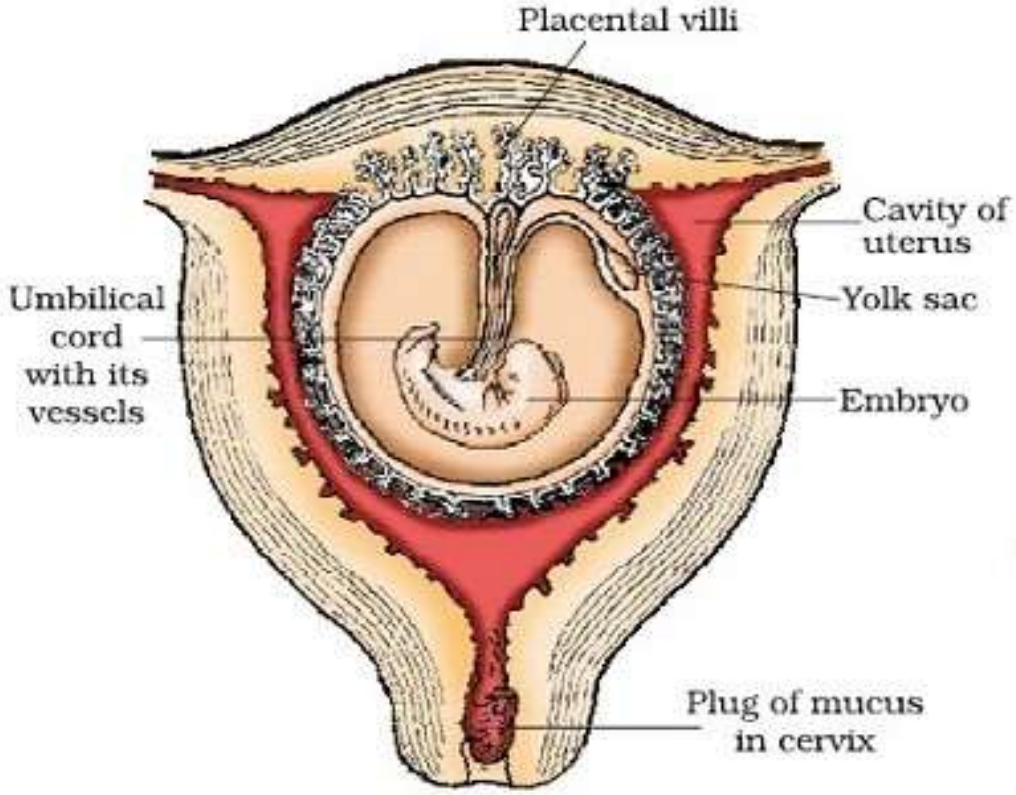
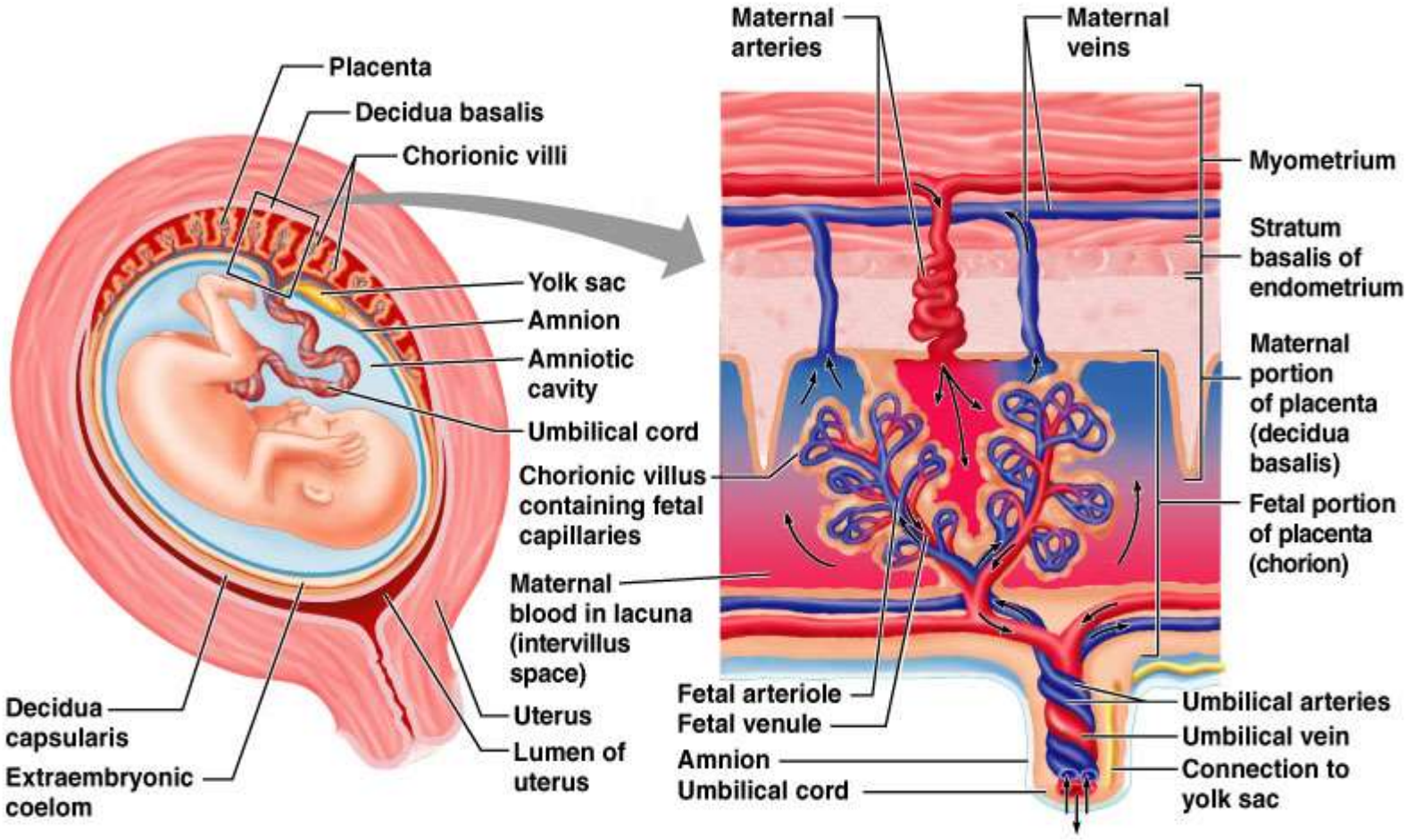


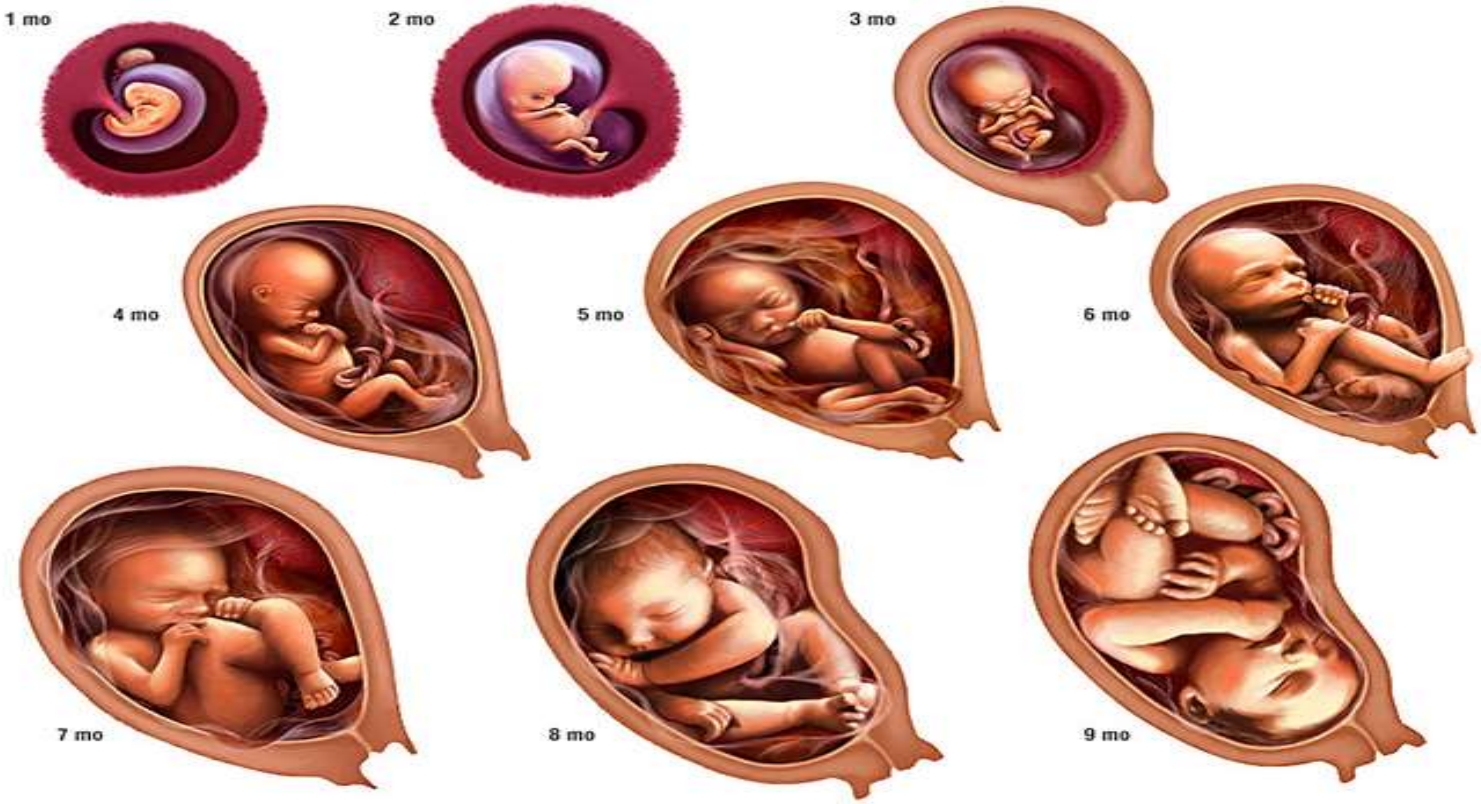
Figure 12. The human foetus within the uterus



(f) 13-week fetus **(g)**

- Later phase of pregnancy **relaxin-** secreted by ovary
- hCG , hPL & relaxin- only during pregnancy
- Other hormones like estrogen, progesterone, cortisol, prolactin, thyroxin- increases several fold in maternal blood
- Hormones- supporting fetal growth, metabolic changes in mother & maintenance of pregnancy
- After implantation- inner cell mass differentiates- outer **ectoderm** and inner **endoderm** & middle **mesoderm** soon appears- tissue & organs
- Inner cell mass contain certain cells- **Stem** cells- potency to give rise to all tissues & organs
- Pregnancy will last for 9 months divided as 3 trimesters - 1st :- end of 3rd month, 2nd :- end of 6th month & 3rd :- end of 9th month

- 1st month- embryo heart formed
- First sign- listening heart sound through stethoscope
- 2nd month- limbs & digits, end of 12 weeks(first trimester)- major organ system- limbs, external genital organs
- 1st movement & hair on head- during fifth month
- End of 24 week (second trimester)- body covered with fine hair, eye lid separate, eyelashes formed
- End of nine month- foetus fully developed & ready for delivery



PARTURITION

- The period of pregnancy is called **gestation** period. It is 9 months in human.
- The delivery of foetus is called **parturition.** It occurs by the contraction of uterine Myometrium.
- The signal of parturition is originated from the fully developed foetus and the placenta. It induces mild contraction of uterus called **fetal ejection reflex.**
- Hormone (adrenal gland) secreted by foetus diffuses to maternal blood & stimulate oxytocin secretion
- Oxytocin causes forceful contraction of myometrium (labour pain) & stimulates further secretion of oxytocin
- Stimulatory reflex between uterine contraction & Oxytocin secretion continues inducing stronger contraction & pushes the foetus by dilated cervix (birth canal) facilitated by **relaxin- parturition**
- After delivery the placenta is also expelled out of the uterus.

LACTATION

- Mammary gland of female undergo differentiation & produce milk towards end of pregnancy- **Lactation**
- The mammary gland starts producing milk towards the end of the pregnancy.
- Milk produced during initial days of lactation is called **colostrum**. It contains several antibodies which provide immunity (passive) or resistance to the new born baby.
- The milk production is controlled by Lacto trophic or prolactin hormone secreted by pituitary.
- Breast feeding during initial period of infant growth is recommended for bringing up a healthy baby