CHAPTER-2

HUMAN REPRODUCTION

Topic-1

Human Reproductive System

Concepts Covered ● *Structure of Male Reproductive System,* ● *Structure of Female Reproductive System*

Revision Notes

Reproductive System

- **Male Reproductive System**
  - **It consists of :**
    - **(a)** A pair of testes
    - **(b)** Accessory ducts
    - **(c)** Accessory glands
    - **(d)** External genitalia
- **Testes**
  - Testes are the primary sex organs that produce sperms and testosterone **hormone**.
  - Testes are located in the scrotum present in between upper thighs.
  - The low temperature (2 – 2.5°C less than the normal internal body temperature) in the scrotum helps for the proper functioning of testes and spermatogenesis.
  - Each testis is oval in shape and has about 250 (200 – 300) compartments called testicular lobules.
  - Each lobule is filled with connective tissue and contains 1-3 coiled yellow seminiferous tubules in which sperm are produced.
  - Seminiferous tubule is lined internally with spermatogenic cells called spermatogonia or primary male germ cells and sertoli cells or supporting cells.
  - Spermatogonia undergo meiotic divisions and leads to sperm formation.
  - Sertoli cells give shape and nourishment to developing spermatogenic cells and therefore also called as **nurse cells.**
  - The regions outside the seminiferous tubules are the interstitial spaces which contain small blood vessels and interstitial cells or Leydig cells.
  - The Leydig cells are endocrine in nature and secrete testicular hormones called androgens.
  - Immunologically competent cells are also present.
- **Accessory Ducts**
  - The duct system includes **rete testis, vasa efferentia, epididymis** and **vas deferens.**
  - The seminiferous tubules open into the vasa efferentia through rete testis.
  - The vasa efferentia open into the epididymis.
  - The epididymis leads to vas deferens that ascends into the abdomen and loops over the urinary bladder.
  - It receives a duct from the seminal vesicle and opens into the urethra as the ejaculatory duct.
  - These ducts store and transport the sperms from the testis to the outside through urethra.
  - The urethra originates from the urinary bladder and extends through the penis to its external opening called the urethral meatus.

- **Accessory Male Genital Glands**
  - It includes paired seminal vesicles, prostate and paired bulbourethral glands (Cowper's glands).
  - The secretions of these glands constitute the seminal plasma, which is rich in fructose, calcium and certain enzymes.
  - Seminal vesicles produce seminal fluid and form 60 – 70% of semen.
  - The secretion of bulbourethral glands is alkaline and rich in mucus. It helps in the lubrication of the penis, supplies nutrient to sperms and provides an alkaline medium to counteract the acidity of the uterus.
- **External Genitalia**
  - The penis is the male external genitalia.
  - It is made up of special tissue that helps in the erection of the penis to facilitate insemination.
  - The enlarged end of the penis is called the glans. The penis is covered by a loose fold of skin called foreskin.

IMPORTANT DIAGRAMS

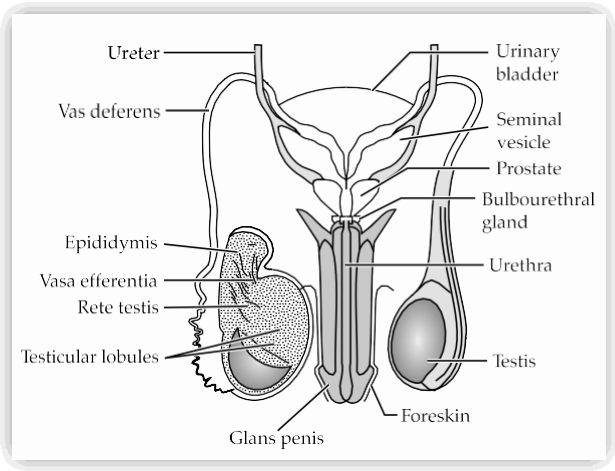

Fig 2.1 : Human Male Reproductive System

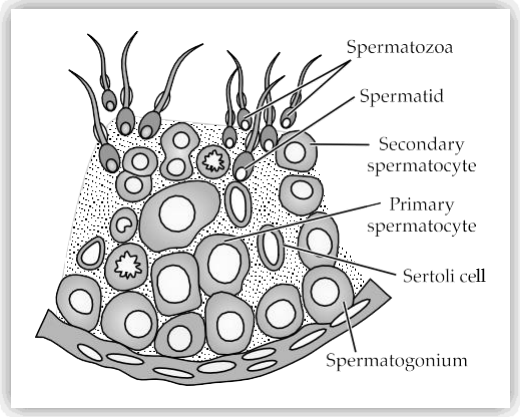

Fig 2.2 : Sectional view of human seminiferous tubule

- **The Female Reproductive System**
  - It includes a pair of **ovaries, accessory ducts** and **external genitalia.**
- **Ovaries**
  - They are the primary female sex organs that produce ova or the female gametes. It secretes many steroid ovarian hormones such as estrogen and progesterone.
  - Ovaries are located on both sides of the lower abdomen.
  - Each ovary is about 2-4 cm in length.
  - The ovaries are connected to the pelvic wall and uterus by ligaments.
  - Each ovary is covered by a thin epithelium which encloses the ovarian stroma.
  - The stroma has outer cortex and an inner medulla.
  - The ovary contains groups of cells known as Ovarian or Graafian follicles.
  - Each follicle carries a centrally placed ovum.

- **Accessory Ducts**
  - It includes two **oviducts** or **fallopian tubes,** cervix, a **uterus** and **vagina.**
  - Each oviduct is 10-12 cm long and has four parts namely, infundibulum, ampulla, isthmus and uterine part.

  (a) Infundibulum
  - It is the funnel-shaped opening provided with many finger-like fimbriae for catching released ovum.
  - It helps to collect the ovum after its release from the ovary.

  (b) Ampulla
  - The infundibulum leads to the curved and dilated part called the ampulla.

  (c) Isthmus
  - It is the last straight part of the oviduct.
  - It has a narrow lumen and joins the uterus.

  (d) Uterine part
  - It is about 1 cm long part of the oviduct which passes into the uterus.
- **Uterus**
  - It is single and also called the womb.
  - The shape of the uterus is like an inverted pear.
  - It is supported by ligaments attached to the pelvic wall.
    The uterus opens into the vagina through a narrow **cervix**.
  - The cavity of the cervix is called the cervical canal which along with the vagina forms the birth canal.
  - The wall of the uterus is thick and muscular and is differentiated into three layers of tissue namely,
    - **(a)** The external thin membranous perimetrium.
    - **(b)** The middle thick layer of smooth muscle, myometrium.
    - **(c)** The inner glandular layer called the endometrium.
  - The endometrium undergoes cyclic changes during the menstrual cycle while the myometrium exhibits strong contraction during delivery of the baby.
  - The vagina opens to the exterior between the urethra and anus.
  - The lumen of the vagina is lined by a glycogen-rich mucous membrane consisting of sensitive papillae and Bartholin's glands.
  - The secretions of Bartholin's glands lubricate the penis during sexual activity.
- **External Genitalia**
  - It includes the **mons pubis, labia majora, labia minora, hymen** and **clitoris.** The external genitalia are collectively called the vulva.
  - Mons pubis is a cushion of fatty tissue covered by skin and pubic hair.
  - The labia majora are a pair of large thicker fleshy folds of tissue, which surround the vaginal opening.
  - The labia minora are a pair of narrow fleshy folds of tissue found below labia majora.
  - The opening of the vagina is often covered partially by a membrane called the **hymen**.
  - The **hymen** is often torn during the first coitus (intercourse) or accidentally.
  - The clitoris is a tiny finger-like structure that lies at the upper junction of the two labia minora above the urethral opening.

Key Words

Cervix : Connects vagina and uterus

Hymen : Thin membrane partially covering the vaginal aperture

- **Mammary Glands**
  - A pair of mammary glands containing glandular tissue and fat is present in the chest region.
  - The glandular tissue of each breast has 15-20 mammary lobes containing clusters of cells called alveoli.
  - The cells of alveoli secrete milk which is stored in the cavities or lumen 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 which is connected to the lactiferous duct through which milk is sucked out.

Mnemonics

1. Concept: Accessory Male Genital Glands
Mnemonics: Supreme **P**ower in **B**ack or **S**even **P**ieces of **B**anana
Interpretations: Seminal vesicles, Prostate, Bulbo-urethral glands

2. Concept: Structure of Oviducts.
Mnemonics: I Am **I**ntelligent than **U**
Interpretations: Infundibulum, Ampulla, Isthmus, Uterine part.

3. Concept: Female External genitalia
Mnemonics: Mobile's **L**ight **L**ed **H**im **C**razy.
Interpretations: Mons pubis, Labia majora, Labia minora, Hymen Clitoris.

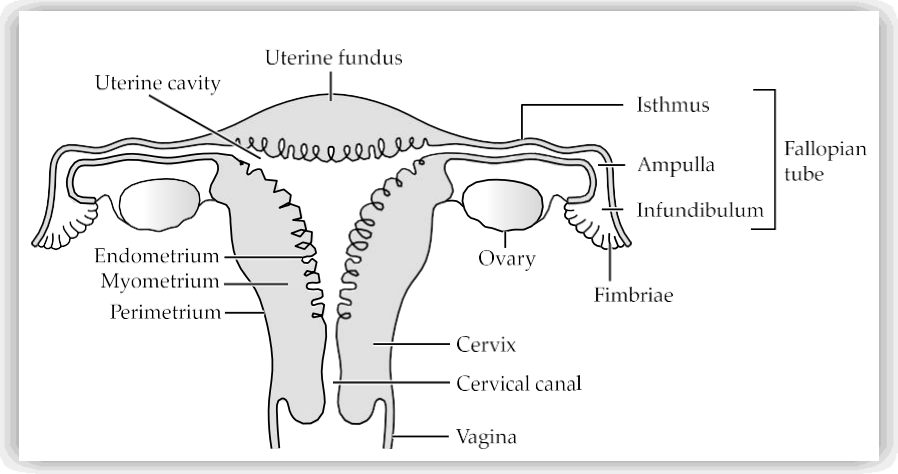

Fig 2.3: Human Female Reproductive system

Topic-2

Gametogenesis and Menstrual Cycle

Concepts Covered ● *Gametogenesis* ● *Structure of Sperm* ● *Structure of Ovum* ● *Menstrual Cycle*

Revision Notes

- **Gametogenesis**
  - The process of formation of gametes or sex cells is known as gametogenesis.
  - It includes spermatogenesis and oogenesis.
- **Spermatogenesis**
  - It is the process of the formation of sperms in seminiferous tubules of testes.
  - It has two stages namely,
    (a) Formation of **spermatids**
    (b) Spermiogenesis
  - During the formation of **spermatids**, spermatogonia i.e., sperm mother cells or immature male germ cells produce spermatids.
  - In spermiogenesis, the spermatids are transformed into sperm.
  - Each primary spermatocyte undergoes meiosis-I and produces two haploid secondary spermatocytes.
  - Each secondary spermatocyte divides by meiosis-II and produces two haploid spermatids.
  - Thus, four spermatids are formed from each primary spermatocyte.
  - The spermatids, under the influence of FSH of the anterior pituitary, are converted into spermatozoa. The process is called spermiogenesis.
  - After spermiogenesis, the sperm head become embedded in the Sertoli cells and are finally released from seminiferous tubules. The process of release of mature spermatozoa from the Sertoli cells into the **lumen** of seminiferous tubules is known as spermiation.
- **Hormones in Spermatogenesis**
  - The hypothalamus releases a large amount of Gonadotropin-releasing hormone (GnRH).
  - GnRH stimulates the anterior pituitary gland to secrete two gonadotropins namely Luteinizing hormone (LH) and Follicle stimulating hormone (FSH).
  - LH acts on the Leydig cells and stimulates the synthesis and secretion of androgens which in turn stimulate the spermatogenesis.
  - FSH acts on the Sertoli cells and stimulates the secretion of some spermatogenic factors which help in the process of spermiogenesis.
- **Structure of Sperm**
  - It is a microscopic structure.
  - A mature sperm measures about 60 μm (0.06 mm) long.
  - A plasma membrane envelops the whole body of sperm.

- Sperm consists of four parts namely, head, neck, a middle piece and a tail region.

(a) Head

- It is oval-shaped, consisting of a nucleus and **acrosome**.
- The **acrosome** is formed from Golgi complex which contains lytic enzymes, that help in fertilisation of the ovum.

Key Words

Spermatids: Formed after the second meiotic division from spermatocyte and develop into spermatozoa.
Acrosome: Membranous organelle located above the anterior part of the sperm nucleus containing number of hydrolytic enzymes.

(b) Neck

- Behind the head is a neck containing proximal and distal centrioles.
- The distal centriole of the neck is connected to the axial filament.

(c) Middle Piece

- It is composed of axial filament surrounded by numerous mitochondria and cytoplasm.
- Mitochondria produce energy for the sperm motility.

(d) Tail

- It consists of a central axial filament.
- The sperm moves in fluid medium and female genital tract by the undulating movement of the tail.
- Sperms are transported through the accessory ducts.
- The secretions of the epididymis, vas deferens, seminal vesicle and prostate are essential for maturation and motility of sperms.
- The seminal plasma and sperms together constitute the semen.
- The human male ejaculates about 200-300 million sperms during a coitus ejaculation.
- For normal fertility at least 60% of sperms must have a normal shape and size and 40% of them, must show vigorous motility.

Key Diagram :

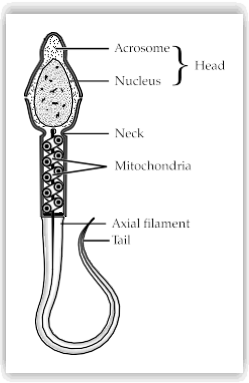

Fig 2.4 : Structure of a Sperm

Oogenesis

- It is the process of formation and maturation of the ovum.
- It takes place in Graafian follicles.
- It is initiated in embryonic stage when millions of egg mother cells (oogonia) are formed within each ovary.
- No oogonia are formed and added after birth.
- Oogonia multiply to form primary oocytes which enter into prophase-I of the meiosis and get temporarily arrested at that stage.
- Each primary oocyte gets surrounded by a layer of granulosa cells to form a primary follicle.
- A large number of primary follicles degenerate during the phase from birth to puberty.
- Therefore at puberty, only 60,000-80,000 primary follicles are left in each ovary.
- The primary follicles get surrounded by more layers of granulosa cells and a new theca to form secondary follicles.
- The secondary follicles get transformed into a tertiary follicle.
- It has a fluid-filled cavity (antrum).
- The theca layer forms an inner theca interna and an outer theca externa.

- The primary oocyte within the tertiary follicle grows in size and undergoes first unequal meiotic division to form a large haploid secondary oocyte and a tiny first polar body.
- The secondary oocyte retains the nutrient-rich cytoplasm of the primary oocyte.
- It is unknown, whether the first polar body divides further or degenerates.
- The tertiary follicle further changes into the mature follicle (Graafian follicle).
- The secondary oocyte forms a new membrane (zona pellucida).
- The Graafian follicle now ruptures to release the secondary oocyte (ovum) from the ovary. This is called ovulation.

Key Diagram :

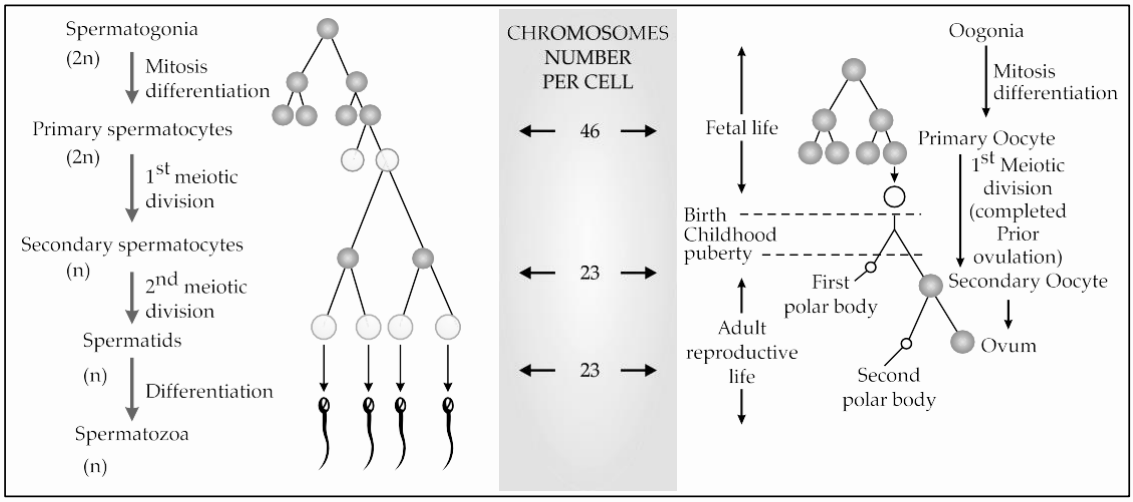

Fig 2.5 : Schematic representation of (a) Spermatogenesis (b) Oogenesis

Structure of Ovum

- It is a spherical or oval and non-motile female gamete.
- It is about 0.2 mm in diameter.
- The human ovum is non cleidoic (without shell) and alecithal (without yolk).
- Ovum has four membranes namely,
  - **(a) Plasma membrane (Oolemma) :** Innermost layer.
  - **(b) Vitelline membrane :** Attached to the plasma membrane.
  - **(c) Zona pellucida :** Transparent non-cellular, thick, glycoprotein rich layer found outer to the vitelline membrane.
  - **(d) Corona radiata :** Outer layer is formed of follicle cells. These cells are held together by a mucopolysaccharide called hyaluronic acid.

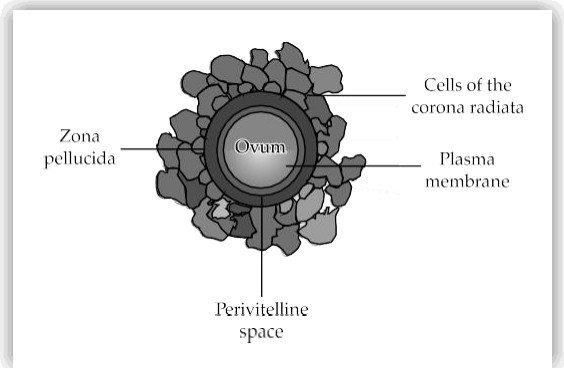

Fig 2.6 : Structure of human ova

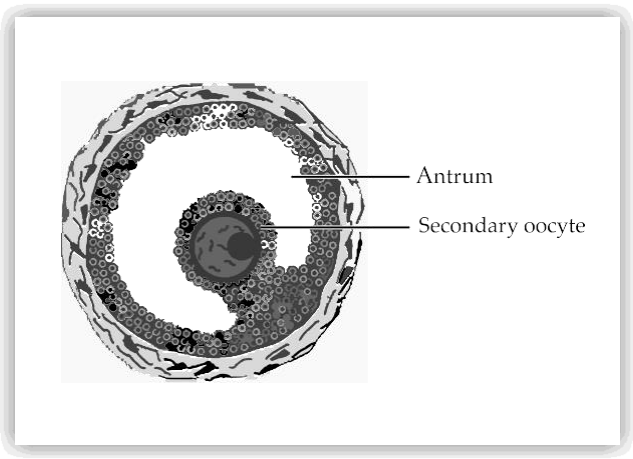

Fig 2.7 : Graafian follicle

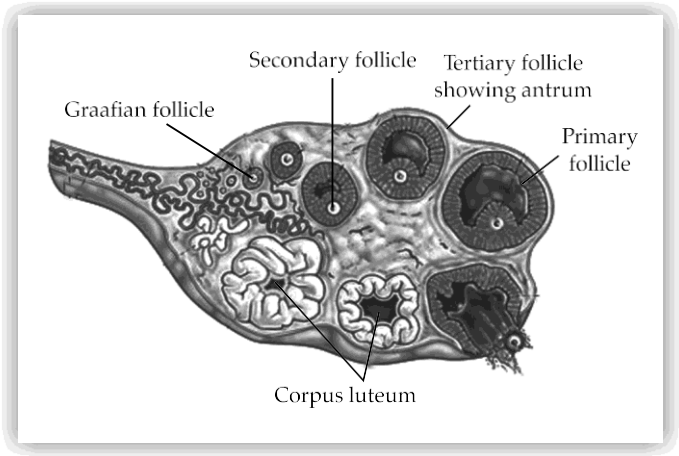

Fig 2.8 : Sectional view of ovary

- **Menstrual Cycle**
  - The reproductive cycle in the human female and related primates is called the menstrual cycle.
  - The first menstruation begins at puberty (at the age of 10-12 years) and is called menarche.
  - In human females, menstruation is repeated at an average interval of about 28/29 days and the cycle of events starting from one menstruation till the next one is called the menstrual cycle.
  - One ovum is released during the middle of each menstrual cycle.
  - The cycle starts with the menstrual phase, when menstrual flow occurs, it lasts for 3-5 days.
  - The menstrual flow results due to the breakdown of the endometrial lining of the uterus and its blood vessels which form the liquid that comes out through the vagina.
  - Menstruation occurs only if the released ovum is not fertilised.
  - Lack of menstruation may be indicative of pregnancy or may also be caused due to some other underlying causes like stress, poor health, etc.
  - The menstrual phase is followed by the follicular phase.
  - During the follicular phase, the primary follicles in the ovary grow to become a fully mature Graafian follicle and simultaneously, the endometrium of uterus regenerates through proliferation. These changes in the ovary and the uterus are induced by changes in the levels of pituitary and ovarian hormones.
  - The secretion of gonadotropins (LH and FSH) increases gradually during the follicular phase and stimulates follicular development as well as secretion of estrogens by the growing follicles.
  - Both LH and FSH attain a peak level in the middle of the cycle (about the 14^{th} day).
  - Rapid secretion of LH leading to its maximum level during the mid-cycle called LH surge induces rupture of Graafian follicle and thereby the release of an ovum (ovulation).
  - The ovulation (ovulatory phase) is followed by the luteal phase during which the remaining parts of the Graafian follicle transform as the corpus luteum.
  - The corpus luteum secretes large amounts of progesterone which is essential for the maintenance of the endometrium.
  - During pregnancy, all events of the menstrual cycle stop and there is no menstruation.
  - In the absence of fertilisation, the corpus luteum degenerates. This causes disintegration of the endometrium leading to menstruation, marking a new cycle.
  - In human beings, the menstrual cycle ceases at around 50 years of age and is termed as menopause.

- Cyclic menstruation is an indicator of the normal reproductive phase and extends between menarche and menopause.

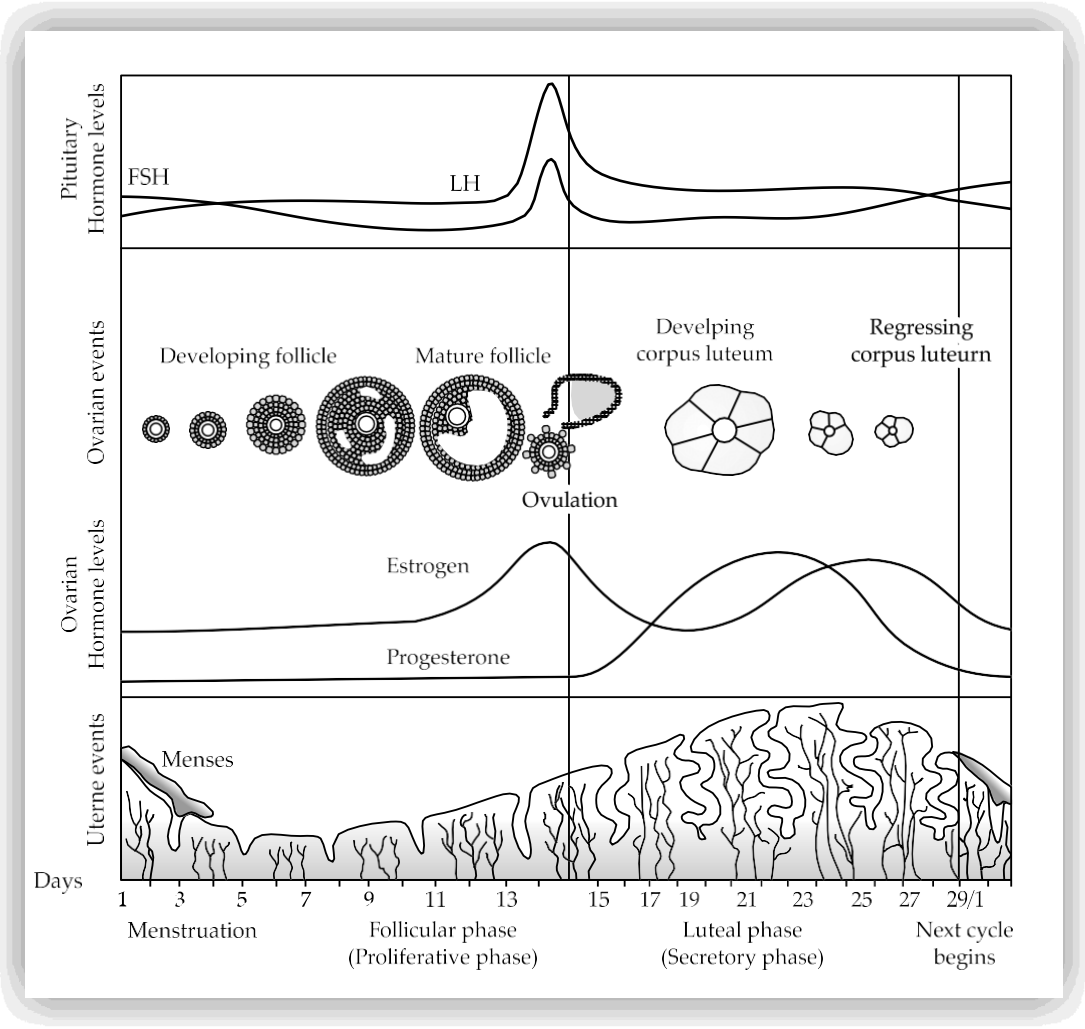

Fig 2.9 : Various events during Menstrual Cycle

Mnemonics

1. Concept: Structure of Sperm
Mnemonics: High **N**ode **M**agnification **T**ime
Interpretations: Head, Neck, Middle piece, Tail
2. Concept: Structure of Ovum
Mnemonics: Please cross **V**ia **Z**ebra **C**rossing
Interpretations: Plasma membrane Vitelline membrane, Zona pellucida, **C**orona radiata

Topic-3 Fertilisation and Post-Fertilisation Events

Concepts Covered ● *Fertilisation* ● *Pregnancy* ● *Placenta Formation and Functions* ● *Lactation* ● *Parturition*

Revision Notes

Fertilisation

- The process of fusion of male gamete (sperm) with the female gamete (ovum) is called fertilisation.
- During copulation, semen is released through the penis into the vagina (insemination).

- After insemination, the sperms swim through the cervix and enter into the uterus and reach the ampullary-isthmic junction of the oviduct where fertilisation takes place.
- The process of fertilisation takes place as follows :

Sperms → vagina → cervical canal → uterus → isthmus
↓
Fertilisation ← Ampullary-isthmic Junction ampulla
↑
Ovum (from ovary) → fimbriae → infundibulum →

- Fertilisation (sperm + ovum → zygote) occurs only if ovum and sperms are transported simultaneously. So all copulations do not lead to fertilisation and pregnancy.
- As soon as sperm contacts with zona pellucida, it induces changes in the membrane that block entry of additional sperms.
- With the help of enzymes of the acrosome, which dissolve the zona pellucida and plasma membrane of the ovum, the sperm enters into the cytoplasm of the ovum. This induces second meiotic division of the secondary oocyte to form a second polar body and a haploid ovum (ootid).
- The haploid nuclei of the sperm and ovum fuse together to form a diploid zygote.

Implantation

- The mitotic division (cleavage) starts as the zygote moves through the isthmus of the oviduct towards the uterus and forms 2, 4, 8, 16 daughter cells called blastomeres.
- The embryo with 8-16 blastomeres is called a **morula**.
- **Morula** continues to divide and transforms into a large mass of cells called the blastocyst, which moves further towards the uterus.

Key Word

Morula: The embryo with 8-16 celled blastomeres.

Chorionic villi: Tiny projections of placental tissue that look like fingers and contain the same genetic material as the foetus.

- The blastomeres in the blastocyst are arranged into an outer layer (trophoblast) and an inner group of cells (inner cell mass) attached to the trophoblast.
- The trophoblast layer then gets attached to the endometrium and the inner cell mass gets differentiated into three germ layers namely, outer ectoderm, middle mesoderm and inner endoderm forming 3-layered structure (gastrula) leading to the formation of the embryo.
- After attachment, uterine cells divide rapidly and cover the blastocyst.
- As a result, the blastocyst becomes embedded in the endometrium of the uterus. This is called implantation.

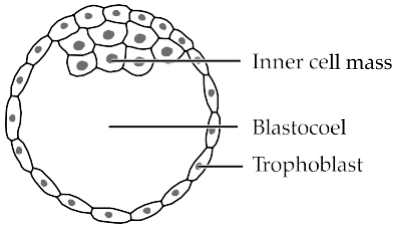

Fig 2.10: Diagram of a Blastocyst

Pregnancy and Embryonic Development

- After implantation, the finger-like projections called **chorionic villi** appear on the trophoblast which is surrounded by the uterine tissue and maternal blood.
- The chorionic villi and uterine tissue become interdigitated with each other and form a structural and functional unit between the developing embryo and the maternal body called the placenta.
- The placenta is a structural and functional unit between the embryo (foetus) and the maternal body.
- The placenta is connected to the embryo by an umbilical cord.
- The umbilical cord helps to transport substances to and from the embryo.

Functions of Placenta

- It acts as a barrier between the foetus and mother.
- Soluble inorganic and organic materials, nutrients, hormones, antibodies, etc. can pass through the placenta from the mother to the foetus.
- It helps in the gas exchange between mother and foetus.
- It helps to eliminate nitrogenous wastes of foetus.
- It acts as an endocrine gland by secreting several hormones like human Chorionic Gonadotropin (hCG), human Placental Lactogen (hPL), oestrogens, progesterone and relaxin.

Pregnancy

- During pregnancy, levels of estrogen, progestogen, cortisol, prolactin, thyroxine, etc. are also increased in maternal blood.

- They support the foetal growth, metabolic changes in the mother and maintain pregnancy.
- Three germ layers (ectoderm, endoderm, mesoderm) give rise to all tissues (organs) in adults.
- The stem cells in inner cell mass have the potency to give rise to all the tissues and organs.
- Human pregnancy (gestation period) lasts 9 months (for cats : 2 months, dogs : 2 months, elephants : 21 months).

Changes in Embryo during Pregnancy

- After one month of pregnancy : The heart is formed.
- End of second month : Limbs and digits are developed.
- End of 12 weeks (first trimester) : The major organs such as limbs, external genital organs etc., are well developed.
- During 5^{th} month : The first movement of foetus and appearance of hair on the head.
- End of 24 weeks (second trimester) : Body is covered with fine hair, eyelids separate and eye lashes are formed.
- End of 9 months : Ready for delivery.

Parturition (Labour) and Lactation

- The process of giving birth to young ones after the gestation period of nine months is known as parturition.
- Parturition is induced by a neuroendocrine mechanism.
- The signals originating from the foetus and placenta induce mild uterine contractions (foetal ejection reflex). This causes the release of oxytocin from the maternal pituitary.
- Oxytocin causes stronger uterine muscle contractions which in turn stimulate further secretion of oxytocin. This process is continued leading to the expulsion of the baby out of the uterus through the birth canal.
- After parturition, the umbilical cord is cut off.
- The placenta and remnants of the umbilical cord are expelled from the maternal body after parturition. This is called “after birth”.

Lactation

- The mammary glands produce milk towards the end of pregnancy by the process called lactation.
- The yellowish milk produced during the initial few days of lactation is called colostrum.
- The colostrum contains several antibodies essential to develop resistance for newborn babies.