

# HUMAN REPRODUCTION

## SYNOPSIS

### Introduction:

- Every kind of living organism by performing reproduction multiplies to form new individuals of its own kind.
- Reproduction is meant for perpetuation of the race/species
- Reproduction is necessary to make up the losses that occur due to natural death after a life span or due to abnormal deaths like competition, predation, disease, starvation etc.
- Animals reproduce by two methods, namely asexual and sexual reproduction.
- In asexual reproduction the parent produce young ones without the mating of gametes
- In sexual reproduction the parents produce young ones with the formation of gametes and fusion of gametes.
- Sexual reproduction is the advanced type of reproduction.
- Human beings are sexually reproducing and viviparous
- In humans the events in the sexual reproduction
  - a) Gametogenesis      b) Insemination      c) Fertilisation      d) Implantation
  - e) Gestation          f) Parturition
- Formation of gametes (males – sperms, females – ovum) – **Gametogenesis**
- Transfer of sperms into the female genital tract – **Insemination**
- Fusion of male & female gametes lead to the formation of zygote – **Fertilisation**
- Attachment of blastocyst to the uterine wall – **Implantation**
- Embryonic development – **Gestation**
- Delivery of the baby – **Parturition**
- Reproductive events in both males and females occur after puberty (onset of maturity)
- In male humans formation of sperms (spermatogenesis) continues even in oldmen until death
- In women formation of ovum ceases around the age of 50 yrs (**menopause**)

### The male reproductive system:

- Male reproductive system in human is located in the pelvis region.
- Male reproductive system in humans includes
  - a) 1 pair of testes (singular testis)
  - b) Accessory ducts
  - c) glands
  - d) External genitalia
- a) **Testes:** a pair of oval, pinkish and primary sex organs
  - The testes are situated outside the abdominal cavity within a pouch called scrotum (extra abdominal) (Primates)
  - The scrotum helps in maintaining 2-2.5°C low temperature than the normal internal body temperature.
  - Human sperms can not develop at the high temperature found within the body cavity, hence the testes are extra abdominal.
  - In **whale, elephant, seal** and **rhinoceros** the testes remain permanently in the abdominal cavity

- Scrotum is in front of penis in **Kangaroo**.
- In foetus the testes develop in the abdomen but descend into scrotum through passages called **inguinal canal**.
- Failure of testes to descend into scrotum is **cryptorchidism** which causes **sterility**
- Each testis is 4-5 cm in length, 2-3 cm in width
- Testis is covered by a dense covering (Fibrous capsule) called **tunica albuginea**
- Each testis contains about 250 lobules called **testicular lobules**
- Each lobule contains 1-3 highly coiled **seminiferous tubules**
- In seminiferous tubules only sperms are produced
- Each seminiferous tubule is lined inside by 2 types of cells.
  - a) Male germ cells (spermatogonia) (epithelial cells)
  - b) Sertoli cells / nurse cells / sustentacular cells.
- Male germ cells undergo meiotic division and finally form the male gamete – **sperm**
- Sertoli cells / nurse cells / sustentacular cells are large slender pyramidal cells that extend from the basement membrane of seminiferous tubules up to the lumen of the tubule.
- Sertoli cells provide nutrition and support to the germ cells.
- The regions among the seminiferous tubules are called interstitial spaces
- Interstitial spaces contain
  - a) Blood vessels
  - b) Interstitial cells (or) Leydig cells
  - c) Other immunologically competent cells
- Leydig cells are endocrine in nature; they synthesise and secrete testicular hormones called **androgens** which influence spermatogenesis and secondary sexual characters in males.
  - c) Accessory ducts : Includes
    - i) Rete testis      ii) vasa efferentia      iii) epididymis      iv) vas deferens
- **Rete testis**: Several seminiferous tubules unite to form straight tubules which fuse and unite to form rete testis
- **Vasa efferentia**: Rete testis joins up to form the vasa efferentia which leave the testes and open into epididymis
- **Epididymis**: Located along the posterior surface of each testis. This leads to vas deferens
- **Vas deferens**: Ascends to the abdomen and loops over the urinary bladder.
- Vas deferens receives a duct from seminal vesicle and opens into urethra as **ejaculatory duct**
- These ducts store & transport the sperms from testis to the outside through **urethra**
- Urethra extends through penis and is originated from **urinary bladder**
- Urinary bladder extends through to its external opening called **urethral meatus**.
- **d) Accessory glands** : They include
  - i) Paired seminal vesicles      ii) Prostate gland
  - iii) Paired bulbourethral glands (Cowper's gland)
- Secretions of accessory glands constitute **seminal plasma**
- Seminal plasma is rich in **fructose, calcium** and **certain enzymes**.
- The secretions of bulbourethral glands help in the lubrication of the penis.
  - iv) **External genitalia** – Penis is the male external genitalia
- Penis is made up of
  - a) corpora cavernosa      b) corpus spongiosummuscles help in **erection**.
- Erection of penis facilitates **insemination**.
- The tip of penis enlarged to form a bulb-like part called **glans penis**

- Glans penis is covered by a loose fold of skin is called **foreskin or prepuse**.

### The female reproductive system

- The female reproductive system is located in pelvic region.
- It consist of
  - a) A pair of ovaries      b) a pair of oviducts (fallopian tubes)
  - c) Uterusd) cervix      e) vagina      f) external genitalia
- A pair of mammary glands is also associated structurally and functionally to support the process of ovulation, fertilization, pregnancy, birth and child care.

### Ovaries:

- Primary female sex ogans which produces female gametes – ovum and several steroid hormones.
- The ovaries are solid situated on the sides of vertebral column behind the kidneys and located on each side of the lower abdomen
- Each ovary is 2-4 cm in length
- Ovaries are attached to the dorsal body wall through a connective tissue – **mesovarium**
- Ovaries are connected to the pelvic wall and uterus by **ligaments**
- Ovaries are covered by thin epithelium – **germinal epithelium**
- Germinal epithelium encloses the interior part of ovary – **stroma**
- Stroma is divided into
  - a) Peripheral **cortex**                      b) Inner **medulla**

### Oviducts or fallopian tubes

- A pair of muscular and internally ciliated tubes.
- Oviducts arising from the periphery of each ovary having 10-12 cm length and ending at uterus.
- The part of oviduct closed to the ovary which is funnelshped – **infundibulum**
- The free end/edges of bears a number of finger like projections called **fimbriae**
- Fimbriae have longitudinal folds lined with cilia
- Fimbriae help in collection of the ovum after ovulation
- The wider part of oviduct is **ampulla**
- The part of oviduct which has narrow lumen and straight part of fallopian tube is **isthmus** which joins the uterus.

### Uterus (womb)

- It is single in human beings (**uterine simplex**)
- Shape is like an inverted pear
- Uterus is attached to pelvic wall with the support of ligaments
- Uterus opens into vagina through a narrow cervix
- The cavity of cervix is **cervical canal**
- Cervical canal along with vagina forms the **birth canal**.
- The wall of uterus has 3 layers of tissue
  - a) The external thin membranous layer – **perimetrium**
  - b) Middle thick layer of smooth muscles – **myometrium**
  - c) Inner glandular layer – **endometrium**
- Endometrium lines the uterine cavity
- During menstrual cycle endometrium undergoes the cyclical changes
- Myometrium shows strong contraction during delivery of baby (Parturition)
-

### **Cervix: (Neck of the uterus)**

- 2-5 cm long narrow inferior extremity of uterus which protrudes into vagina

**Vagina:** Tubular passage way for menstrual flow.

- It is a birth canal about 7-9 cm length.

### **Female external genitalia / Vulva:**

- It includes
  - a) **Monspubis** (mons veneris) – cushion of fatty tissue covered by skin and pubic hair
  - b) **Labia majora** – fleshy folds of tissue surround the vaginal opening extend down from mons pubis
  - c) **Labia minora** – paired folds of tissue under the labia majora
  - d) **Hymen** – A perforated membrane partially covering the vaginal opening
- During the first coitus or intercourse the hymen is often torn
- Hymen is also broken in sudden fall/jolt, insertion of vaginal tampon, active participation in horseback riding, cycling etc.
- Hymen presence or absence is not an indicator of virginity or sexual experience.

### **Clitoris (Homologous to penis of male)**

- Tiny, finger like, erectile.
- It lies above the vertical opening at the junction of two labia minora.

### **Mammary glands (breasts)**

- A paired structures contain glandular tissue and variable amount of fat
- Functional mammary glands is characteristic of all female mammals
- In primate males mammary glands are nonfunctional (vestigial)
- Mammary glands develop during puberty but become active only after child birth
- The glandular tissue of each breast is divided into 15-20 **mammary lobes**
- Mammary lobes contain clusters of cells – **alveoli**
- The alveoli cells secrete milk which is under the control of a hormone – **prolactin**
- Milk is stored in the **cavities of alveoli**
- Alveoli opens into **mammary tubules**
- Mammary tubules join to form **mammary duct**.
- Several mammary ducts join to form a wider **mammary ampulla**
- Mammary ampulla is connected to **lactiferous duct** towards nipple
- Nipple is median part of each breast
- Nipple is multiporous rounded tip, pigmented and sensitive.
- Through lactiferous duct the milk is sucked out.

### **Gametogenesis**

- Production of gametes from the primary sex organs in males & females is **gametogenesis**
- In males sperms and in females ovum are produced respectively

### **Spermatogenesis:**

- In testis (Primary sex organ of male) immature male germ cell (Spermatogonia) produces sperms by **spermatogenesis** which begins at **puberty**.
- Spermatogonia (immature male germ cells) are present inside the wall of seminiferous tubules.
- Spermatogonium is diploid containing 46 chromosomes.
- Spermatogonium multiplies by mitosis and increase in numbers. (Multiplication phase)
- Spermatogonium after multiplication is differentiated into 2 different types of cells
- Some spermatogonium cells function as stem cells and produce more spermatogonia

- Some spermatogonia formed into primary spermatocytes (spermatocytogenesis)
- Each primary spermatocyte which is diploid (46 chromosomes) undergoes **meiosis I** division (reduction division) form 2 haploid, equal cells called secondary spermatocytes (23 chromosomes)
- 2 secondary spermatocytes (haploid) undergoes **meiosis II** division to form 4 equal, haploid spermatids (23 chromosomes)
- Each spermatid is partially embedded in the sertolicells for nourishment & support
- Each spermatid transforms (metamorphosis) into spermatozoa (sperms) by a process spermiogenesis
- Sperm heads are embedded in the sertolicells
- Release of sperms into the lumen of seminiferous tubules is called **spermiation**
- Spermatogenesis starts during adolescence (puberty)
- Spermatogenesis a process is due to the significant increase in the secretion of gonadotropin releasing hormone (GnRH).
- GnRH is an hypothalamic hormone which acts on anterior part of pituitary gland (adenohypophysis)
- Anterior pituitary gland inturn stimulates the secretion of 2 **gonadtropins**
  - a) Leutinising hormone (LH)    b) Follicular stimulating hormone (FSH)
- LH acts on leydigcells (interstitial cells) which stimulates the secretions of androgens
- Androgens stimulates the process of spermatogenesis
- FSH acts on sertolicells and stimulates certain factors which helps in the process of spermiogenesis

#### Structure of sperm (spermatozoan)

- It is microscopic flagellate structure of 60  $\mu$  m length 3.5  $\mu$  m in breadth
- A plasma membrane covers the whole body of sperm
- Each sperm (spermatozoan) has 4 parts
  - a) Head knob like, contain an elongated haploid nucleus, anterior portion of head is covered by a cap like structure **acrosome**.
- Acrosome is filled with enzymes **helps in fertilization of the ovum**.
- b) **Neck:** short narrow part between head and middle piece.
- c) **Middle piece (boy) :** It is cylindrical, posses numerous mitochondria which produce energy for the movement of tail which is essential for fertilization.
- d) **Tail:** Narrow, vibratile long part of sperm.
- During a coitus (intercourse) human male ejaculates about 200-300 million sperms
- For normal fertility 60% sperms must have normal shape and size at least 40% of them must show vigorous motility.
- The sperms released from seminiferous tubules are transported by accessory ducts
- Secretions of epididymis, vas deferens, seminal vesicle and prostate are essential for maturation and motility of sperms.
- Seminal plasma with sperms constitutes semen
- Male sex accessory ducts, glands functions are maintained by androgens (testicular hormones)

#### Oogenesis:

- It is a process of formation of a mature female gamete
- Couples of million gamete mother cells (Oogonia) are formed within each foetal ovary during early embryonic development stage.
- Additional oogonia are not formed or added after birth
- Oogonia start division and enter into **prophase – I** of meiotic division and get temporarily arrested at that stage called **primary oocytes**.



- Each primary oocyte gets surrounded by a layer of granulose cells – **primary follicle**
- A large number of primary follicles do degenerate during the phase from birth to puberty
- At puberty only 60000 – 80000 primary follicles are left in each ovary.
- Each primary follicle is surrounded by more layers of granulose cells and a new theca called **secondary follicle**.
- Secondary follicle transforms into **tertiary follicle**
- Tertiary follicle is characterized by a fluid filled cavity called **antrum**.
- The thecal layers are differentiated into outer **theca externa** and inner **theca interna**.
- The primary oocyte in the tertiary follicle grows in size and couplets **meiosis – I** division
- Meiosis – I division is unequal and forms a large haploid secondary **oocyte** (23 chromosomes) and a tiny polar body.
- Secondary oocyte retains rich nutrients in the cytoplasm
- Further division of 1<sup>st</sup> polar body is not clear
- The tertiary follicle further changes into mature follicle (graafian follicle)
- Now a new membrane is formed around the secondary follicle – **zona pellucida**
- Graafian follicle ruptures and release the secondary oocyte (Ovum) from the ovary - **ovulation**.

#### Schematic representation of spermatogenesis

- **Spermatogonia** (primary germ cells)  $\xrightarrow{\text{Growth}}$  **Primary Spermatocytes** (Diploid, 46 chromosomes)  $\xrightarrow{\text{Meiosis-I}}$  **Secondary Spermatocytes** (haploid, 23 chromosomes)  $\xrightarrow{\text{Meiosis-II}}$  **Spermatids** (Haploid, 23 chromosomes)  $\xrightarrow[\text{spermeogenesis (differentiation)}]{\text{metamorphosis}}$  **Spermatozoa** (Haploid, 23 chromosome)

#### Oogenesis:

- **Oogonia** (Diploid) (46 chromosomes)  $\xrightarrow{\text{Mitosis}}$  **Primary oocytes** (Diploid, 46 chromosomes)  $\xrightarrow[\text{spermeogenesis (differentiation) Prior to ovulation}]{\text{Meiosis (Unequal)}}$  **I polar body, Secondary oocyte** (Haploid, 23 chromosomes)  $\rightarrow$  **II polar body, ovum** (Haploid, 23 chromosomes)

#### Menstrual cycle (Ovarian cycle)

- In primates eg monkeys, apes and human being the reproductive cycle is menstrual cycle.
- The first menstruation begins at puberty – menarche
- In human females the periodicity of menstruation at an average of 28/29 days right from menarche to menopause (Production of ovum is ceased)
- Cyclical events start from one menstruation till the next one is called the menstrual cycle.
- During the middle stage of each menstrual cycle one ovum is released (Ovulation) by one of the two ovaries.
- Menstrual cycle starts with **menstrual phase**
- Menstrual flow is the release of fluid which consists of breakdown tissue of endometrial lining of uterus and blood vessels.
- Menstrual flow comes out through vagina
- Menstrual flow lasts for 3-5 days
- Stoppage of menstruation is a sign of pregnancy
- Sometimes it may be due to stress, poor health etc.
- Menstrual phase is followed by follicular phase.

- During follicular phase primary follicles becomes mature graffian follicle and simultaneously endometrium of uterus regenerates by proliferation
- The changes are under the control of levels of pituitary and ovarian hormones
- FSH & LH secretions raises gradually in follicular phase
- FSH & LH raised levels stimulates follicular development as well as secretions of oestrogen by growing follicles.
- LH & FSH attain peak level in the middle of the cycle (about 14<sup>th</sup> day)
- Rapid secretion LH lead the rupture of graffian follicle and release the ovum – ovulation.
- The ovulation phase is followed by luteal phase during which remaining part of the graffian follicle transform as **corpus luteum**.
- Corpus luteum secretes large amount of **progesterone**
- Progesterone is essential for maintenance of endometrium
- Endometrium is necessary for implantation of fertilized ovum & other events of pregnancy.
- All events of the menstrual cycle stop during pregnancy
- In the absence of fertilization the corpus luteum degenerates
- Degeneration of the endometrium leading to menstruation on set of a new cycle
- In human beings menstrual cycle ceases round 50 years of age – **menopause**
- Normal and cyclic menstruation is an indicator of normal reproductive phase extends between **menarche** and **menopause**.

### Fertilisation and Implantation

- During coitus (intercourse) semen containing millions of sperms is released through **Penis**
- The process of depositing the semen in the vagina is called as **insemination**
- The sperms are highly **motile** and **swim** rapidly
- Motile sperms pass through the cervix, enter into the uterus and finally reach the junction of **isthmus and ampulla** of fallopian tube.
- After ovulation the ovum released by the ovary also transported to the junction of the **isthmus and ampulla** (ampullary – isthmic junction)
- Fertilisation occurs in the **ampullary isthmic junction** (fallopian tube)
- The condition for the fertilisation is the simultaneous transport of sperms and ovum to the **ampullary – isthmic junction**. (All copulations do not cause fertilisation or pregnancy)
- The process of fusion of a sperm with an ovum is called **fertilisation**
- Usually only one single sperm gets the success in **fertilisation**
- During fertilization, a single sperm comes in contact with **Zona pellucida**, outermost layer of secondary oocyte
- The sperm induces the changes in the membrane which block the entry of additional sperms (**monospermy**)
- The penetration of sperm through zona pellucida and the plasma membrane is due to the secretions of **acrosome** (cap of the sperm)

- The entry of sperm into the ovum induces the completion of meiotic division – II in the **secondary oocyte**.
- Meiosis – II division is unequal results in the formation of 2<sup>nd</sup> **polar body** which is haploid ovum (ootid) having 23 chromosomes
- The fusion of haploid nucleus of sperm and haploid nucleus of ootid fuse to form **Zygote** (diploid, having 46 chromosomes)
- Sex determination in man occurs in this stage only
- Human females are having XX sex chromosomes
- Human males are having XY sex chromosomes
- Female human beings always produces same type of ovum having X sex chromosome (homogametic) (100% ovum carry X chromosome only)
- Male human beings always produces 2 types of sperms having either X sex chromosome or Y sex chromosome (heterogametic)
- 50% of sperms carry X chromosome
- 50% of sperms carry Y chromosome
- After fusion of sperm and ovum the Zygote is formed which is either XX or XY depending on whether X carrying sperm or Y carrying sperm is fertilised with ovum
- Zygote with X develop into female baby
- Zygote with XY develop into male baby
- Scientifically the sex of the new born baby is determined by father but not mother.
- The cleavage (mitotic division) starts as the zygote moves through the isthmus
- Zygote now moves toward the uterus.
- The resultant cells of cleavage are called **blastomeres**
- The blastomeres are formed in a sequence like 2,4,8,16 daughter cells
- The embryo with 8-16 blastomeres having the shape of compact ball of cells called as **morula**
- Morula continues to divide and rearrangement of blastomeres occurs creating a central cavity inside the morula and transforming into **blastocyst**
- Blastula stage is absent in human beings
- Blastocyst further moves into the uterus
- In the blastocyst the blastomeres are arranged in 2 layers
- Outer layer is called **trophoblast**
- Trophoblast cells of implanted embryo withdraw the nourishment from the mother.



- Inner group of cells attached to the trophoblast are called the **inner cell mass**
- Inner cell mass further differentiated into **embryo**
- Trophoblast layer gets attached to the endometrium of the uterus.
- Uterine cells divide rapidly and cover the blastocyst after the attachment.
- Blastocyst now embedded in the endometrium of the uterus this process is called as **Implantation**, which leads to the pregnancy

### **Pregnancy and Embryonic development**

- Immediately after the implantation on the trophoblast finger like projections appears called **chorionic villi**
- The uterine tissue (internal tissue) and the finge like projections of blastocyst (chorionic villi) become interdigitated with each other.
- These two structures jointly form a structural and functional unit between developing embryo (foetus) and internal body called **placenta**
- Placenta (Gr.placenta – flat cake) is a special structure sustains the embryo and foetus throughout the pregnancy
- Placenta supplies oxygen and nutrients to the embryo
- Placenta removes carbon dioxide / excretory / waste material from the embryo.
- The Phenomenon of placentation is related to **Viviparity**
- The placenta is connected to the abdomen of foetus by **Umbilical cord**
- Umbilical cord transport the substances to and from the embryo
- The placenta is an endocrine in nature
- Placenta produces the several hormones like hCG (Human Chorionic Gonadotropin) hPL (Human placental lactogen), estrogens, progestogen, etc.
- In the later phase of pregnancy the ovary secretes **relaxin**
- hCG, hPL and relaxin are produced in women only during pregnancy
- During pregnancy in addition to those hormones the levels of estrogens, progestogens, cortisol, prolactin, thyroxine etc are raised in the maternal blood
- Increased levels of all these hormones are most essential for supporting the fetal growth, metabolic changes in the mother and maintenance of pregnancy
- After implantation the inner cell mass of blastocyst is differentiated into **ectoderm, endoderm and mesoderm** (Primary germ layers)
- Ectoderm is an outer layer

- Endoderm is an inner layer
- Mesoderm is middle layer appears between ectoderm and the endoderm
- The 3 primary germ layers give rise the tissues which in turn form organs in adults
- The inner cell mass does contain certain cell called **stem cells** which have the capacity to give rise all the tissues and organs
- The gestation period (Human pregnancy) in humans lasts for 9 months.
- Dogs – 60 – 65 days
- Cats – 58 – 65 days
- Elephants – 607 – 641 days (longest gestation period)

#### **In human beings**

- After one month of pregnancy – **heart is formed**
- Listening to the heart sound carefully through the stethoscope is the first sign of growing foetus.
- By the end of second month of pregnancy – Development of limbs and digits occurs in foetus
- By the end of 12 weeks of pregnancy (first trimester) - most of the major organ systems are formed eg: **limbs and external genital organs.**
- During 5<sup>th</sup> month – first movements of the foetus and appearance of hair on the head are usually observed
- By the end of 24 weeks (Second trimester) the body is covered with fine hair, eye – lids separate, eyelashes are formed.
- By the end of 9 months of pregnancy foetus is fully developed and is ready for delivery (Parturition)

#### **Parturition and Lactation**

- At the end of gestation period (about 9 months in humans) parturition occurs.
- Parturition is a process of delivery of the baby
- During parturition vigorous contraction of uterine muscles occurs (the sequence of events called labour)
- Parturition is a complex neuroendocrine mechanism
- The fully developed foetus gives the signals for parturition
- Placenta also induces the mild uterine contractions called foetal ejection **reflex** which triggers the release of oxytocin from posterior pituitary
- Oxytocin acts on the uterine muscles and cause strong uterine contractions
- Strong uterine contractions further stimulates the secretion of oxytocin

- Stimulatory reflex between the uterine contraction and oxytocin secretion continues results in stronger and stronger contractions.
- Stronger contractions leads to expulsion of the baby out of uterus through birth canal
- After the delivery of baby the placenta is also expelled out of the uterus
- Injection of oxytocin induce the delivery
- During pregnancy the mammary glands undergo differentiation and starts producing milk towards the end of gestation period the process is called as **lactation**
- Lactation is influenced by **prolactin** hormone in mammals
- Lactation is useful in feeding the newborn in mammals
- The milk produced during the initial few days of lactation is called **colostrum**
- Colostrum contain several antibodies which are essential to develop resistance for new born babies
- Breast feeding is must during the initial period of infant growth for bringing up a healthy baby.