HUMAN REPRODUCTION

- Sexual reproduction is the process by which new organisms are created, by combining genetic information from two individuals of different sexes.

-Sexual dimorphism is evident in human beings i.e male and female individuals are separately distinguishable.

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Human beings are unisexual, male produce gametes in old age also in case of women the formation of ovum stops at the age of 50 years.

Male reproductive system:

It has

1. A pair testes
2. Accessory ducts
3. Male accessory glands
4. External genetalia.

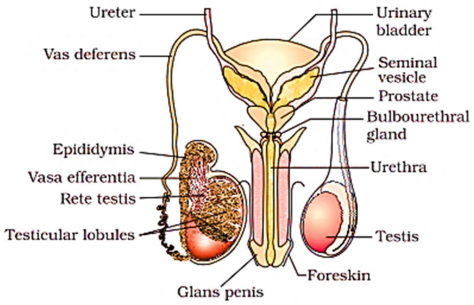


Figure 3.1(b) Diagrammatic view of male reproductive system (part of testis is open to show inner details)

Testes:

- The testes are situated outside the abdominal cavity within a pouch called scrotum.
- The scrotum helps in maintaining the low temperature of the testes (2–2.5° C lower than the normal internal body temperature) necessary for spermatogenesis.
- In adults, each testis is oval in shape, with a length of about 4 to 5 cm and a width of about 2 to 3 cm. The testis is covered by a dense covering.
- Each testis has about 250 compartments called testicular lobules.
- Each lobule contains one to three highly coiled seminiferous tubules in which sperms are produced.

Seminiferous tubule:

- This is the site where sperms are produced.
- Each seminiferous tubule is lined on its inside by two types of cells called
  i. Male germ cells (*spermatogonia*)
  ii. Sertoli cells (Nurse cells)
- The male germ cells undergo meiotic divisions finally leading to sperm formation, while Sertoli cells provide nutrition to the germ cells.

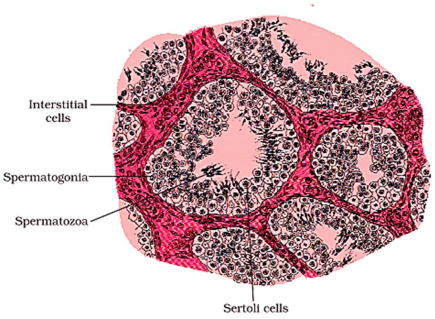


Figure 3.2 Diagrammatic sectional view of seminiferous tubule

Leydig cells (Interstitial cells)

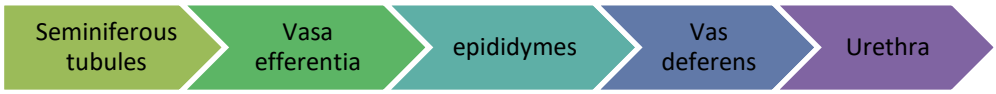
- The regions outside the seminiferous tubules called interstitial spaces contain small blood vessels and interstitial cells or Leydig cells.
- Leydig cells synthesise and secrete testicular hormones called androgens.

Accessory ducts:

1. Rete testis
2. Vasa efferentia
3. Epididymes
4. Vas deferens
5. Urethra

- The seminiferous tubules of the testes open into the vasa efferentia through rete testis.
- The vasa efferentia leave the testis and opens into epididymes located along the posterior surface of each testis.
- The epididymis leads to vas deferens that ascends to the abdomen and loops over the urinary bladder.

- Vas deferns receives a duct from seminal vesicle and opens into 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 urethral meatus.



Functions of the male accessory ducts:
The store and transport the sperms from the testes to the outside through the urethra.

Male external genetalia:
- The penis is the male external genitalia. It is made up of special tissue that helps in erection of the penis to facilitate insemination.
- The enlarged end of penis called the glans penis is covered by a loose fold of skin called foreskin.

Male accessory glands:
The male accessory glands include paired
1. seminal vesicles
2. a prostate
3. Paired bulbourethral glands

Functions of male accessory sex glands:
- Secretions of these glands constitute the seminal plasma which is rich in fructose, calcium and certain enzymes.
- The secretions of bulbourethral glands also help in the lubrication of the penis.
- The seminal plasma when it is mixed with sperms, it is said to be semen.

Female reproductive system:
The female reproductive system consists of
1. A pair of ovaries
2. A pair of oviducts
3. Uterus
4. Cervix
5. Vagina
6. External genitalia
7. Mammary glands

Ovary:
- Ovary is the primary female sex organ that produces the female gamete (ovum) and several steroid hormones (ovarian hormones).
- The ovaries are located one on each side of the lower abdomen.
- Each ovary is about 2 to 4 cm in length and is connected to the pelvic wall and uterus by ligaments.
- Each ovary is covered by a thin epithelium which encloses the ovarian stroma.
- The stroma is divided into two zones – a peripheral cortex and an inner medulla.

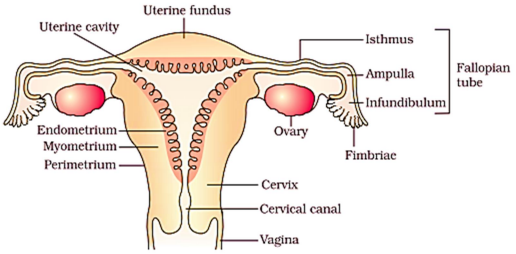


Figure 3.3 (b) Diagrammatic sectional view of the female reproductive system

Oviduct:
- The oviducts (fallopian tubes), uterus and vagina constitute the female accessory ducts.
- Each fallopian tube is about 10-12 cm long and extends from the periphery of each ovary to the uterus.

Parts of oviduct:

1. Infundibulum 2. Ampulla 3. Isthmus

1. Infundibulum:

- Infundibulum is a funnel-shaped structure closer to the ovary.
- The edges of the infundibulum possess finger-like projections called fimbriae.
- Fimbriae help in collection of the ovum after ovulation.

2. Ampulla:

The infundibulum leads to a wider part of the oviduct called ampulla.

3. Isthmus:

The last part of the oviduct, isthmus has a narrow lumen and it joins the uterus.

Uterus:

- The uterus is single and it is also called 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 vagina through a narrow cervix.
- The cavity of the cervix is called cervical canal which along with vagina forms the birth canal.
- The wall of the uterus has three layers of tissue.
  i. The external thin membranous perimetrium
  ii. Middle thick layer of smooth muscle, myometrium
  iii. Inner glandular layer called endometrium that lines the uterine cavity.
- The endometrium undergoes cyclical changes during menstrual cycle.
- Myometrium exhibits strong contraction during delivery of the baby.

Female external genetalia:

- The female external genitalia include 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 opening of the vagina is often covered partially by a membrane called **hymen**.
- The **clitoris** is a tiny finger-like structure which lies at the upper junction of the two labia minora above the urethral opening.
- The hymen is often torn during the first coitus (intercourse) or fall or jolt, insertion of a vaginal tampon, active participation in some sports like horseback riding, cycling, etc.

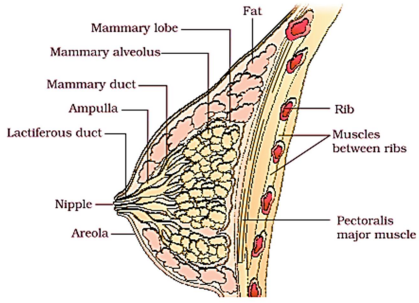


Figure 3.4 A diagrammatic sectional view of Mammary gland

Mammary glands:

- A functional mammary gland is characteristic of all female mammals.
- The mammary glands are paired structures (breasts) that contain glandular tissue and variable amount of fat.
- The glandular tissue of each breast 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) 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 lactiferous duct through which milk is sucked out.

GAMETOGENESIS:

- Formation of the haploid gametes from the diploid cells by reductional division.

- In case of male, gametogenesis occurs in the testes, which the primary sex organ.
- In case of female, gametogenesis occurs in the ovary which is the primary sex organ.

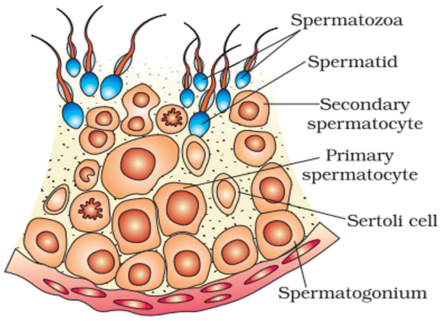


Figure 3.5 Diagrammatic sectional view of a seminiferous tubule (enlarged)

Spermatogenesis:

- Production of the sperms from diploid spermatogonia by meiosis is called spermatogenesis.
- It occurs in the seminiferous tubule of the testes.

Events in spermatogenesis:

- The spermatogonia (sing. spermatogonium) cells present on the inside wall of seminiferous tubules multiply by mitotic division and increase in numbers.
- Each spermatogonium is diploid and contains 46 chromosomes.
- Some of the spermatogonia called primary spermatocytes (2n) periodically undergo meiosis.
- A primary spermatocyte completes the first meiotic division (reduction division) leading to formation of two equal, haploid cells called secondary spermatocytes.
- Secondary spermatocytes have only 23 chromosomes each.
- The secondary spermatocytes undergo the second meiotic division to produce four equal, haploid spermatids.

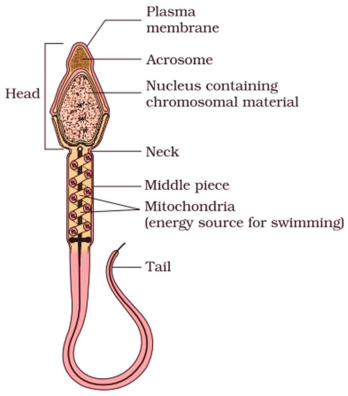


Figure 3.6 Structure of a sperm

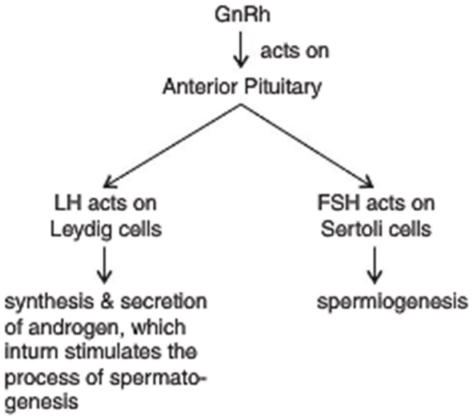
- **Spermiogenesis**: The spermatids are transformed into spermatozoa (sperms) by the process called spermiogenesis.
- **Spermiation**: After spermiogenesis, sperm heads become embedded in the Sertoli cells, and are finally released from the seminiferous tubules by the process called spermiation.
- The secretions of vas deferens, epididymis, seminal vesicle, prostate are essential for the maturation and motility of the sperms.

Structure of sperm:

- Sperm has Head, neck, middle piece, and tail.
- Acrosome is a cap like structure which covers the anterior portion of the nucleus.
- The acrosome is filled with enzymes that help fertilization of the ovum.
- The middle piece possesses numerous mitochondria, which produce energy for the movement of tail that facilitate sperm motility essential for fertilization.

Hormonal control of spermatogenesis:

- Spermatogenesis starts at the age of puberty due to significant increase in the secretion of gonadotropin releasing hormone (GnRH). This, if you recall, is a hypothalamic hormone.
- 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).
- LH acts at the Leydig cells and stimulates synthesis and secretion of androgens.
- Androgens, in turn, stimulate the process of spermatogenesis.



- FSH acts on the Sertoli cells and stimulates secretion of some factors which help in the process of spermiogenesis.

Oogenesis:

- The process of formation of a mature female gamete is called oogenesis which is markedly different from spermatogenesis.

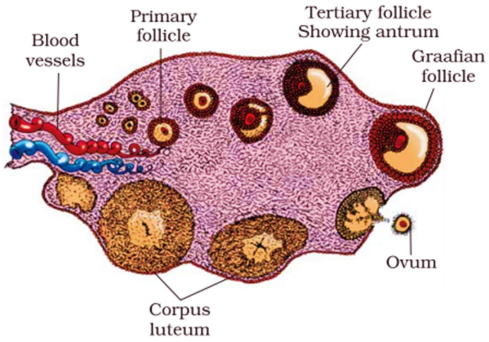


Figure 3.7 Diagrammatic Section view of ovary

Steps in the oogenesis:

- Oogenesis is initiated during the embryonic development stage when a couple of million gamete mother cells (oogonia) are formed within each fetal ovary; no more oogonia are formed and added after birth.

Primary oocyte:

- Oogonia start division and enter into prophase-I of the meiotic division and get temporarily arrested at that stage, called primary oocytes.
- Each primary oocyte then gets surrounded by a layer of granulosa cells and then called the primary follicle.
- A large number of these follicles degenerate during the phase from birth to puberty.
- 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 and called secondary follicles.
- The secondary follicle soon transforms into a tertiary follicle which is characterized by a fluid filled cavity called antrum.
- The theca layer is organized into an inner theca interna and an outer theca externa.

Secondary oocyte (ovum):

- At this stage that the primary oocyte within the tertiary follicle grows in size and completes its first meiotic division.
- The division is unequal division resulting in the formation of a large haploid secondary oocyte and a tiny first polar body.

Graafian follicle:

- The tertiary follicle further changes into the mature follicle or **Graafian follicle.**

Structure of ovum:

- The secondary oocyte (ovum) forms two membrane, inner membrane is called zona pellucida and outer layer is called corona radiate.

Ovulation:

- The Graafian follicle ruptures to release the secondary oocyte (ovum) from the ovary by the process called ovulation.

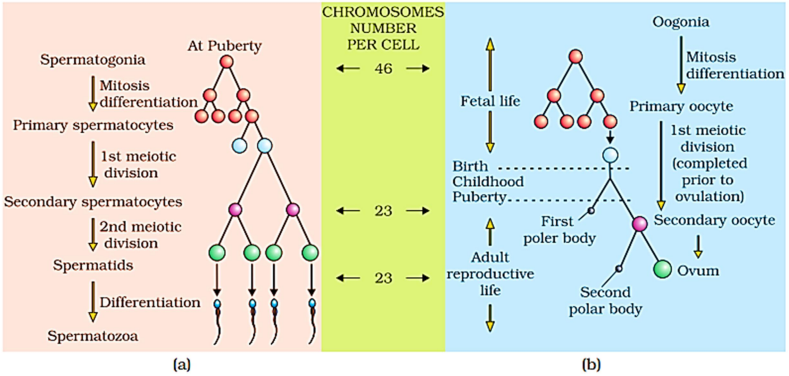


Figure 3.8 Schematic representation of (a) Spermatogenesis; (b) Oogenesis

Menstrual cycle:

- The reproductive cycle in the female primates (e.g. monkeys, apes and human beings) is called menstrual cycle.
- The first menstruation begins at puberty and is called menarche.
- Menstrual cycle ceases around the age 50 years is called menopause.
- 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.
- Cyclic menstruation is an indicator of normal reproductive phase and extends between menarche and menopause.

Phases in the menstrual cycle:

It involves four phases- 1. Menstrual phase
2. Proliferative phase
3. Ovulatory phase
4. Luteal phase

1. Menstrual phase:

- The cycle starts with the menstrual phase, when menstrual flow occurs and it lasts for 3-5 days.
- The menstrual flow results 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 fertilized.

2**. Proliferative phase**:

- This phase is also called as follicular phase.
- During this 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

Events in the proliferative phase:

- The secretions of gonadotropins (LH and FSH) increase gradually during the follicular phase.
- These increased secretions of gonadotropins bring two changes
  i. **Changes in the ovary**-stimulates follicular development
  The primary follicle in the ovary grows to become a fully mature Graafian follicle, this Graafian follicle secretes estrogen.
  ii. **Changes in the uterus-** The endometrium of uterus regenerates through the proliferation.

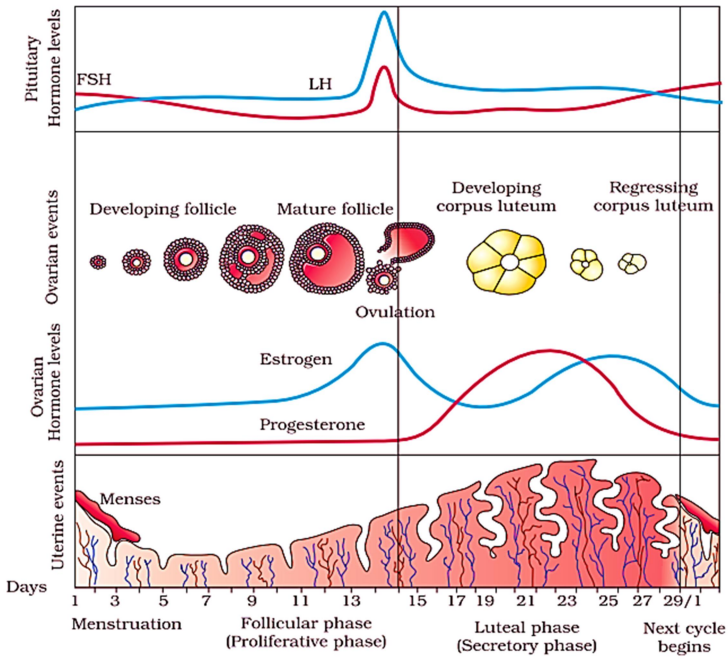


Figure 3.9 Diagrammatic presenation of various events during a menstrual cycle

3. Ovulatory phase:

1. Both LH Both LH and FSH attain a peak level in the middle of cycle (about 14th day).
2. Rapid secretion of LH leading to its maximum level during the mid-cycle called LH surge
3. LH surge induces rupture of graafian follicle and thereby the release of ovum (ovulation)

4. Luteal phase:

- This also called secretory phase.
- It is from 15th to 28th or 29th day.

Events in luteal phase:

- After ovulation (ovulatory phase) the remaining parts of the Graafian follicle transform as the corpus luteum, so it called as luteal phase.
- The corpus luteum secretes large amounts of progesterone which is essential for maintenance of the endometrium.
- Endometrium becomes thick, such an endometrium is necessary for implantation of the fertilized ovum and other events of pregnancy.
- During pregnancy all events of the menstrual cycle stop and there is no menstruation.
- In the absence of fertilization, the corpus luteum degenerates. This causes disintegration of the endometrium leading to menstruation, marking a new cycle.

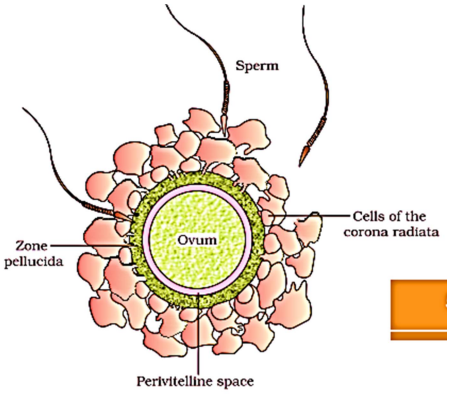


Figure 3.10 Ovum surrounded by few sperms

Fertilization:

- During copulation (coitus) semen is released by the penis into the vagina is called as 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.
- The ovum released by the ovary is also transported to the ampullary-isthmic junction where fertilization takes place.
- Fertilization can only occur if the ovum and sperms are transported simultaneously to the ampullary-isthmic junction. This is the reason why not all copulations lead to fertilization and pregnancy.
- The process of fusion of a sperm with an ovum is called fertilization.
- The product of fertilization is zygote.

How entry of additional sperms is prevented?

- During fertilization, a sperm comes in contact with zona pellucida layer of the ovum.
- It includes the changes in the membrane that block the entry of additional sperms.
- This ensures only one sperm can fertilize 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

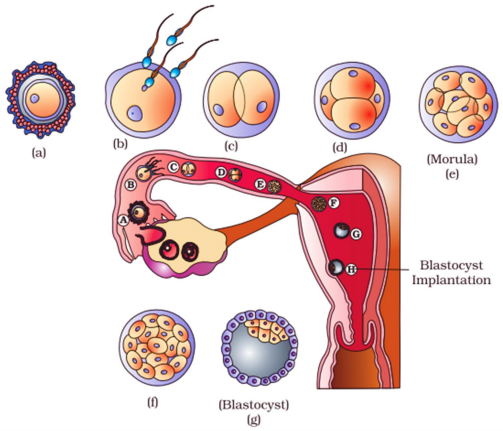


Figure 3.11 Transport of ovum, fertilisation and passage of growing embryo through fallopian tube

Sex determination:

Embryonic development:

- Zygote undergoes mitotic divisions when it comes through the isthmus of the oviduct towards the uterus.
- These mitotic divisions of zygote are called as cleavage.
- Cleavage division results in the formation of 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 as it moves further into the uterus.

Structure of blastocyst:

- The blastomeres in the blastocyst are arranged into an outer layer called trophoblast and an inner group of cells attached to trophoblast called the inner cell mass.

Implantation:

- At blastocyst stage the embryo gets implanted on the endometrium.
- The trophoblast layer then gets attached to the endometrium and the inner cell mass gets differentiated as the embryo.
- After attachment, the uterine cells divide rapidly and cover the blastocyst.
- As a result, the blastocyst becomes embedded in the endometrium of the uterus, this process is called implantation and it leads to pregnancy.

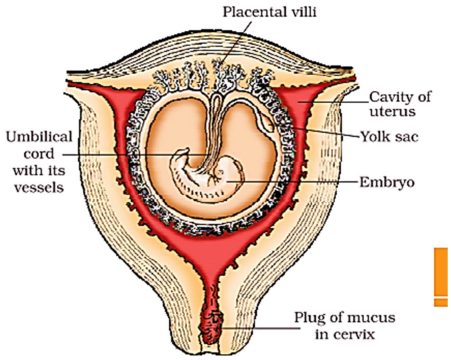


Figure 3.12 The human foetus within the uterus

Placenta:

Formation of placenta-

- After implantation finger like projections appear on the trophoblast. These projections are called chorionic villi (placental villi).
- Chorionic villi are surrounded by uterine tissue and maternal blood.
- Chorionic villi and uterine tissue becomes interdigitated with each other & jointly form structural and functional unit between developing embryo and maternal body called placenta.

Functions of placenta-

- It facilitates the supply of oxygen and nutrients to the embryo.
- It removes the carbon dioxide and waste materials produced by the embryo.
- Placenta also acts as endocrine gland and produces several hormones-
    1. Human chrionic gonadotrophin (hCG)
    2. Human Placental Lactogen (hPL),
    3. Estrogens
    4. Progestogens.

Umbilical cord:

- The placenta is connected to the embryo (foetus) through the umblical cord.
- **Function** – it helps in the transport of substances to and fro from the embryo.

Relaxin:

- This is the hormone which is produced in the later phase of the pregnancy.
- Source- ovary.
- Function – It dilates the cervix during the child birth.

The hormones that are produced only during the pregnancy:

1. hCG- Human Chorionic Gonadotrophin.
2. hPL- Human Placental Lactogen
3. Relaxin.

- During the pregnancy the levels of other hormones like estrogens, progesterone, cortisol, prolactin, thyroxin are increased several folds in maternal blood.
- Increased production of these hormones is essential for:
    1. Supporting fetal growth
    2. Metabolic changes in the mother
    3. Maintenance of pregnancy

Changes from implantation to child birth:

- Formation of chorionic villi on the surface of the trophoblast. The chorionic villi (placental villi) join with uterine tissues and maternal blood to form the placenta.
- Soon after the implantation the inner cell mass of the blastocyst differentiates in to two layers i.e
    1. Ectoderm – outer layer
    2. Endoderm- inner layer
    3. Mesoderm – it appears between ectoderm and endoderm.

    All the body organs will be formed from these three layers.

- **Embryo After one month:**
    - After one month of pregnancy, the embryo's heart is formed.
    - The first sign of the growing fetus may be noticed by listening the heart sound carefully through the stethoscope.
- **Embryo after two months**:
    - By the end of second month of pregnancy the fetus develops limbs and digits.
- **Embryo at first trimester:**
    - By the end of 12 weeks most of the major organs systems are formed.
    - The limbs and external genetalia organs are well developed.

Five months baby:

- The first movement of the fetus and appearance of hair on the head are observed during fifth month.

Fetal development at 2nd trimester-

- By the end of 24 weeks fetus body is covered with fine air, separate eyelids, eye lashes are formed.

Fully term fetus:

- By the end of the nine months of pregnancy, the fetus is fully developed and is ready for delivery.

Gestation and Parturition:

- The average duration of human pregnancy is about 9 months which is called the gestation period.
- Vigorous contraction of the uterus at the end of pregnancy causes expulsion/delivery of the foetus. This process of delivery of the foetus (child birth) is called **parturition.**

Mechanism of parturition:

- The signals for parturition originate from the fully developed fetus and the placenta which induces mild uterine contractions called **foetal ejection reflex.**
- Foetal ejection reflex 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.
- The stimulatory reflex between the uterine contraction and oxytocin secretion continues resulting in stronger and stronger contractions.
- This leads to expulsion of the baby out of the uterus through the birth canal – **parturition.**
- Once infant is taken birth, it is expelled with placenta from uterus.

Lactation:

- 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 is called **colostrum** which contains several antibodies absolutely essential to develop resistance for the new-born babies.
- Breast-feeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby