HUMAN REPRODUCTION

Introduction:

- Humans are sexually reproducing and viviparous organisms (give birth to young ones).
- The correct sequence of reproductive events in humans is gametogenesis → insemination → fertilisation implantation → gestation → parturition.

Male Reproductive System:

- It consists of a pair of testis (primary sex organs), accessory ducts and glands (secondary sex organs), external genitalia.
- **Testes** are situated outside the abdominal cavity within the **scrotum**, which keeps the temperature of the testes about 2-2.5°C below than the normal internal body temperature.
- Each testis contains about 250 **testicular lobules,** which further contain one to three highly coiled **seminiferous tubules**.
- The seminiferous tubules internally lined by **male germ cells (spermatogonia-** undergo meiosis leading to sperm formation**), sertoli cells** (provide nutrition to the germ cells) and externally by **interstitial** or **leydig cells.**

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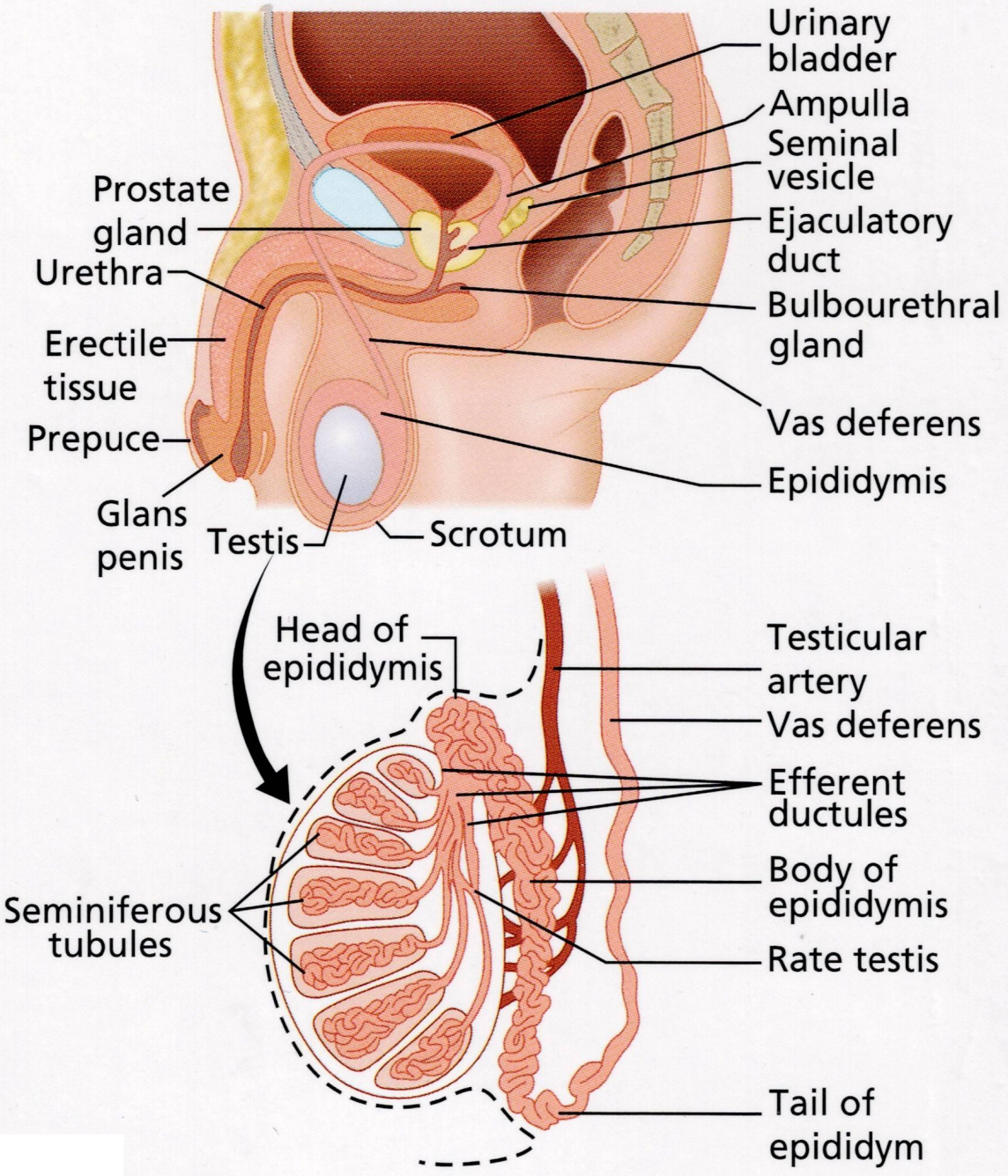

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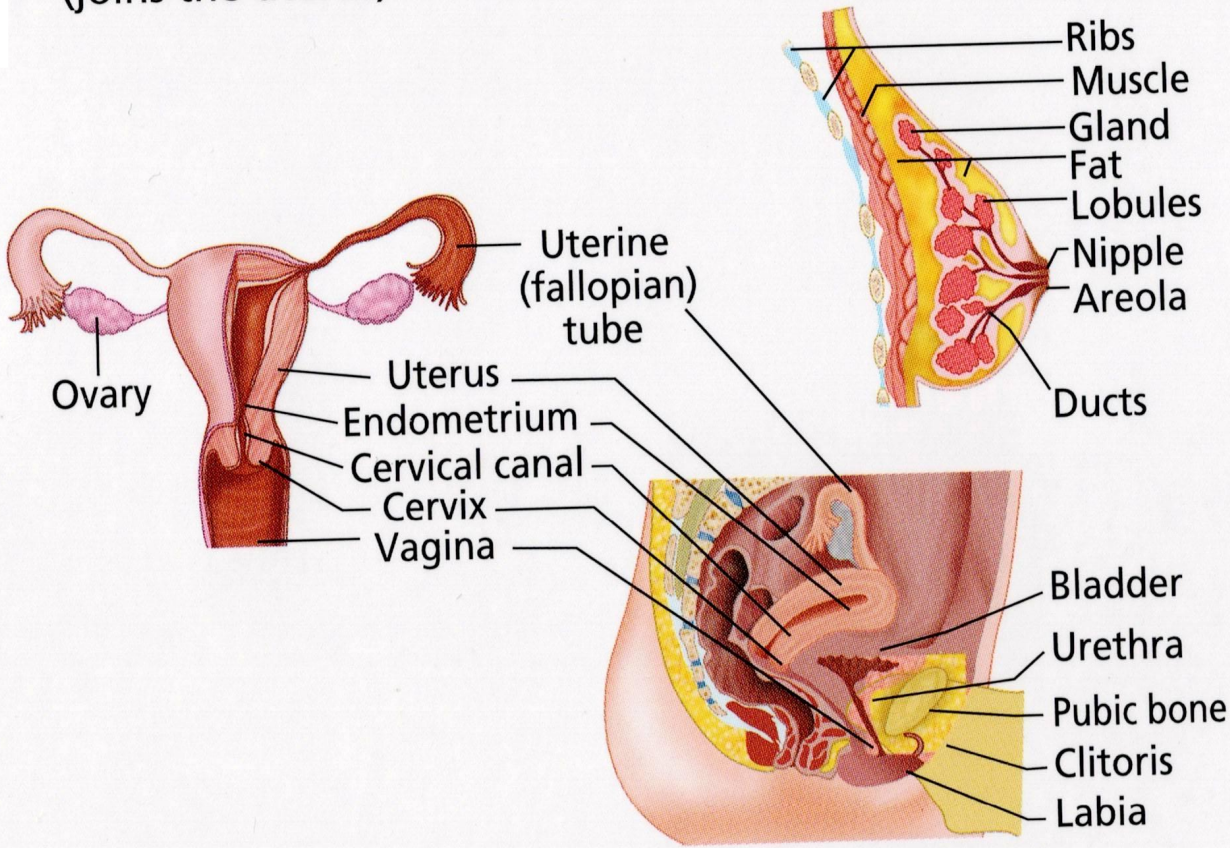
- The male accessory ducts make a series of channel to transport the sperm outside the body. It includes **rete testis, vasa efferentia, epididymis** and **vas deferens.**
- Vas deferens receives a duct from seminal vesicle and forms the **ejaculatory duct,** which opens into urethra and extends through the penis to its external opening called **urethral meatus.**
- Accessory glands include paired **seminal vesicles, prostate gland** and paired **bulbourethral** or **cowper's** glands (helps in lubricating the penis). These glands secrete **seminal plasma** (rich in fructose, calcium and some enzymes).
- Seminal plasma along with sperms is called as **semen** or seminal fluid.
- The male **external genitalia** is penis which has special erectile tissue that helps in its erection. The enlarged tip of penis is **glans penis** which is covered by loose fold of **foreskin**.

Female Reproductive System:

- It consists of a pair of ovaries (primary sex organs), accessory ducts and glands (secondary sex organs), mammary glands, external genitalia.
- The female accessory ducts constitute **oviducts** (fallopian tubes), **uterus**

and **vagina**. Oviducts consists of **infundibulum** (funnel-shaped and possesses fimbriae), **fimbriae** (help in collection of ovum), **ampulla** (wider part connects with the infundibulum), **isthmus** (joins the uterus).



Sagittal section

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- Uterus (**womb**) wall composed of the outer thin membrane **perimetrium** (protects uterus from friction), middle thick layer of smooth muscle **myometrium** (exhibits strong contraction during parturition), inner glandular layer **endometrium** (undergoes cyclical changes during menstrual cycle).
- Uterus opens into the **vagina** through **cervix**. The cervical canal along with vagina forms the **birth canal**.
- Accessory glands include paired **bartholin's** or vestibular glands which secrete a fluid during sexual excitement.
- The female **external genitalia** include mons pubis, labia majora (surround the vaginal opening), labia minora, hymen (covers the opening of vagina) and clitoris (small erectile organ; homologous to glans penis).
- **Mammary glands** contain fat and **glandular tissues** (each have 15-20 mammary lobes containing clusters of alveoli). Cells and lumen of **alveoli** secrete and stores milk, respectively. Alveoli open into **mammary tubules** which join to form a **mammary duct** which further join to form **mammary ampulla** (connects to **lactiferous duct** through which milk is sucked out).

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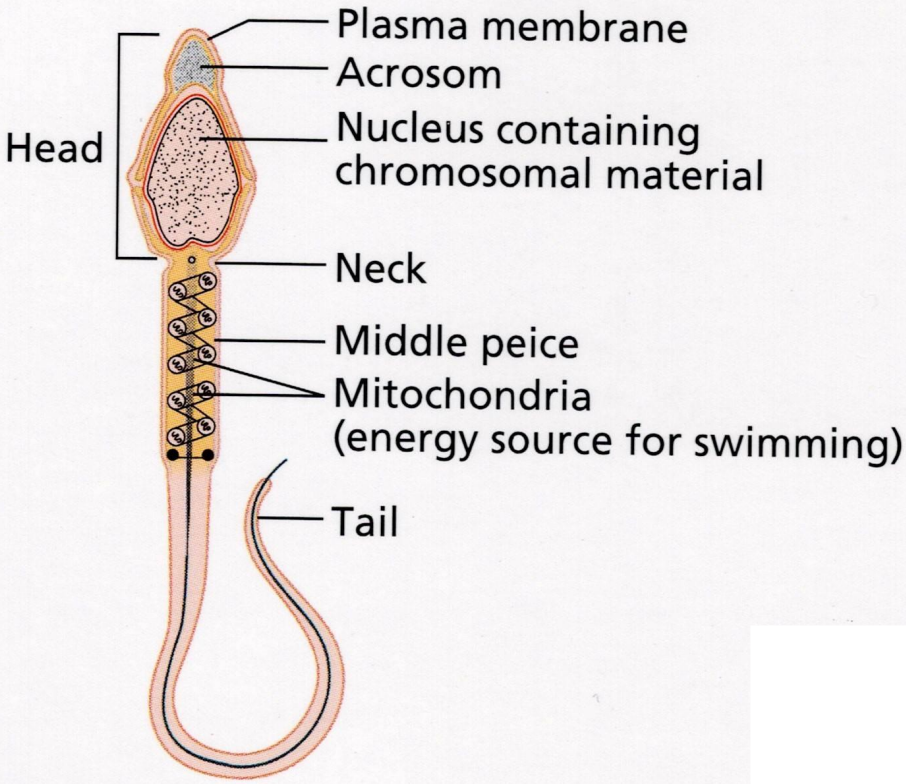

Structure of Sperm:

➔ Sperm consists of a head, neck, a middle piece and a tail. Its head contain haploid nucleus, anterior portion of which is covered by acrosome (contains **hydrolytic enzymes**).

Fertilisation:

➔ **Fertilisation** is the process of fusion of sperm with ovum. It takes place at the **ampullary-isthmic** junction of fallopian tube.

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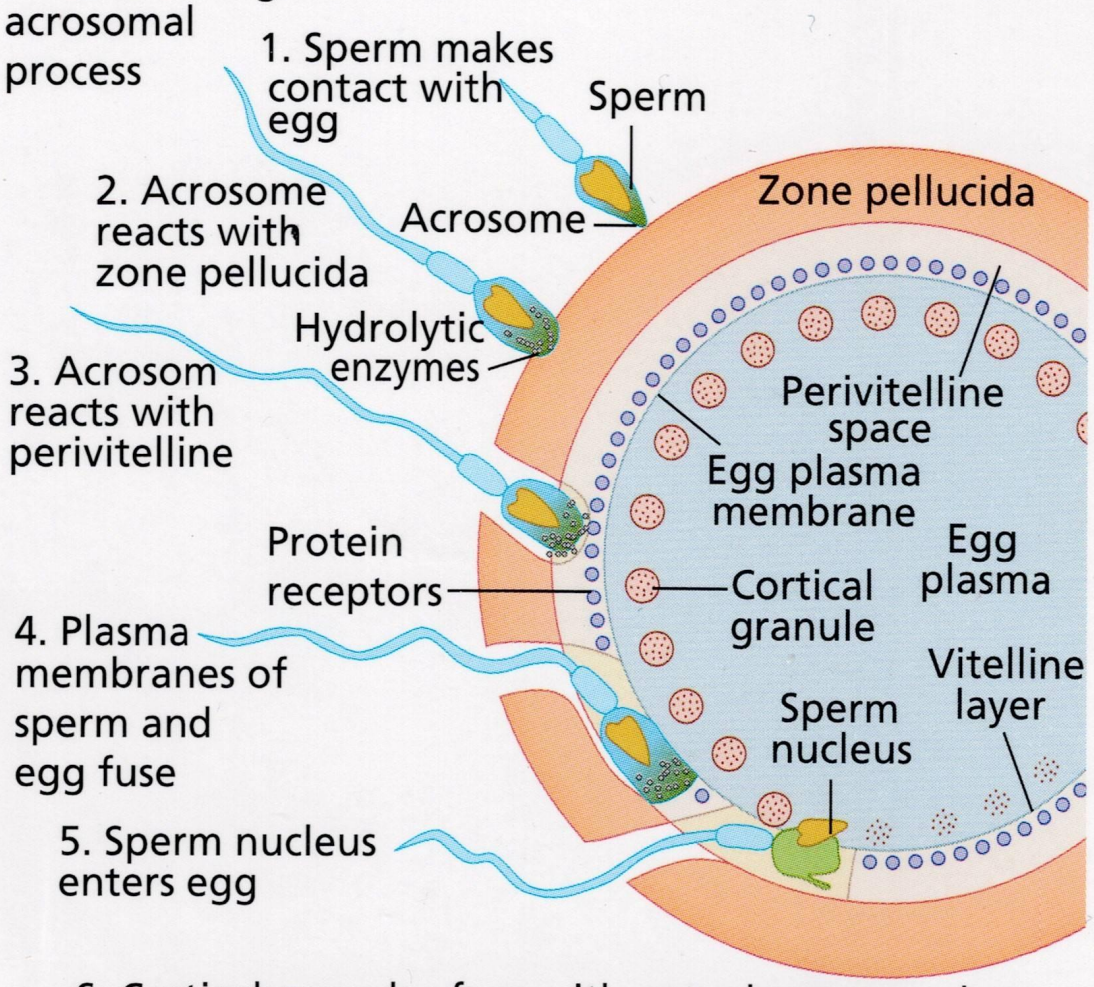
➔ Sperm after reaching this junction comes in contact with the zona-pellucida layer of the ovum and induces some changes in it, which block the entry of the additional sperms (prevents polyspermy).

Fertilization: generalized acrosomal process



6. Cortical granules fuse with egg plasma membrane, which renders the vitelline layer impenetrable to spe

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- Acrosome of sperm undergoes acrosomal reaction and releases certain sperm lysins which dissolve the egg envelops and helps the sperm to enter into the ovum.

Parturition:

- It is the process of delivery of fully developed foetus.
- Signals for parturition originate from the fully developed foetus and placenta, which induce mild uterine contractions called **Foetal ejection reflex**.
- This reflex triggers the release of **oxytocin** from maternal pituitary which in turn causes the contraction of uterus. Due to strong contractions foetus expel out of the uterus through birth canal.

Lactation:

- The mammary glands of female differentiate during pregnancy and start producing the milk after the birth of the baby by the process called lactation.
- The milk produced during the initial few days of lactation is called **colostrum**, which contain several antibodies.

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Spermatogenesis:

- It is the process of producing sperms in testes. It includes the following stages:
  - In **multiplication** phase, spermatogonia or **sperm mother cells** (46 chromosomes) multiply by mitotic division and increase in number.
  - In **growth** phase, spermatogonia differentiate to form **primary spermatocytes** (46 chromosomes).
  - In **maturation** phase, primary spermatocyte undergoes first and second meiotic division to produce two **secondary spermatocytes** and four **spermatids** (23 chromosomes), respectively. These spermatids transform into sperms, by **spermiogenesis**.
  - In **differentiation** phase, sperm heads get embedded in the sertoli cells and are released from the seminiferous tubules by **spermiation.**
- Spermatogenesis initiated due to increase in Gonadotropin Releasing Hormone (**GnRH**) which further stimulates the **anterior pituitary** to secrete Luteinizing Hormone **(LH)** and Follicle Stimulating Hormone **(FSH).**
- LH acts on **Leydig cells** and stimulates them to **secrete androgens** while FSH acts on **Sertoli cells** which stimulate secretion of some factors which help in **spermiogenesis.**

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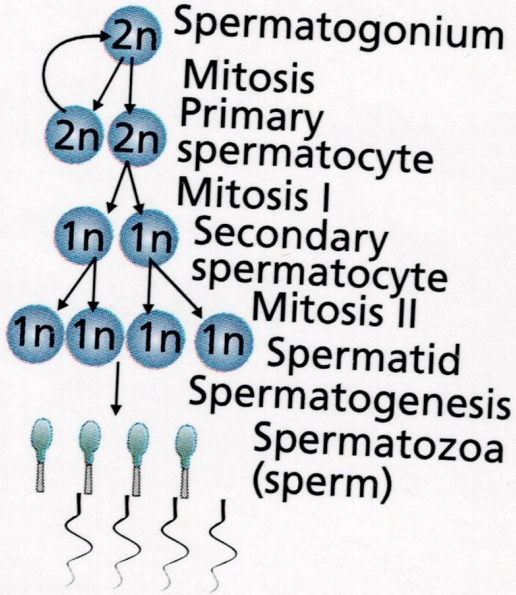
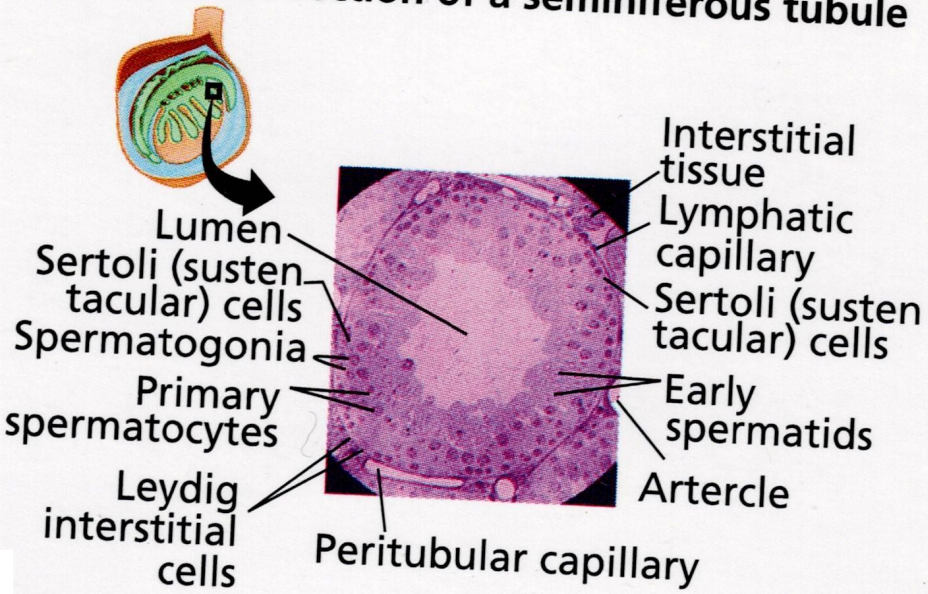
(a) spermatogenesis



(b) Cross section of a seminiferous tubule



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Oogenesis:

- It is the process of producing ovum in ovaries. It started during embryonic development stage but completed only after fertilisation. It includes the following stages:
  - In **multiplication** phase, germinal epithelial cells divide by mitosis to produce **oogonia** or egg mother cells which further form **primary oocytes** by the process of meiosis and get arrested at the stage of Prophase.
  - In **growth** phase, primary oocytes surrounded by layer of granulosa cells and called as **primary follicle**, further it gets surrounded by more layers of granulosa cells as well as a new theca to form the **secondary follicle**.
  - In **maturation** phase, secondary follicle transform into tertiary follicle (contain **antrum** and two layers of theca) which further changes into the mature **Graafian follicle** which rupture to release secondary oocyte (surrounded by layer, **zona pellucida**) from the ovary by the process of ovulation.

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Menstrual Cycle:

- It is the reproductive cycle in female primates which repeats after an interval of about 28-29 days. The first menstruation is called as **menarche** while its stoppage is termed as **menopause**. It includes the following phases:

Phase	Days	Changes in Ovary	Changes in Uterus	Hormonal Changes
Menstrual phase	4-5 days	Development of primary follicles	Breakdown of uterine endomentrial lining leads to bleeding	Decrease in progesterone and oestrogen
Follicular phase	6^{th} to 13^{th} day	Primary follicles grow to become a fully mature Graafian follicle	Endometrium regenerates through proliferation	FSH and oestrogen increase

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Ovu-latory phase	14th day	The Graafian follicle ruptures, and releases the ovum (egg)	Increase in endometrial thickness	LH peak
Luteal phase	15th to 28th day	Empted Graafian follicle develops into corpus luteum	Endometrium is prepared for implantation if fertiliza-tion of egg takes place, if fertilization does not occur corpus luteum, degenerated, uterine wall ruptures, bleeding starts and unferti-lized egg is expelled	LH and FSH decrease, Corpus luteum produces progester-one and its level increases followed by a decline, if menstrual bleeding occurs

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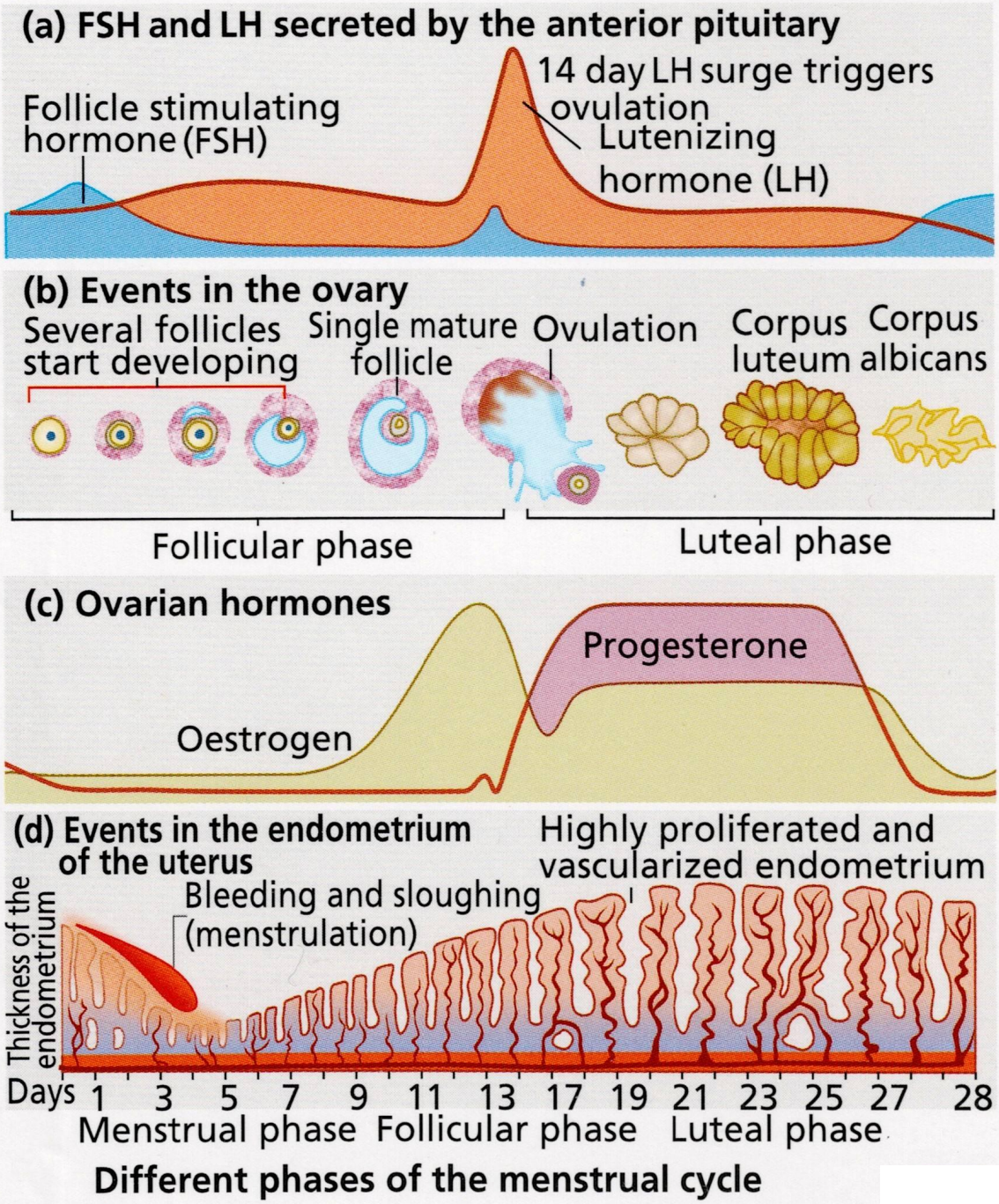

Different phases of the menstrual cycle

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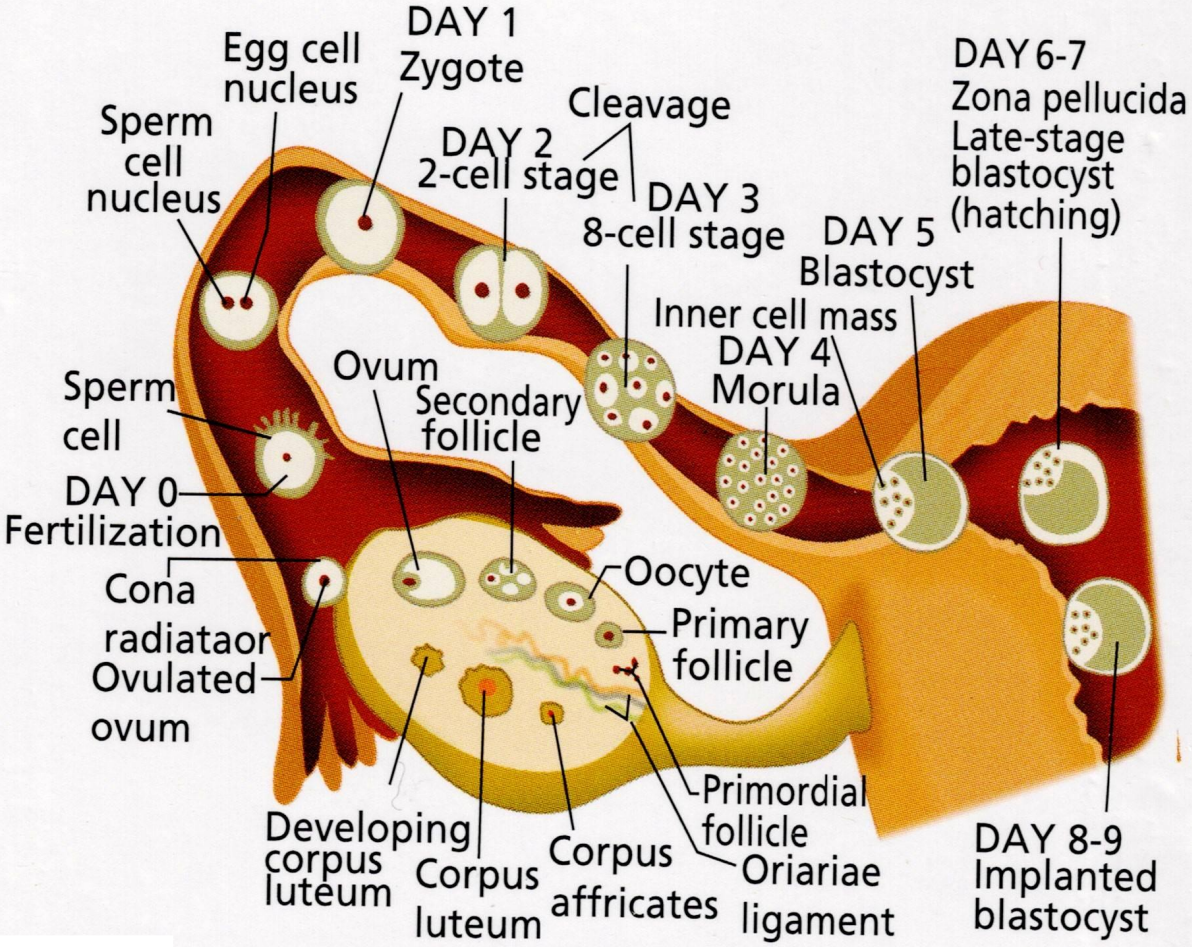
Cleavage and Implantation:

- After fertilisation, zygote moves towards the uterus and at that same time it starts dividing by mitosis and forms 2, 4, 8, 16 daughter cells called as **blastomeres.**
- The embryo with 8 to 16 blastomeres is called **morula** which divides further and transforms into **blastocyst.**



From ovulation to implantation

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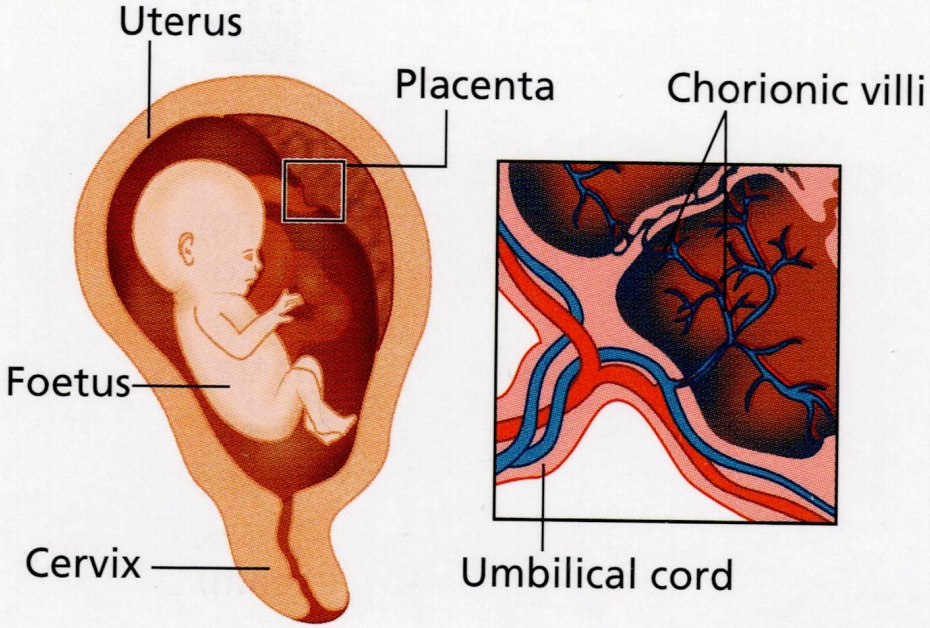
- The blastomeres in the blastocyst are arranged into an outer layer called **trophoblast** (attach to endometrium) and inner to trophoblast is **inner cell mass** (differentiate into embryo).
- As a result, inner cell mass divide to cover the blastocyst hence blastocyst becomes embedded in the uterine wall. This process is called as **implantation** which leads to **pregnancy**.

Pregnancy and Embryonic Development:

- After implantation, the finger-like projections called **chorionic villi** form on trophoblast which inter-digitate with uterine tissue and forms **placenta** (a connection between foetus and mother).



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- Placenta is attached with foetus with an **umbilical cord** that helps in transport of substances to and from the embryo.

- Hormones like **hCG** (human Chorionic Gonadotropin), **hPL** (human Placental Lactogen) and **relaxin** are produced by placenta only during pregnancy.

- The inner cell mass also differentiates after implantation into **ectoderm, endoderm** and **mesoderm**. These layers give rise to all tissues and organs in adults. It is important to note that the inner cell mass possess **stem cells** which have the ability to give rise to all the tissues and organs.

- The average duration of pregnancy in humans is about 9 months and it is called as **gestation period**.

- During pregnancy, humans heart develop after one month, limbs and digits develop by the end of second month, major organ systems are formed by the end of third month. First movement and appearance of hairs observed in fifth month. By the end of 24 weeks, the body covers with fine hair, eye-lids separate, eyelashes form.

TEST

HUMAN REPRODUCTION

1. After spermiogenesis, sperm heads become embedded in which of the following cells?
   (a) Leydig cells
   (b) Sertoli cells
   (c) Germinal epithelium
   (d) Seminal vesicles.
2. Foetal ejection reflex in human female is induced by:
   (a) Oxytocin release
   (b) Differentiation of mammary glands
   (c) Fully developed foetus and placenta
   (d) None of the above.
3. The testes in human are situated outside the abdominal cavity inside the scrotum. This is to:
   (a) Escaping any possible compression by the visceral organs.
   (b) Maintaining the scrotal temperature lower than the internal body temperature.
   (c) Providing a secondary sexual feature for exhibiting the male sex.
   (d) Providing more space for the growth of epididymis.

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Solutions:

1. **Option (b) is correct.**

   During spermiogenesis, haploid spermatids undergo differentiation and transform into sperms. After this process, their heads become embedded in the sertoli cells which further undergo spermiation to be released from the seminiferous tubules.

2. **Option (c) is correct.**

   Foetal ejection reflex is induced by fully developed foetus and placenta. Initially, it induces mild uterine contractions but with the release of oxytocin uterine contractions become stronger. As a result, foetus expel out through the birth canal.

3. **Option (b) is correct.**

   The testes in human are situated outside the abdominal cavity within the scrotum, which keeps the scrotal temperature about 2-2.5°C below than the normal internal body temperature, which is necessary for spermatogenesis.

4. Which of the following statements about the mammalian blastocyst is not true?

   (a) The trophoblast gives rise to the embryo proper.

   (b) Maternal genes are expressed during cleavage.

   (c) The blastocyst implants in the mother's uterus.

   (d) Early mammalian development is slow.

5. Shortest phase in the menstruation cycle of women is:

   (a) Menses

   (b) Luteal phase

   (c) Ovulatory phase

   (d) Follicular phase

6. By the end of how many weeks, major organ systems are formed during the embryonic development?

   (a) 4 weeks

   (b) 8 weeks

   (c) 12 weeks

   (d) 24 weeks

Solutions:

4. **Option (a) is correct.**

   In the mammalian blastocyst, the inner cell inner to the trophoblast differentiates into embryo, whereas the trophoblast forms the foetal part of the placenta.

5. **Option (c) is correct.**

   Shortest phase in the menstruation cycle of women is Ovulatory phase. It lasts for 24 hours only. During this phase, ovary releases the mature ovum.

6. **Option (c) is correct.**

   During the embryonic development, major organ systems are formed by the end of 12 weeks. While, heart develops after 4 weeks, limbs and digits develop by the end of 8 weeks and eye-lids separate, eyelashes form by the end of 24 weeks.

7. Fertilisation in humans is practically feasible only if

   (a) the sperms are transported into cervix within 48 hours of release of ovum in uterus.

   (b) the ovum and sperms are transported simultaneously to ampullary–isthmic junction of the cervix.

   (c) the ovum and sperms are transported simultaneously to ampullary–isthmic junction of the fallopian tube.

   (d) the sperms are transported into vagina just after the release of ovum in fallopian tube.

8. Several hormones like hCG, hPL, estrogen and progesterone are produced by:

   (a) placenta

   (b) ovary

   (c) pituitary

   (d) fallopian tube

Solutions:

7. **Option (c) is correct.**

Fertilisation is the process of fusion of sperm with the ovum. It is practically feasible only if the ovum and sperms are transported simultaneously to ampullary-isthmic junction of fallopian tube.

8. **Option (a) is correct.**

During pregnancy, placenta acts as temporary endocrine gland. It secretes various hormones like hCG (human Chorionic Gonadotropin), hPL (human Placental Lactogen), estrogen and progesterone.