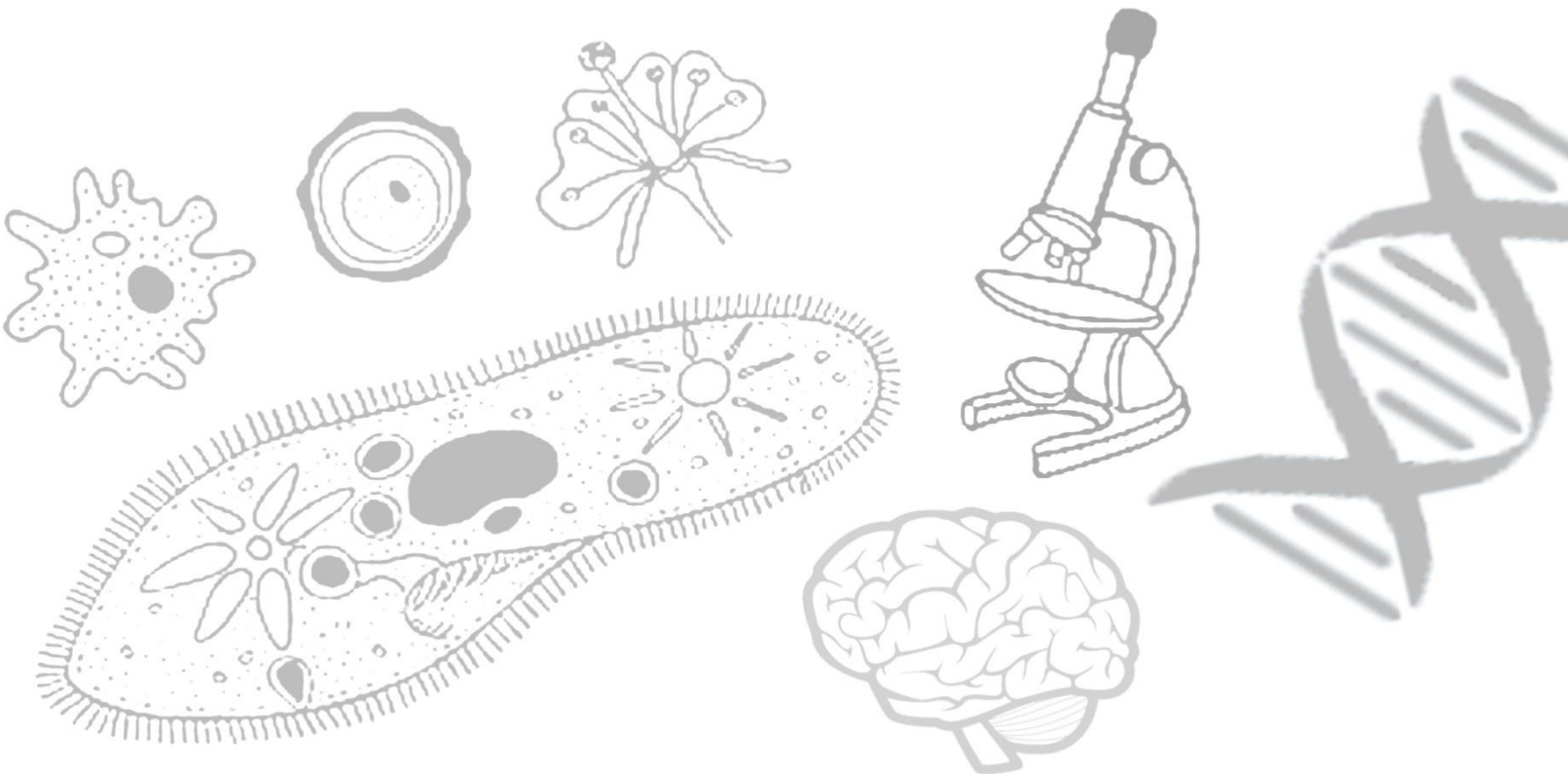
Chapter Notes

BIOLOGY



Gametogenesis and Menstrual Cycle

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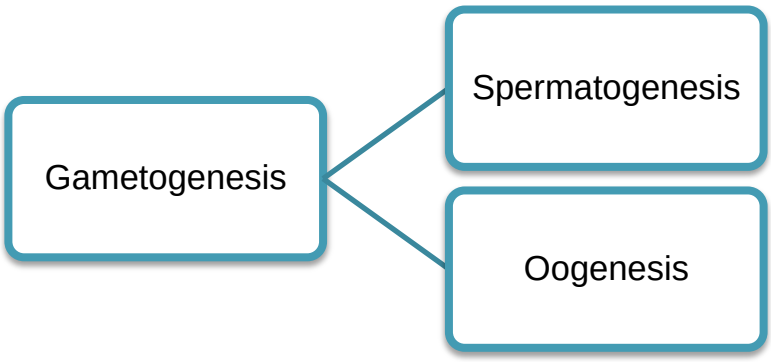
Gametogenesis

What is Gametogenesis?

- The process by which male and female sex cells or gametes (sperms and ova) are formed in the male and female gonads (testes and ovaries) is called gametogenesis.



- Gametogenesis involves the following sequential changes:
  i. Multiplication phase
  ii. Growth phase
  iii. Maturation phase

Spermatogenesis

- The process of the formation of spermatozoa or sperms from spore mother cells or spermatogonia of the germinal epithelium lining the seminiferous tubules is called spermatogenesis.
- It occurs in the seminiferous tubules of the testes of males.
- Spermatogenesis includes the formation of spermatids and spermatozoa.

Formation of Spermatids

Multiplication Phase	○ The undifferentiated primordial germ cells divide several times by mitosis to produce a large number of spermatogonia (2*n*). ○ Spermatogonia are of two types—A and B. ○ Type A spermatogonia act as stem cells which divide and produce more spermatogonia, while type B spermatogonia are the precursors of sperms.
Growth Phase	○ Each type B spermatogonia actively grows to form a larger primary spermatocyte by obtaining nourishment from nursing cells.
Maturation Phase	○ Each primary spermatocyte undergoes two successive divisions called maturation divisions. ○ The first division is reductional or meiotic division where each primary spermatocyte divides into two haploid daughter cells called secondary spermatocytes. ○ Both secondary spermatocytes undergo a second maturation division to form four haploid spermatids from a single primary spermatocyte.

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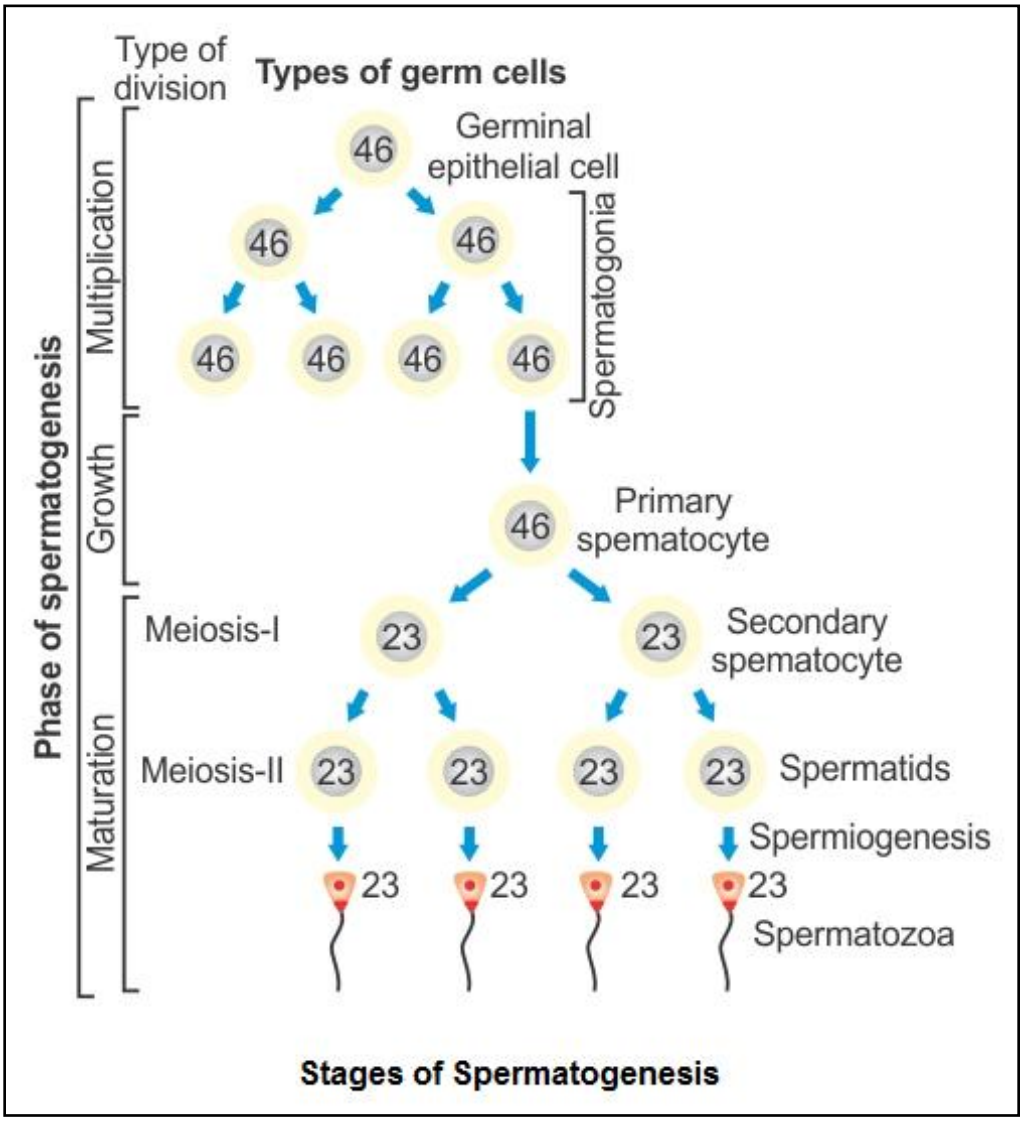

Formation of Spermatozoa from Spermatids

- The transformation of spermatids into spermatozoa is called spermiogenesis or spermateliosis.
- Four sperms are formed from one single spermatogonium.
- After spermiogenesis, sperm heads become embedded in the Sertoli cells. They are released from the seminiferous tubules by spermiation.

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Hormonal Control of Spermatogenesis

Spermatogenesis occurs because of increase in gonadotropin-releasing hormone (GnRH) by the hypothalamus.

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GnRH acts on the pituitary gland to secrete luteinising hormone (LH) and follicle-stimulating hormone (FSH).

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LH acts on Leydig cells to secrete testosterone.

↓

FSH acts on Sertoli cells to secrete an androgen-binding protein (ABP) and inhibin.

↓

ABP concentrates testosterone.

↓

Inhibin suppresses FSH synthesis.

↓

FSH acts on spermatogonia to stimulate sperm production.

Sertoli cells synthesise an androgen-binding protein which helps to maintain a high androgen level in the seminiferous tubules necessary for spermatogenesis. Sertoli cells also act as phagocytes. They consume the residual cytoplasm discarded during spermiogenesis. Translocation of germ cells from the base to the lumen of the seminiferous tubules occurs by conformation changes in the lateral margins of the Sertoli cells.

Significance of Spermatogenesis

- It helps to maintain the chromosome number of the species—haploid in sperms and diploid in the zygote.
- During meiosis I, crossing over takes place which brings about variation.
- The occurrence of spermatogenesis in various organisms supports the evidence of the basic relationship of the organisms.

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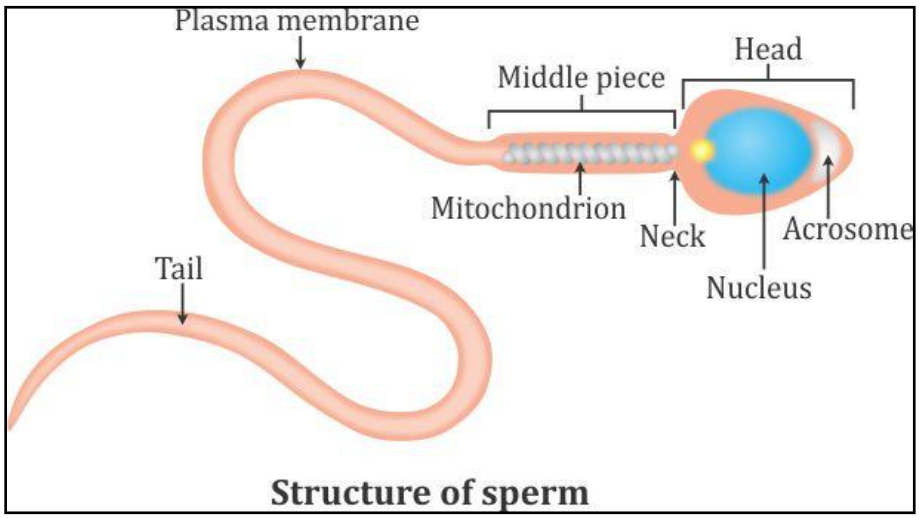
Structure of Spermatozoa/Sperm

- Spermatozoa or sperms are microscopic and motile cells. They constitute the male gametes in humans.
- Sperms are specialised for swimming and delivering themselves into the ovum to complete the act of fertilisation.
- A human sperm consists of four parts—head, neck, middle piece and tail or flagellum.



Structure of sperm

Head	○ The sperm head is formed of an anterior small acrosome and a posterior large nucleus enclosed in a thin membrane. ○ The acrosome is formed from the Golgi complex. It contains hyaluronidase proteolytic enzymes called sperm lysins which are used to contact and penetrate the egg at the time of fertilisation. ○ The sperm nucleus contains DNA and proteins.
Neck	○ The neck is very short and is present between the head and middle piece. ○ It consists of proximal centriole and distal centriole. ○ The proximal centriole is present towards the nucleus and plays a role in the first cleavage of the zygote. ○ The distal centriole gives rise to the axial filament of the sperm.
Middle piece	○ The middle piece contains mitochondria coiled round the axial filament called a mitochondrial spiral. ○ The mitochondria contain oxidative enzymes and provide energy for sperm motility. ○ A thin sheath of the cytoplasm called manchette is present around the mitochondria and plasma membrane.
Tail	○ The tail or flagellum consists of a central axial filament, thin layer of the cytoplasm and an outer smooth plasma membrane. ○ The axial filament is formed of nine pairs of longitudinal fibres. Another set of nine thicker and band-shaped fibres is present outside the longitudinal fibres. ○ The free end of the sperm tail without additional fibres is called the end piece. ○ Flagellar movements enable the sperm to ascend in the female reproductive tract.

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DID YOU KNOW ?

In 1675, Leeuwenhoek discovered human spermatozoa in the semen with a self-designed microscope.

Oogenesis

- The process of the formation of a mature female gamete (ovum) is called oogenesis.
- It occurs in the ovaries of females.
- Oogenesis consists of the following three phases:

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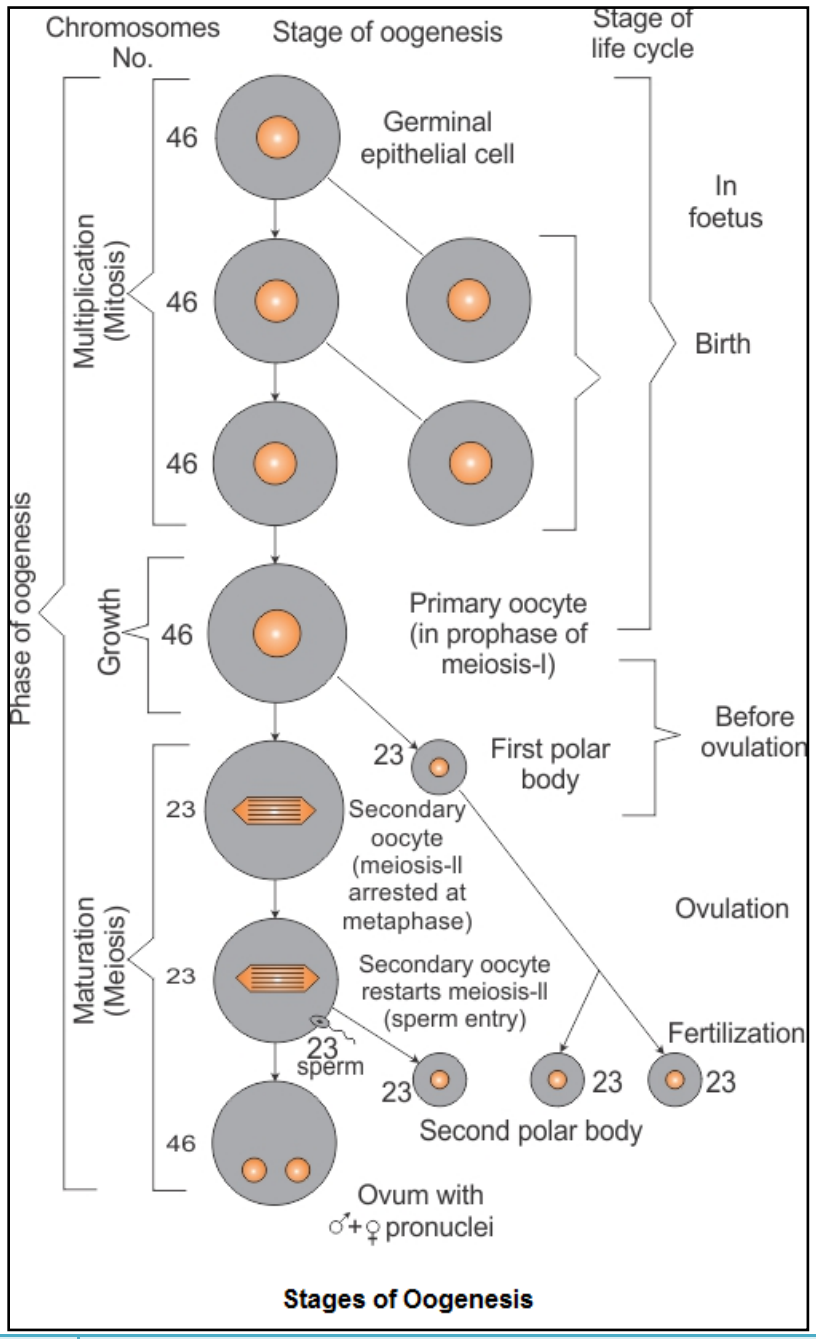

Stages of Oogenesis

Multiplication Phase	During foetal development, certain cells of the germinal epithelium become larger than the other cells. These cells divide by mitosis and form undifferentiated germ cells called oogonia or egg mother cells (2*n*). The oogonia multiply by mitosis to form primary oocytes.
Growth Phase	The oogonium grows into large primary oocytes. Each primary oocyte gets surrounded by a layer of granulosa cells to form the primary follicle. The fluid-filled cavity of the follicle is called antrum. A large number of these follicles degenerate during the period from birth to puberty. At puberty, only 60000–80000 follicles are left in each ovary.
Maturation Phase	Each primary oocyte undergoes two maturation meiotic divisions.

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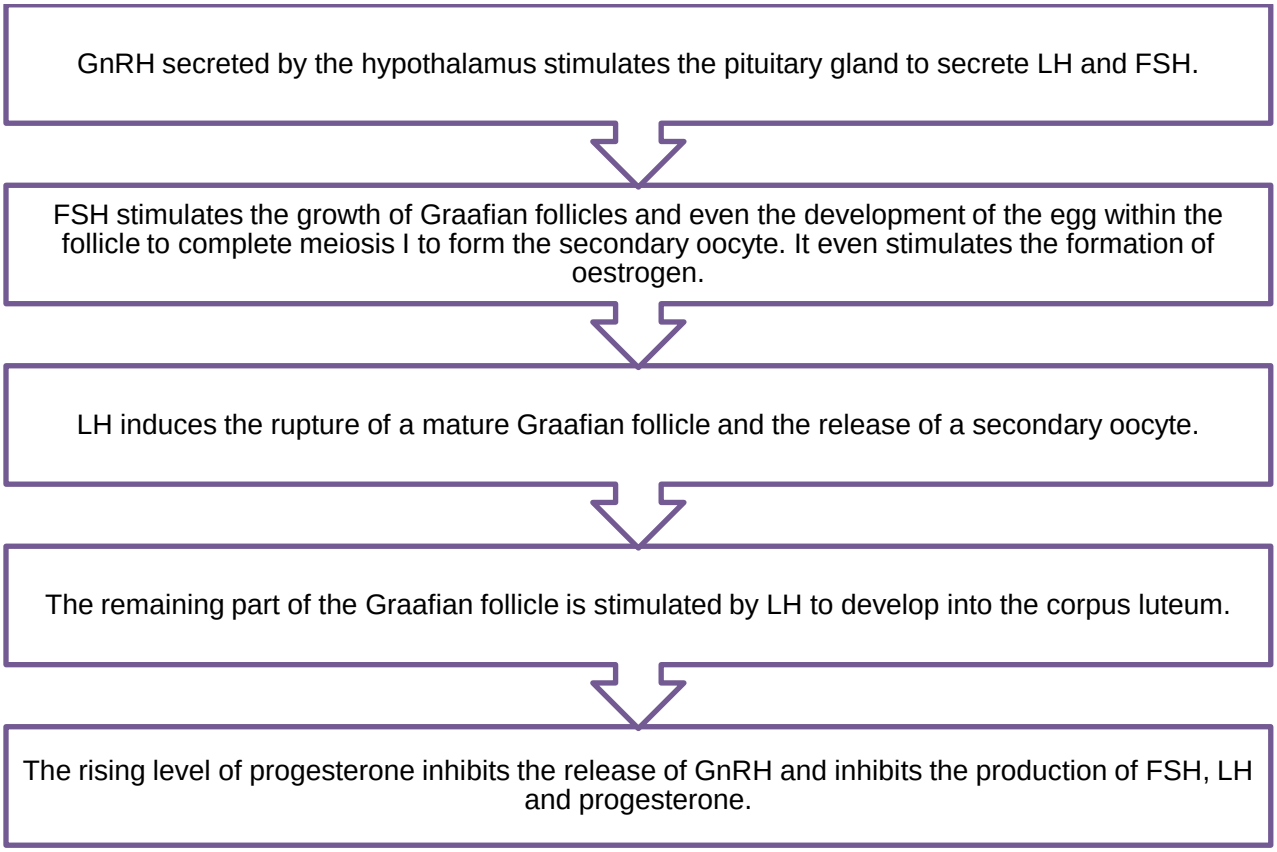
	In the first meiotic division, the primary oocyte divides into two very unequal haploid daughter cells—a large secondary oocyte and a small first polar body or polocyte. In the second maturation division, the first polar body may divide to form two second polar bodies. The secondary oocyte again divides into unequal daughter cells, a large ootid and a very small second polar body. The ootid grows into a functional haploid ovum. One oogonium gives rise to one ovum and three polar bodies.

Hormonal Control of Oogenesis



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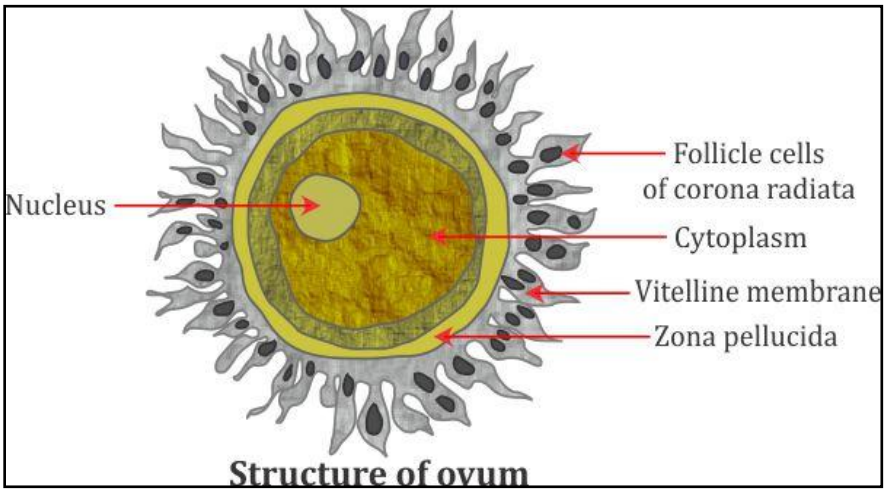
Significance of Oogenesis

- It helps to maintain the chromosome number of the species—haploid in egg and diploid in zygote.
- It helps to retain sufficient amount of the cytoplasm in the ovum which is essential for the development of the early embryo.
- During meiosis, first crossing over takes place which brings about variation.
- The occurrence of oogenesis in various organisms supports the evidence of the basic relationship of the organisms.

Structure of Egg/Ovum

- The mature ovum is the haploid gamete of human females.
- It is spherical or ovoid and non-motile.



Structure of ovum

- The human ovum is alecithal or devoid of a yolk
- It has abundant cytoplasm called ooplasm and a centrally located nucleus called the germinal vesicle which contains a prominent nucleolus.
- The ovum is surrounded by a transparent, non-cellular layer called zona pellucida and an outer thick corona radiata formed of radially elongated follicular cells.
- A distinct space called the perivitelline space exists between the vitelline membrane and the zona pellucida.
- The ovum exhibits polarity. The side which extrudes polar bodies is called the animal pole. The pole opposite to the animal pole is called the vegetal pole.
- In human beings, the ovum is released from the ovary as a secondary oocyte.

DID YOU KNOW ?

Regnier de Graaf discovered follicles in the human ovary in 1671 and considered them to be eggs. Thus, the follicles are also called Graafian follicles.

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Differences between Human Sperm and Ovum

Sperm	Ovum
•Sperms are produced in the testes. •Four sperms are produced from one spermatogonium. •Sperm can be externally differentiated into head, neck, middle piece and tail. •It has a very small amount of cytoplasm. •Mitochondria are spirally arranged in the middle piece. •Sperm penetrates the ovum by releasing hydrolytic enzymes.	•Ova are produced in the ovaries. •One ovum is produced from one oogonium. •Ovum cannot be externally differentiated into distinct regions. •It has a large amount of cytoplasm. •Mitochondria are scattered in the cytoplasm. •Ovum engulfs the sperm by forming a reception cone.

Similarities and Differences between Spermatogenesis and Oogenesis

Similarities	
1. Both processes consist of three main phases—multiplication, growth and maturation.	
2. In the multiplication phase, the primordial cells of the testes and ovaries divide mitotically to form numerous spermatogonia and oogonia, respectively.	
3. In the growth phase, the cells accumulate food reserves and grow to primary spermatocytes and oocytes, respectively.	
4. The maturation phase in both processes comprise two successive divisions, first meiotic and second meiotic, resulting in the formation of secondary gametocytes and gametes, respectively.	
Differences	
Spermatogenesis	**Oogenesis**
1. It occurs in the testes.	1. It occurs in the ovaries.
2. Spermatogonia change to primary spermatocytes.	2. Oogonia change to primary oocytes.
3. A primary spermatocyte divides to form two secondary spermatocytes.	3. A primary oocytes divides to form one secondary oocyte and one polar body.
4. A secondary spermatocyte divides to form two spermatids.	4. A secondary oocyte divides to form one ootid and one polar body.
5. No polar body is formed.	5. Two polar bodies are formed.
6. One spermatogonium forms four spermatozoa.	6. One oogonium forms one ovum.
7. Sperms are minute, yolkless and motile.	7. Ova are much bigger with yolk and non-motile.

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Differentiation of Gametes

Differentiation of Sperm	Differentiation of Ovum
1. The shape of the nucleus changes from spherical to elongated.	1. The nucleus enlarges because of the production of a large amount of nuclear sap. The nucleolus greatly increases in size.
2. The acrosome is derived from the Golgi complex.	2. Mitochondria increase in number during the growth of the oocyte.
3. The centrosome consists of two centrioles—distal and proximal.	3. Golgi bodies disappear completely in mature oocytes.
4. The mitochondria form a mitochondrial spiral around the axial filament.	4. The membranes of the endoplasmic reticulum do not have ribosomes but are perforated by pores.
5. The cytoplasm is reduced to a condensed layer.	5. Formation of cortical granules takes place in mature oocytes.
6. The plasma membrane extends to surround the acrosome, nucleus, middle piece and the main portion of the axial filament of the tail.	6. Yolk is synthesised in the primary oocytes (vitellogenesis).
7. Formation of ring centriole.	
8. The axial filament arises from the distal centriole.	

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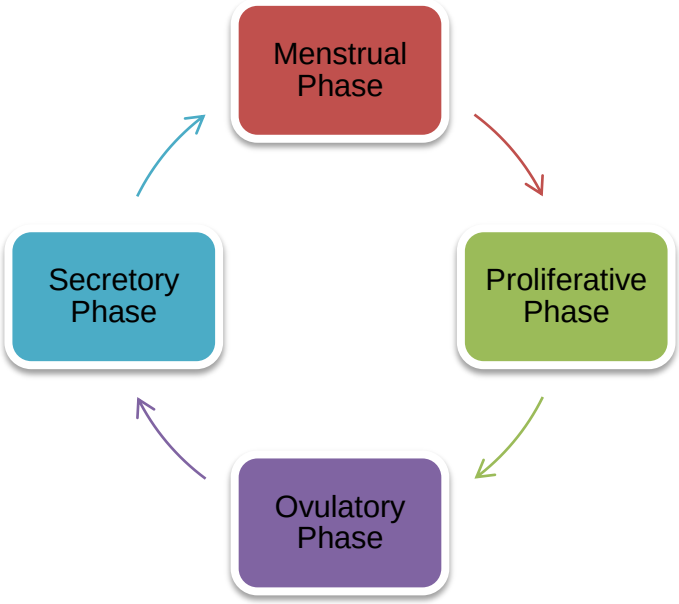
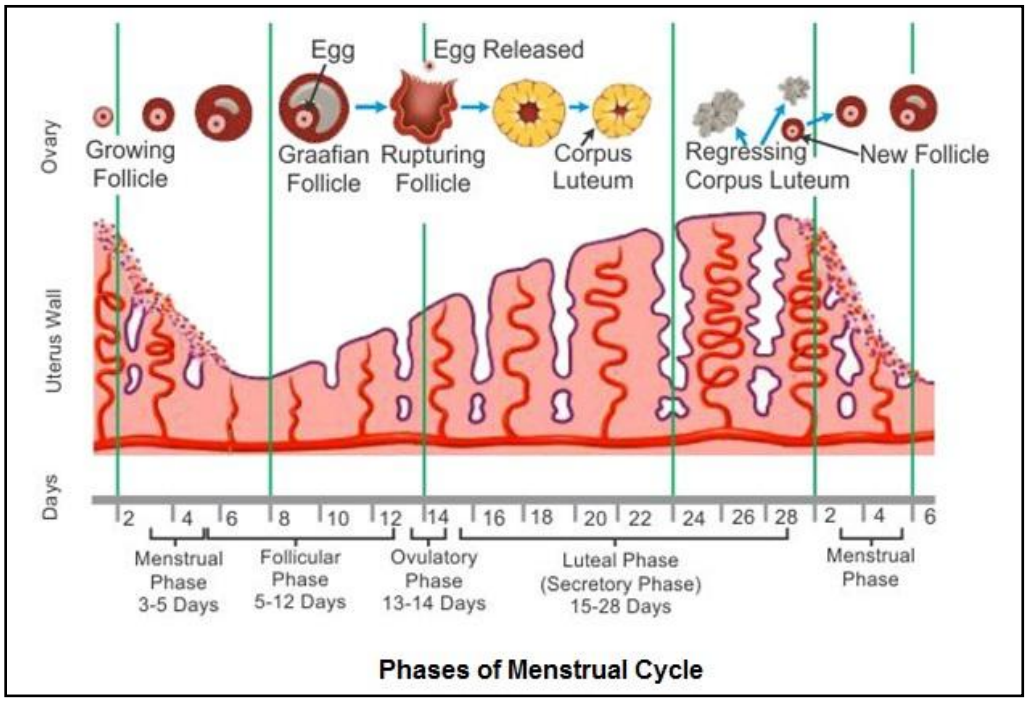
Menstrual Cycle

What is Menstruation?

- Menstruation is the bleeding from the uterus of adult females at an interval of one lunar month.
- In human females, menstruation occurs at an average interval of 28–29 days. The cycle of events starting from menstruation till the next one is called the menstrual cycle.
- One ovum is released during the middle of each menstrual cycle.
- Menstruation starts between 12 and 15 years of age and continues until 45–50 years.

Phases of the Menstrual Cycle





Phases of Menstrual Cycle

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Menstrual Phase

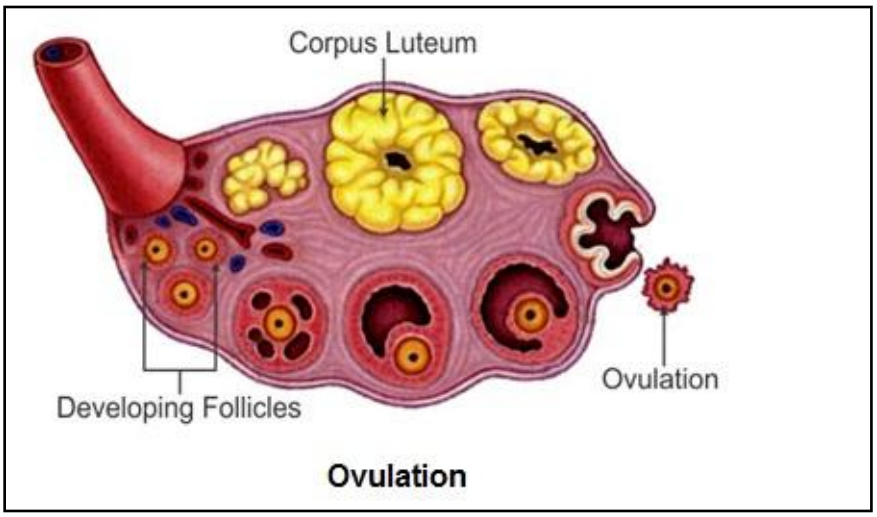
- Menses takes place on the 3rd–5th day of the menstrual cycle of 28 days.
- The production of LH is considerably reduced.
- This causes degeneration of the corpus luteum and reduction in the production of progesterone and oestrogen.
- The uterine endometrium breaks down and menstruation starts.
- Cells of the endometrium, secretions, blood and the unfertilised ovum constitute menstrual flow.

Follicular/Proliferative Phase

- The follicular phase begins on the 6th and lasts up to the 13th or 14th day in a 28-day menstrual cycle.
- FSH stimulates the ovarian follicle to secrete oestrogen.
- Oestrogen stimulates the proliferation of cells of the uterine endometrium.
- The endometrium becomes thicker because of rapid cell multiplication. This is accompanied by the growth of the uterine glands and blood vessels.

Ovulatory Phase

- At about the 14th day of the menstrual cycle, both FSH and LH attain a peak level.
- Rapid secretion of LH induces rupturing of the Graafian follicle and the release of the ovum (ovulation).



Ovulation

Luteal/Secretory Phase

- The luteal phase begins on the 15th and lasts up to the 28th day in a 28-day menstrual cycle.
- LH causes ovulation. The remaining cells of the ovarian follicles are stimulated by LH to develop the corpus luteum.
- The corpus luteum secretes a large amount of progesterone which stimulates the uterine glands to produce an increased amount of watery mucus.
- The secretions of watery mucus by the vaginal glands and the glands of the fallopian tubes also increase.
- Progesterone also maintains the endothelium which is necessary for the implantation of the fertilised ovum and other events of pregnancy.

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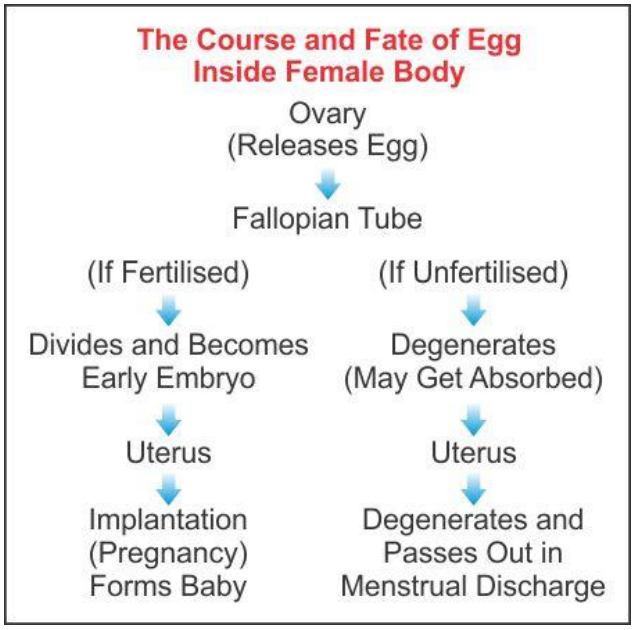
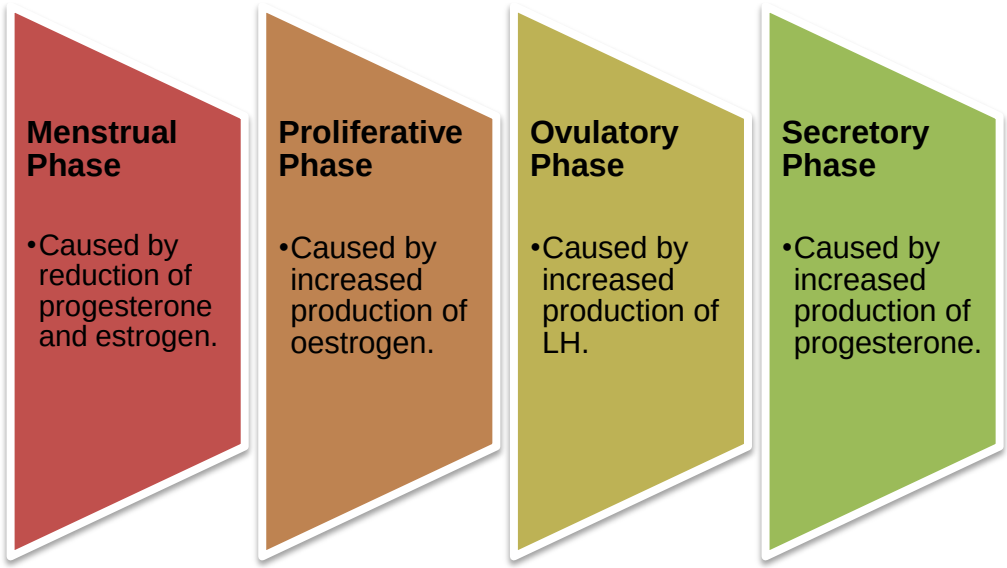
- In the absence of fertilisation, the corpus luteum degenerates which causes disintegration of the endothelium, leading to menstruation and the start of a new cycle.



Hormonal Control of the Menstrual Cycle

- Gonadotropin-releasing hormone (GnRH) stimulates the release of FSH and LH.
- FSH stimulates the ovarian follicles to produce oestrogen during the proliferative phase, while LH stimulates the corpus luteum of the ovary to secrete progesterone.



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FACT

A girl's first menstrual flow on attaining puberty at the age of 11–13 years is called menarche.

Menopause

Definition

- The permanent cessation or stoppage of ovulation and menstruation is called menopause.

Period

- It occurs between 45 and 55 years of age.

Cause

- It may occur because of changes in the pituitary gland and the nearby hypothalamus.
- It may also occur when no follicles are left in the ovaries.
- A decline in oestrogen and progesterone levels leads to menopause.

Symptoms

- The uterus and vagina gradually become atrophic.
- Women suffer from depression, hot flashes and other physiological and psychological problems.

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