Model Answer
M Sc III sem. Examination 2014
LZT-304: Male and Female Reproduction
Section A

Q. 1.

(i) a, (ii) d, (iii) c, (iv) d, (v) a,

(vi) d, (vii) b, (viii) d, (ix) a, (x) c

Section B

Ans. No. 2.). Give a diagrammatic representation of oogenesis and follicular development

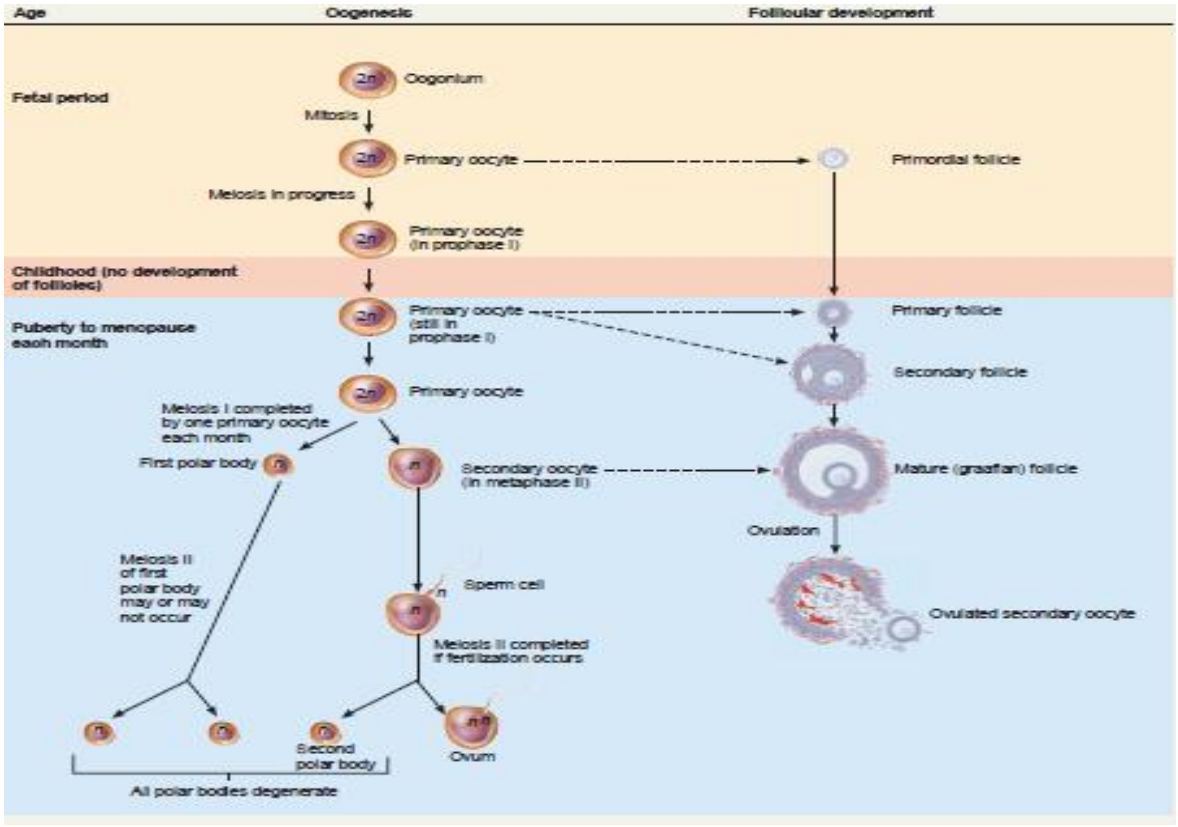
The formation of gametes in the ovaries is termed **oogenesis.** In contrast to spermatogenesis, which begins in males at puberty, oogenesis begins in females before they are even born. Oogenesis occurs in essentially the same manner as spermatogenesis; meiosis takes place and the resulting germ cells undergo maturation. During early fetal development, primordial (primitive) germ cells migrate from the yolk sac to the ovaries. There, germ cells differentiate within the ovaries into **oogonia**. Oogonia are diploid (2*n*) stem cells that divide dividemitotically to produce millions of germ cells. Even before birth, most of these germ cells degenerate in a process known as **atresia**. A few, however, develop into larger cells called **primary oocytes** that enter prophase of meiosis I during fetal development but do not complete that phase until after puberty.

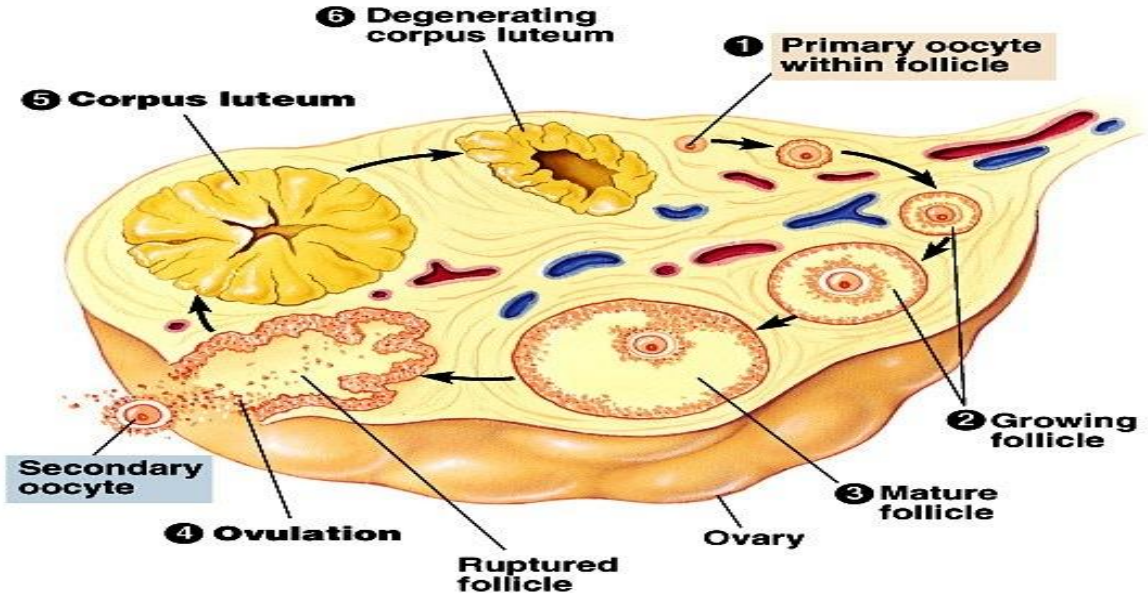
During this arrested stage of development, each primary oocyte is surrounded by a single layer of flat follicular cells, and the entire structure is called a **primordial follicle .**The ovarian cortex surrounding the primordial follicles consists of collagen fibers and fibroblast-like **stromal cells.** At birth, approximately 200,000 to 2,000,000 primary oocytes remain in each ovary. Of these, about 40,000 are still present at puberty, and around 400 will mature and ovulate during a woman's reproductive lifetime. The remainder of the primary oocytes undergo atresia. Each

month after puberty until menopause, gonadotropins (FSH and LH) secreted by the anterior pituitary further stimulate the development of several primordial follicles, although only one will typically reach the maturity needed for ovulation. A few primordial follicles start to grow, developing into **primary follicles** . Each primary follicle consists of a primary oocyte that is surrounded in a later stage of development by several layers of cuboidal and low-columnar cells called **granulosa cells.** The outermost granulosa cells rest on a basement membrane. As the primary follicle grows, it forms a clear glycoprotein layer called the **zona pellucida** between the primary oocyte and the granulosa cells. In addition, stromal cells surrounding the basement membrane begin to form an organized layer called the **theca folliculi.**

With continuing maturation, a primary follicle develops into a secondary follicle In a **secondary follicle,** the theca differentiates into two layers: (1) the **theca interna,** a highly vascularized internal layer of cuboidal secretory cells that secrete estrogens and (2) the **theca externa,** an outer layer of stromal cells and collagen fibers. In addition, the granulosa cells begin to secrete follicular fluid, which builds up in a cavity called the **antrum** in the center of the secondary follicle. The innermost layer of granulosa cells becomes firmly attached to the zona pellucida and is now called the **corona radiata** (*corona* = crown; *radiata* = radiation) . The secondary follicle eventually becomes larger, turning into a **mature (graafian) follicle** . While in this follicle, and just before ovulation, the diploid primary oocyte completes meiosis I, producing two haploid (*n*) cells of unequal size—each with 23 chromosomes . The smaller cell produced by meiosis I, called the **first polar body,** is essentially a packet of discarded nuclear material. The larger cell, known as the **secondary oocyte,** receives most of the cytoplasm. Once a secondary oocyte is formed, it begins meiosis II but then stops in metaphase. The mature (graafian) follicle soon ruptures nand releases its secondary oocyte, a process known as **ovulation.** At ovulation, the secondary oocyte is expelled into the pelvic cavity together with the first polar body and corona radiata. Normally these cells are swept into the uterine tube. If fertilization does not occur, the cells degenerate. If sperm are present in the uterine tube and one penetrates the secondary oocyte, however, meiosis II resumes. The secondary oocyte splits into two haploid cells, again of unequal size.

The larger cell is the **ovum,** or mature egg; the smaller one is the **second polar body.** The nuclei of the sperm cell and the ovum then unite, forming a diploid **zygote**





Oogenesis and Folliculogenesis

3) What are the different photoperiod factor including hormone associated in regulation of seasonal reproduction. Provide the synthesis of responsible hormone acting as signal stimuli.

Photoperiod as the Main Proximate Factor

The use of photoperiod as a predictive cue was first demonstrated in a mammal by Baker and Ransom (12). They observed that in a colony of field voles held on 15 hours of light, reproduction was continuous. However, when exposed to 9 hours of light per day, reproduction was blocked. Since then, photoperiodism has been shown to influence reproduction in most mammalian orders but has been most thoroughly studied in hamsters and sheep. In Siberian hamsters, exposure to short days induces reproductive inhibition, winter molt, onset of hibernation, and increase in body mass, whereas maintenance of animals in long days prevents these changes (13). When sexually mature male Syrian hamsters are exposed to photoperiods shorter than 12.5 hours of light per day, their circulating luteinizing hormone (LH), follicle-stimulating hormone (FSH), and testosterone concentrations decline markedly. Within 8–12 weeks their testes regress and spermatogenetic activity ceases (Fig. 2) (14). In sheep, the reversal of the photoperiodic cycle, without any modification of other environmental factors, causes the breeding season to phase shift by 6 months, that is, decreasing day length is associated with reproductive activation and increasing day length with reproductive arrest (15). The reduction of the photoperiodic cycle to 6 months induces the appearance of two periods of activity every year (7,8). Photoperiod is also critical in these species for the attainment of puberty (see Chapter 39).

A clear feature of photoperiodic responses observed in all these treatments is that most photoperiod-induced changes are expressed after a latency of several weeks. Stimulation of ovulation after short-day exposure takes about 6 weeks in sheep and induction of testicular regression by short days in hamsters about 8 weeks (7,14). This feature of the response is consistent with the predictive nature of photoperiodic information.

Circannual Versus Noncircannual Species

Photoperiodic species are divided in two main categories depending on how photoperiod controls the annual rhythms and on the endogenous nature of the annual changes. Circannual species display endogenously generated rhythms, and photoperiod synchronizes these internally generated rhythms (referred to as type II rhythms). Noncircannual species do not display endogenous rhythms and are at least partially dependent on the environment for the generation of the seasonal cycle.

Circannual Species

A circannual rhythm is composed of an endogenously generated sequence of events that takes approximately 1 year to complete. Three conditions must be met for an annual rhythm to be considered as circannual (16). First, the cycle must persist for at least 2 years in experimental conditions that provide no external information about its period (e.g., constant photoperiod, temperature). Second, its period in such conditions must differ from 365 days, demonstrating that the cycle is not synchronized by an annually recurring environmental cue. Third, desynchrony must be observed among individuals in such conditions, also demonstrating that the cycle is not being driven by an environmental cue.

Circannual cycles have been described in animals exposed to a constant photoperiod, instead of constant darkness, which is sufficient to prevent the animal from receiving any information about time of the year. Circannual rhythms are expressed by many mammals, including bats, ferrets, squirrels, marmots, sheep, deer, and primates (16,17). One of the best studied examples is the change in body weight, reproduction, and hibernation in the Golden-mantled ground squirrel. During summer, body weight increases as a result of fat storage and reaches a plateau in the autumn. At this time, animals enter their underground burrows where they spend the winter. During winter they enter deep torpor with occasional arousal every 1 to 14 days. The final

→ How photoperiod entrains a circannual rhythm has been well studied in the case of reproductive activity in the ewe. This animal normally enters the breeding season in the autumn and, in the absence of pregnancy, has regular ovulatory cycles until mid-winter. Ovulations then cease, and the ewe remains anovulatory throughout the summer. When these animals are deprived of information about time of year, either by being kept in constant photoperiod or by blinding, they continue in most cases to show changes in ovulatory activity, if they are intact, or in LH secretion if they are ovariectomized, bearing an estradiol implant (18,19). If ewes are kept for 5 years in constant short photoperiod (8 hours of light), a cycle of LH secretion is observed with a period shorter than a year and cycles are desynchronous among individuals and out of phase with respect to the cycles of sheep maintained outdoors (Fig. 5) (19). The expression of this circannual rhythm is responsible for the timing of the onset and the end of the breeding season (20,21).

TRANSDUCTION OF LIGHT–DARK INFORMATION INTO A RHYTHM OF MELATONIN SECRETION

Retinohypothalamopineal Pathways

Photoreceptors

Photic information is relayed to the pineal gland through a multisynaptic neural pathway including the central clock, the suprachiasmatic nuclei (SCN) (32), where it is then transduced into an endocrine signal that takes the form of a diurnally modulated rhythm of melatonin production (Fig. 6). Light is perceived by the retina because enucleation abolishes the light control of pineal melatonin production (33). Retinal rods and cones with their opsin-based visual pigments are necessary for the conscious perception of light. They were also thought to be the only ocular photoreceptors involved in forwarding light–dark information. However, the regulation of pineal melatonin production as well as the entrainment of circadian rhythms by light remains intact in a transgenic mouse model (*rd/rd cl*) that lacks all functional rods and cones. Enucleation abolishes these light effects in these null mice. Ocular photoreception is therefore not confined to rods and cones, and novel ocular photoreceptors are involved (34). The photopigment, melanopsin (*Opn4*), originally isolated from photosensitive melanophores of *Xenopus laevis* (35), has emerged as a strong candidate to mediate these effects of light. A subset of retinal ganglion cells expresses melanopsin (36) and projects to the SCN (37–40). These cells are intrinsically light responsive as their light-evoked depolarizations persist after anatomical and pharmacological isolation (41,42). In melanopsin knockout mice, light-dependent entrainment is attenuated. Bright light can still entrain circadian rhythms but not as much as in mice expressing melanopsin (43–46). The intrinsic photosensitivity of melanopsin retinal ganglion cells is abolished in these knockout mice, indicating the indispensable role of melanopsin in the cellular response (47). In mice lacking melanopsin and functional rods and cones, entrainment to light–dark cycles and masking response to light are completely abolished (44). The visual (rod–cone) and nonvisual (melanopsin retinal ganglion cells) systems together therefore seem to provide all of the photic input for circadian responses to light, and the nature of the interaction between these two systems remains to be elucidated.

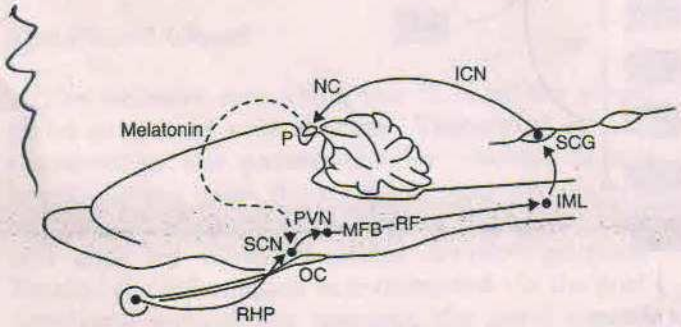
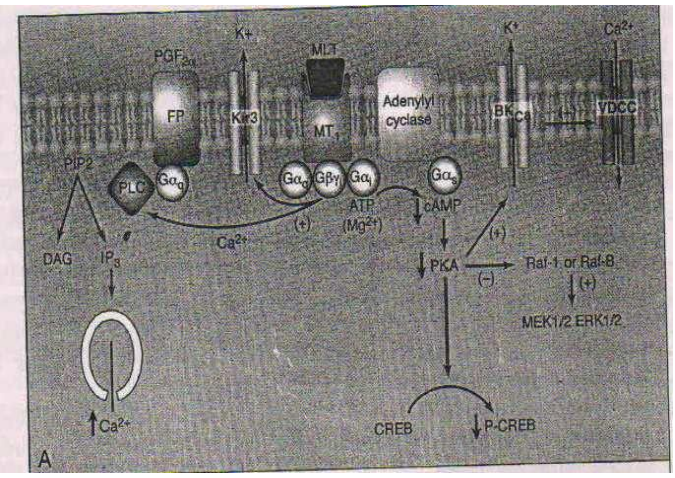


FIG. 6. Mammalian melatonin rhythm generating system. P, pineal gland; SCN, suprachiasmatic nuclei; RHP, retinohypothalamic projection; PVN: paraventricular nucleus, IML, intermediolateral cell column; ICN, inferior carotid nerve; NC, nervi conarii; OC, Optic chiasm, MFB, medial forebrain bundle, RF, reticular formation. [Reproduced from (114).]

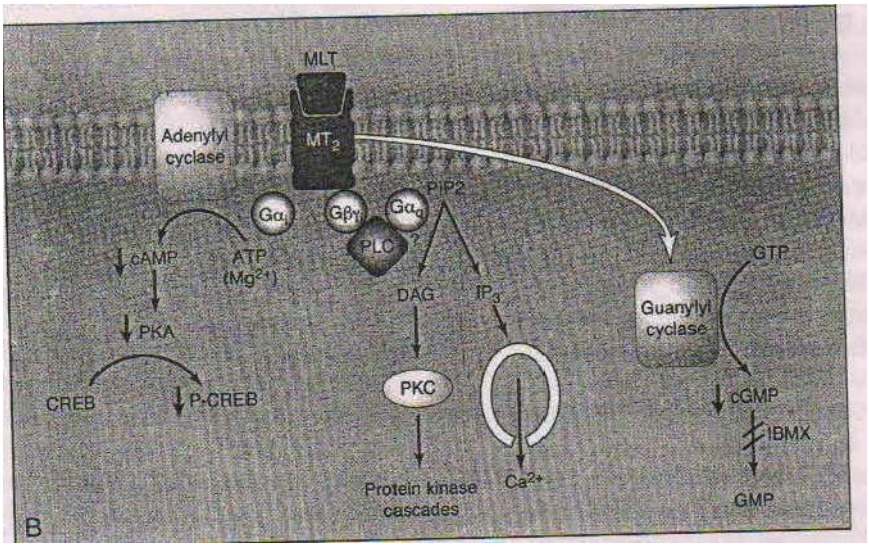


Retinohypothalamic Tract

From retinal photoreceptors, photic information is conveyed to the SCN via the retinohypothalamic tract that generally terminates within the ventral and lateral SCN. The retinohypothalamic tract neurotransmitters are mainly glutamate (48,49) and pituitary adenylate cyclase-activating peptide (50). In response to light, they are released from the retinohypothalamic tract terminal and stimulate their receptors expressed in the SCN. Photic and nonphotic information also reaches the SCN indirectly through the thalamic intergeniculate leaflet (neuropeptide Y [NPY], enkephalin, and γ-aminobutyric acid) and the raphe nucleus (serotonin) (51–54).

Suprachiasmatic Nuclei

The SCN are localized in the anteroventral hypothalamus, and a large body of evidence has established that the central pacemaker resides in these hypothalamic nuclei [for review see (55)]. Lesioning of



Answer No.4 Give in brief the steps involved during fertilization. Give a detailed account about the role of Zona Protein during the acrosomal reaction during sperm penetration.

Fertilization is the process whereby two sex cells (gametes) fuse together to create a new individual with genetic potentials derived from both parents. The act of fusion of the sperm and the method of approach, entry and eventual fusion of the male and female nuclei constitutes the mechanism of fertilization. This is believed to take place in the following stages.

1. Movement of the sperm towards the egg.
2. Capacitation and contact.
3. Penetration of sperm into ovum.
4. Cortical reaction.
5. Activation of the ovum.
6. Fusion of male and female pronuclei (amphimixis).

1. **Movement of the sperm towards the egg:**This is the first step which brings the sperm in physical contact with the ovum. As the male and female gametes are produced in different individuals, there are various mechanisms to bring them nearer. The initial attraction of the sperms towards the egg is supposed to be chmotactic. The sperms swim towards the egg collides with it. Usually several sperms attach themselves to the egg.In individuals with external fertilization large number of eggs and sperms are released outside so that they have a favourable chance of meeting with each other. In individuals with internal fertilization the sperms are discharged into the genital tract of the females by the male individual. From here the sperms move upward and reach the egg present in the uterus.

2. Capacitation and contact: When a large number of sperms approach the egg for contact, the fertilizin and antifertilizin reaction ensures that only a few spermatozoa are allowed to reach the ovum. The initial

attachment of the sperm to the egg is believed to be due to the chemical bonding of fertilizin and antifertilizin.

3. Penetration of sperm into ovum: The acrosome portions of the sperm produces some lytic enzymes called sperm lycines which have the ability to dissolved the egg membrane allowing the entry of the sperm into the egg cytoplasm. Usually only the head and the middle piece of the sperm enter the egg while the tial is left outside.

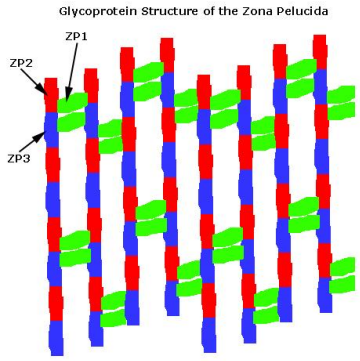
4. Cortical reaction: The entry of the sperm head into the egg brings about several changes in the egg surface. These are the cortical changes and the development of fertilization membrane. In some echinoderm eggs some fine granules are visible in the ooplasm after the entry of the sperm head.

The vitelline membrane starts lifting itself up from the point of sperm entry and a perivitelline space is formed between it and the egg surface. The cortical granules from the egg cortex release their contents into the privitelline space. These contents attach themselves to the inner surface of the vitelline membrane forming what is known as a fertilization membrane. The development of the fertilization membrane prevents the entry of other sperms into the egg.

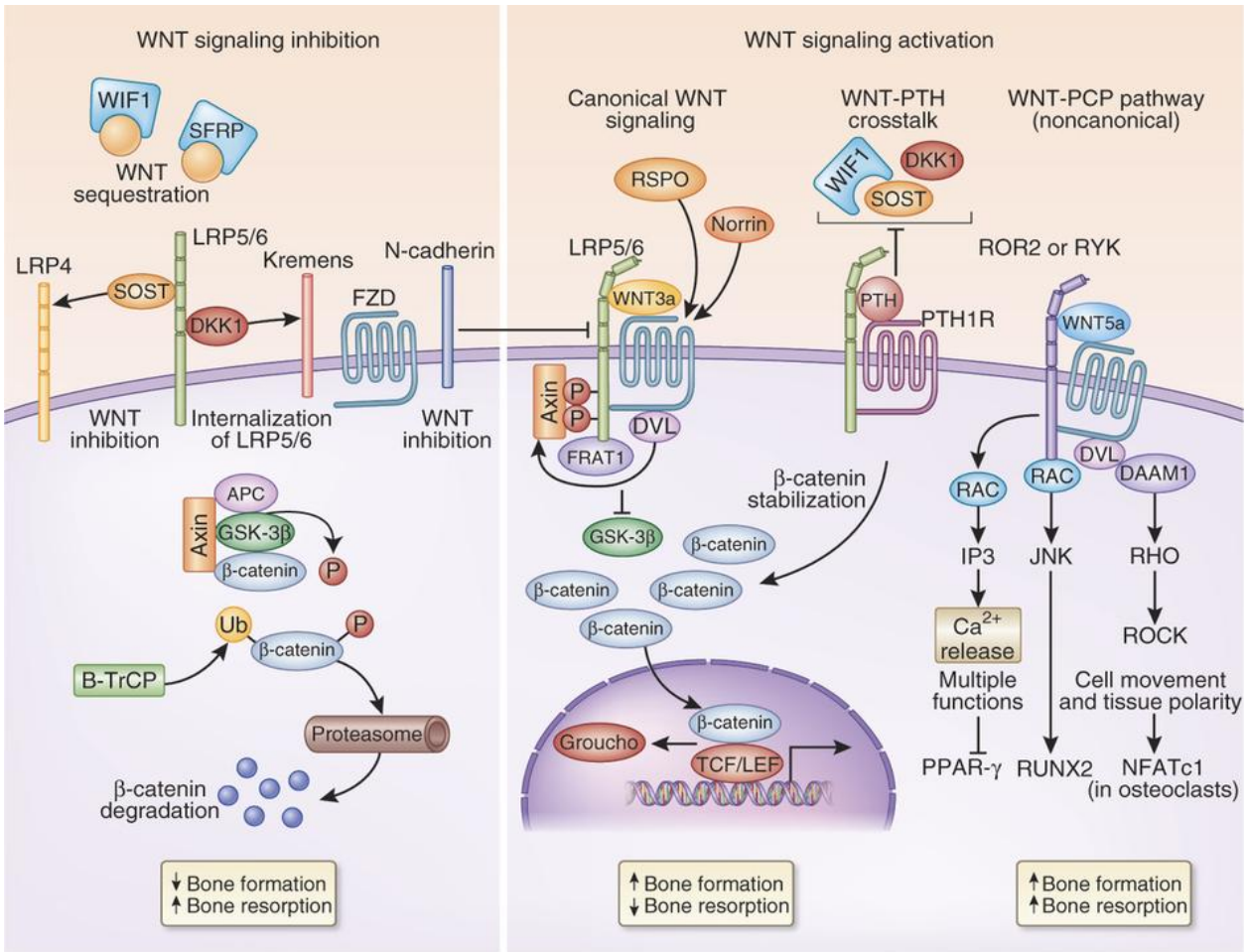
5. Activation of the ovum: The mature egg will be generally in a hibernating condition with very low rates of metabolism and inactive nucleus. The penetration of the sperm triggers the egg into activity. The metabolic rates increase allowing for entry of water and other particles. Metabolically the rate of protein synthesis goes up as these are needed for further cell divisions. At this stage the nucleus (pronucleus) of the egg which has remained in the metaphse II stage (of the meiotic II division) becomes active completing its second division and releases the second polar body.

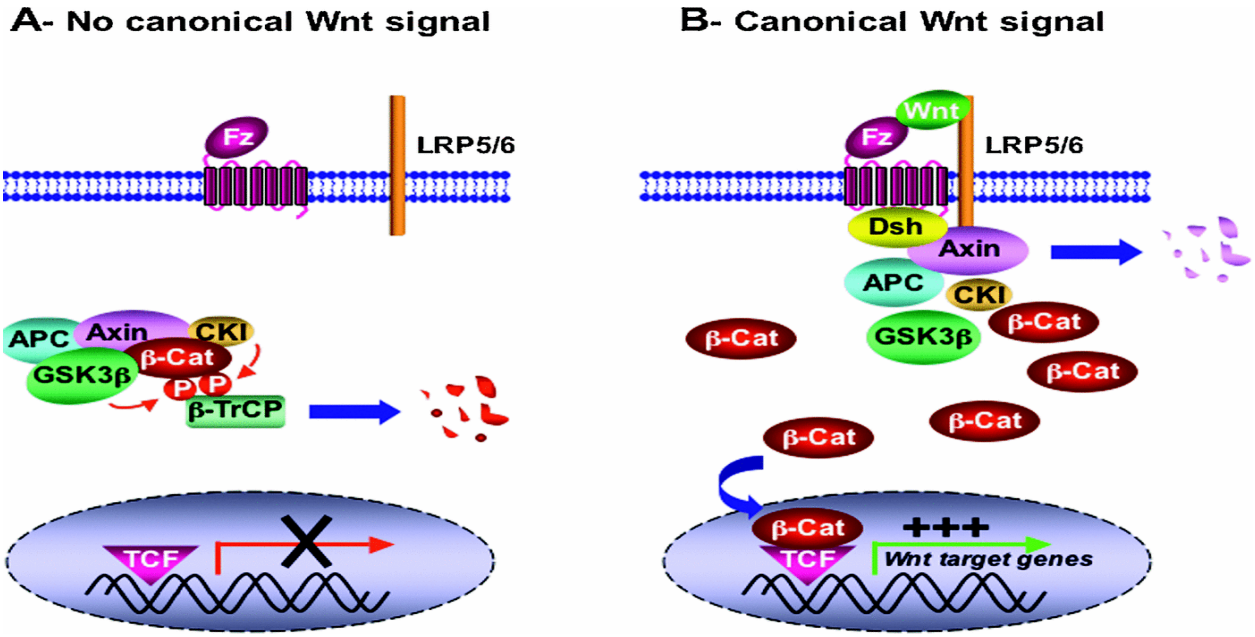
6. Fusion of male and female pronuclei (amphimixis): In this process there is fusion of the male and female nuclei. Initially the two nuclei remain close together and at the point of contact the nuclear membranes disappear and the chromosomes come to lie on the equator. Finally the nuclear fusion is completed and it becomes a zygote nucleus. The egg is said to have been fertilized and it becomes a zygote. It is now ready to undergo cleavage to develop into the embryo.

Zona pellucida (ZP) is a glycoproteinaceous translucent matrix that surrounds the mammalian oocyte and plays a critical role in the accomplishment of fertilization. In humans, it is composed of 4 glycoproteins designated as ZP1, ZP2, ZP3 and ZP4, whereas mouse ZP is composed of ZP1, ZP2 and ZP3 (Zp4 being a pseudogene). In addition to a variable sequence identity of a given zona protein among various species, human ZP1 and ZP4 are paralogs and mature polypeptide chains share an identity of 47%. Employing either affinity purified native or recombinant human zona proteins, it has been demonstrated that ZP1, ZP3 and ZP4 bind to the capacitated human spermatozoa and induce an acrosome reaction, whereas in mice, ZP3 acts as the putative primary sperm receptor



Ans. No. 5). Describe about the different types of cell noted in histological structure of epididymis as specific markers in mammals.





Q. NO. 6). Describe about the different types of cell noted in histological structure of epididymis as specific markers in mammals.

The epididymis is part of the male reproductive system and is present in all male reptiles, birds, and mammals. It is a single, narrow, tightly-coiled tube (in adult humans, six to seven meters in length) connecting the efferent ducts from the rear of each testicle to its vas deferens.

The epididymis can be divided into three main regions:

- The head (Latin: Caput). The head of the epididymis receives spermatozoa via the efferent ducts of the mediastinium of thetestis. It is characterized histologically by a thin myoepithelium. The concentration of the sperm here is dilute.
- The body (Latin: Corpus)
- The tail (Latin: Cauda). This has a thicker myoepithelium than the head region, as it is involved in absorbing fluid to make the sperm more concentrated.
-

Cell Types

The epididymis is covered by a two layered pseudostratified epithelium. The epithelium is separated by a basement membrane from the connective tissue wall which has smooth muscle cells. The major cell types in the epithelium are:

Principal Cells

The main cell type in the epididymis of all mammals is referred to as the principal cell. These cells appear along the entire duct but show structural differences in each region . The most striking feature of these cells is their highly developed secretory and endocytic machinery and their basally aligned nuclei. Depending on the segment examined, principal cells comprise approximately 65% to 80% of the total epithelial cell population of the epididymis. Principal cells synthesize a large number of proteins that are then either retained in the cells or actively secreted into the luminal compartment.

Basal cells

Basal cells are the second most abundant cell type found in the epididymal epithelium, constituting 15-20% of the total epithelial cell population of the epididymis. They are triangular and flat cells and they reside in the base of the epithelium. Basal cells cannot access the luminal compartment. They have elongated or round shaped nuclei, and they are in close association with the overlying principal cells or other basal cells through the presence of cytoplasmatic extensions. Because of this contact with the basement membrane, basal cells form an extensive cellular sheet surrounding the epididymal epithelium.

Apical cells

Apical cells are found primarily in the epithelium of the initial segment and intermediate zone , although they have been seen occasionally in other segments in aging rats . These cells have a characteristic apically located spherical nucleus and do not contact the basement membrane . However, little is known about the specific functions of these cells, aside from their ability to endocytose substances from the lumen. These cells are related to sperm quiescence and to the regulation of the pH in the lumen through the production of enzymes of the carbonic anhydrase family

Narrow cells

Narrow cells are the slender elongated cells. They increase from 3% of the total epithelial population in the initial segment to 6% of the total epithelial population in the corpus. These cells presents numerous C-shaped vesicles and mitochondria with a small flattened nucleus located in the upper half of the cell cytoplasm. The structural features of

both apical and narrow cells suggest that these cells are involved in the process of intracellular transport between the lumen and the epithelial cells, in the degradation of specific proteins and carbohydrates

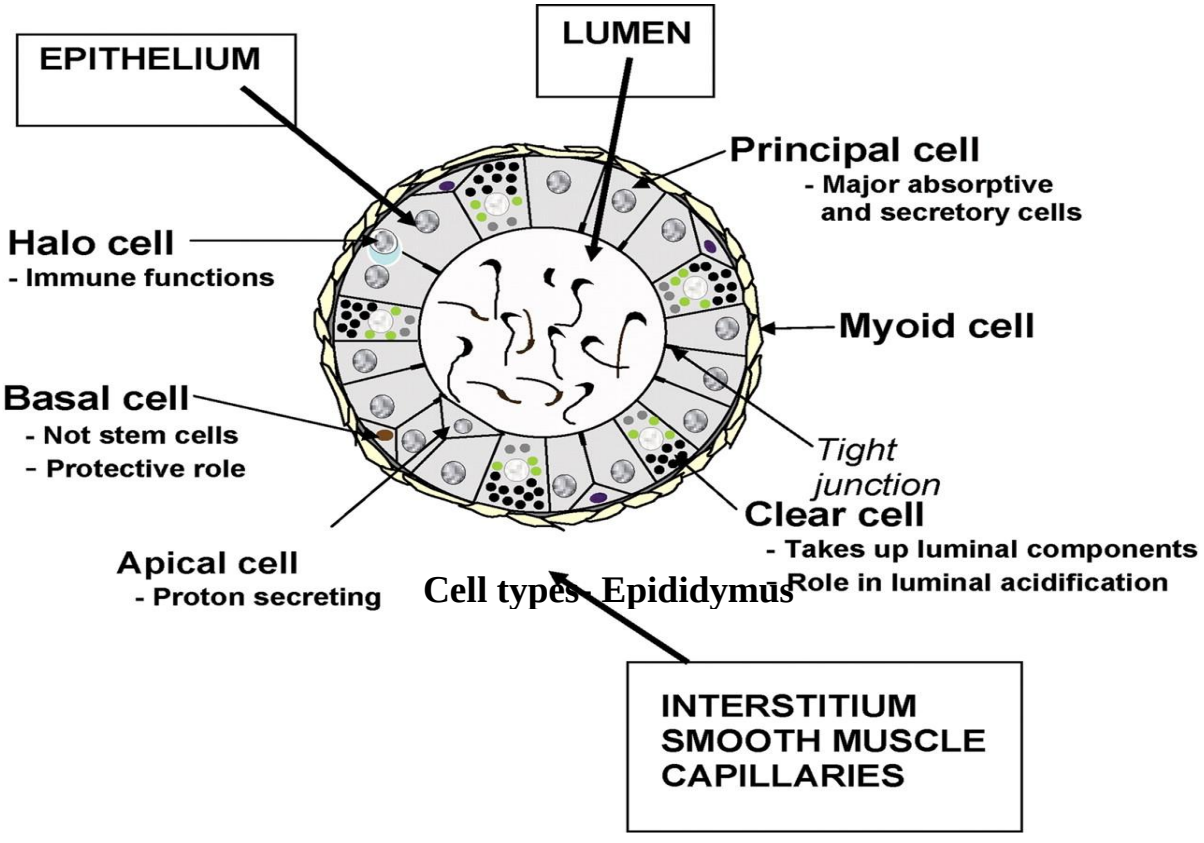
within their lysosomes and in protecting spermatozoa from a changing environment of harmful electrophiles.

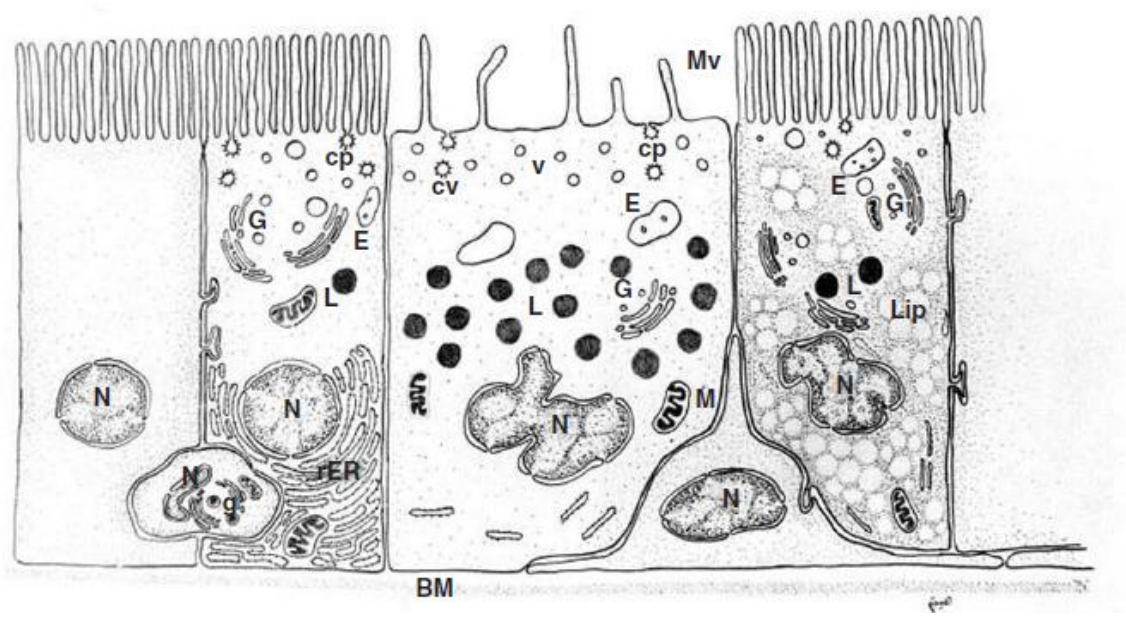
Clear cells

Clear cells along with halo cells, constitute fewer than 5% of the total epithelial cell population. Clear cells are equally distributed through the caput, the corpus and the cauda segments. The dark-stained nucleus of these cells is surrounded by the pale-staining cytoplasm. They are also present in all levels of the epididymal epithelium. Clear cells are also endocytic cells and may be responsible for the clearance of proteins from the epididymal lumen. They normally take up the contents of the cytoplasmic droplets released by the spermatozoa as they transit through the duct.

Halo cells

Halo cells are usually located in the base of the ephitelium where it does not touch the basement membrane. These cells contain variable numbers of dense core granules. They develop in the immune system from a combination of B and T lymphocytes and monocytes.





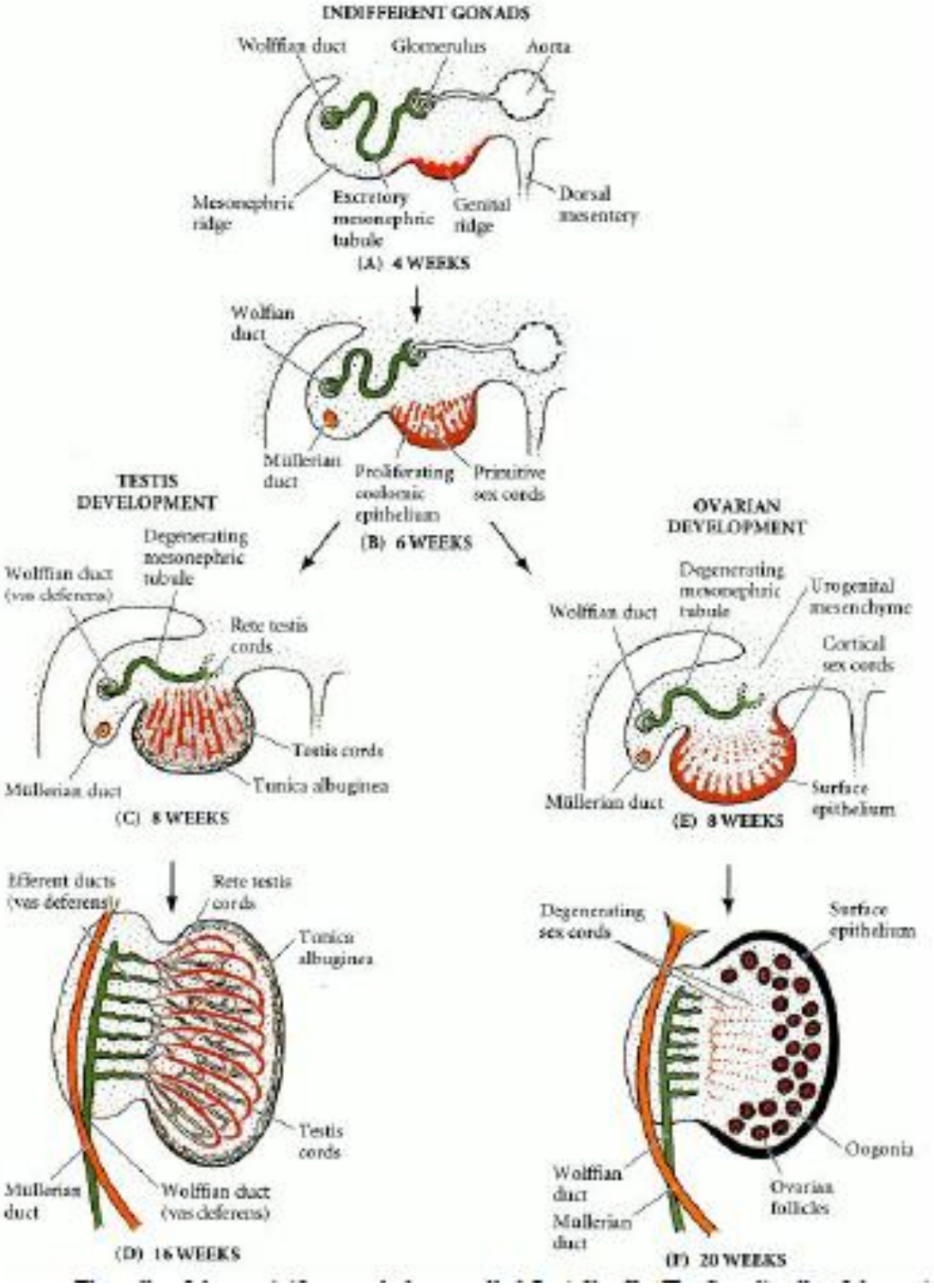
Schematic representation of a principal cell of the caput epididymidis on the left and a principal cell of the corpus epididymidis on the right, with a clear cell in between, as visualized by the electron microscope. Also represented is a halo cell and a basal cell. Principal cells of both regions contain coated pits (cp), endosomes (E) and lysosomes (L), and an elaborate Golgi apparatus (G). Rough endoplasmic reticulum (rER) occupies the basal region of the principal cell of the caput, whereas numerous lipid droplets (lip) occupy the cytoplasm of the principal cells of the corpus region. The clear cell shows few microvilli (Mv), but numerous coated pits (cp), small apical vesicles (v), endosomes (E), and lysosomes (L), all involved in endocytosis. The halo cell is inserted between adjacent principal cells, is located basally, and contains small dense core granules (g), whereas the basal cell stretches itself along the basement membrane (BM). N, nucleus. (Reproduced with permission from Hermo, L., and Robaire, B. [2002]. Epididymis cell types and their function. In *The Epididymis: From Molecules to Clinical Practice* [B. Robaire and B. T. Hinton, Eds.], pp. 81–102. Kluwer Academic/Plenum, New York.)

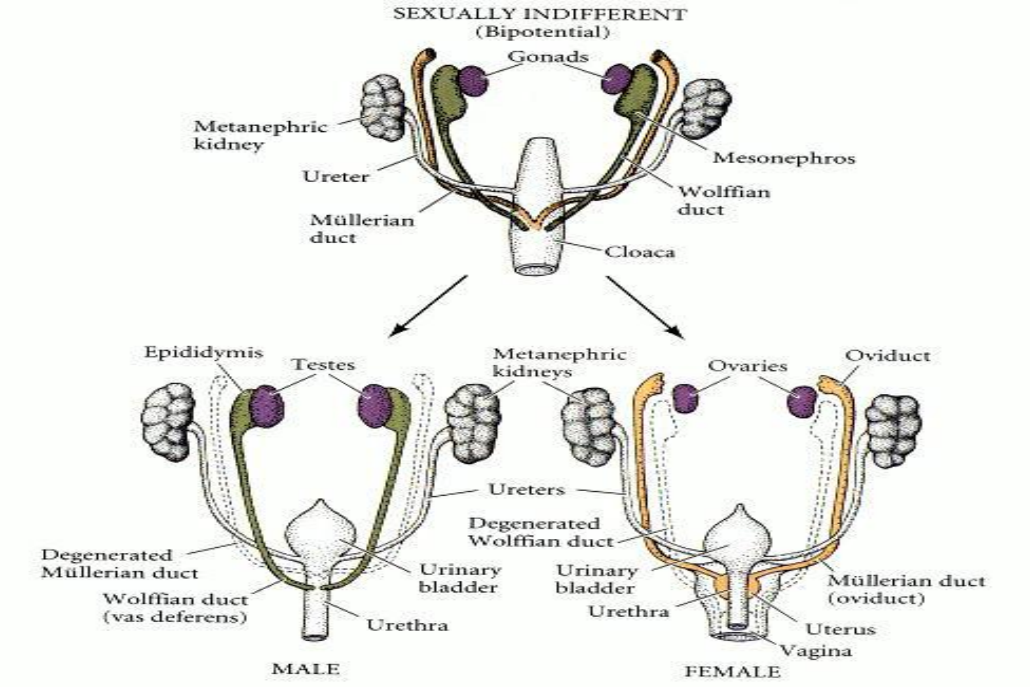
Ans No. 7.

The gonads embody a unique embryological situation. All other organ rudiments can normally differentiate into only one type of organ. A lung rudiment can become only a lung, and a liver rudiment can develop only into a liver. The gonadal rudiment, however, has two normal options. When it differentiates, it can develop into either an ovary or a testis. The path of differentiation taken by this rudiment determines the future sexual development of the organism. But, before

this decision is made, the mammalian gonad first develops through a **bipotential** (**indifferent**) **stage**, during which time it has neither female nor male characteristics.

In humans, the gonadal rudiments appear in the intermediate mesoderm during week 4 and remains sexually indifferent until week 7. The gonadal rudiments are paired regions of the intermediate mesoderm; they form adjacent to the developing kidneys. The ventral portions of the gonadal rudiments are composed of the genital ridge epithelium. During the indifferent stage, the genital ridge epithelium proliferates into the loose connective mesenchymal tissue above it . These epithelial layers form the **sex cords**. The germ cells migrate into the gonad during week 6, and are surrounded by the sex cords. In both XY and XX gonads, the sex cords remain connected to the surface epithelium. If the fetus is XY, the sex cords continue to proliferate through the eighth week, extending deeply into the connective tissue. These cords fuse, forming a network of internal (medullary) sex cords and, at its most distal end, the thinner **rete testis** (Figure 17.3C,D). Eventually, the sex cords now called **testis cords** lose contact with the surface epithelium and become separated from it by a thick extracellular matrix, the **tunica albuginea**. Thus, the germ cells are found in the cords within the testes. During fetal life and childhood, the testis cords remain solid. At puberty, however, the cords will hollow out to form the **seminiferous tubules**, and the germ cells will begin to differentiate into sperm.


INDIFFERENT GONADS
Wolffian duct
Glomerulus
Aorta
Mesonephric ridge
Excretory mesonephric tubule
Genital ridge
Dorsal mesentery
(A) 4 WEEKS
Wolffian duct
Müllerian duct
Proliferating coelomic epithelium
Primitive sex cords
(B) 6 WEEKS
TESTIS DEVELOPMENT
Degenerating mesonephric tubule
Wolffian duct (vas deferens)
Rete testis cords
Testis cords
Tunica albuginea
Müllerian duct
(C) 8 WEEKS
OVARIAN DEVELOPMENT
Degenerating mesonephric tubule
Urogenital mesenchyme
Wolffian duct
Cortical sex cords
Müllerian duct
Surface epithelium
(E) 8 WEEKS
Efferent ducts (vas deferens)
Rete testis cords
Tunica albuginea
Testis cords
Müllerian duct
Wolffian duct (vas deferens)
(D) 16 WEEKS
Degenerating sex cords
Surface epithelium
Oogonia
Wolffian duct
Ovarian follicles
Müllerian duct
(F) 20 WEEKS



GONADS		
Gonadal type	Testis	Ovary
Sex cords	Medullary (internal)	Cortical (external)
DUCTS		
Remaining duct for germ cells	Wolffian	Müllerian
Duct differentiation	Vas deferens, epididymis, seminal vessicle	Oviduct, uterus, cervix, upper portion of vagina

In most animals, differences of exposure of a fetal or infant brain to sex hormones produce significant differences of brain structure and function which correlate with adult reproductive behavior.This is the case in humans as well; sex hormone levels in male and female fetuses and infants differ, and both androgen receptors and estrogen receptors have been identified in brains. Several sex-specific genes not dependent on sex steroids are expressed differently in male and female human brains. Structural sex differences begin to be recognizable by 2 years of age, and in adult men and women include size and shape of corpus callosum (larger in women) and fasciculae connecting each hemisphere internally (larger in men), certain hypothalamic nuclei, and the gonadotropin feedback response to estradiol.

The absence of the genes that generate male genitalia do not single handedly lead to a female brain. The male brain does, in fact, require more hormones, such as testosterone, in order to properly differentiate. These hormones are released due to a gene expressed during embryonic development.

Answer No .8

Fertilization is a complex process which involves the fusion of male and female gametes followed by the fusion of their cytoplasm. The process of fertilization has dual independent functions

(i) to cause the egg to start developing ….. ACTIVATION

(ii) to inject a male haploid nucleus into the egg cytoplasm…… AMPHIMIXIS or

(intermingling of paternal and maternal heriditary characters in the cytoplasm)

Mechanism of fertilization: It constituted five stages

1. Encounter of spermatozoa and ova

a) External fertilization

(In liquid medium outside the body e g Fishes, amphibians, fresh water invertebrates)

b) Internal Fertilization (In oviparous forms like reptiles, birds where the eggs are completely inside impermeable membrane, in ovoviviparous and in viviparous

2. **Capacitaion and contact** : the capacity of spermatozoa to fertilize eggs of the same species but not the other. Fran Lillie was first to show that this happens under the influence of chaemotaxix where sperm responding to the specific jelly like chemical substance which surround the egg. This procee consists

a) Agglitination: The adhesion of spermatozoa or clumping.

b) Fetilizin-antifertilizin reaction: to block polyspermy

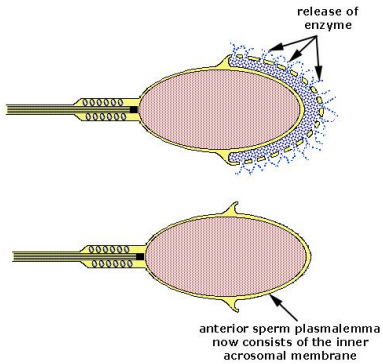
Fertilizin – is mucoplysaccharide or glycoprotein present in egg

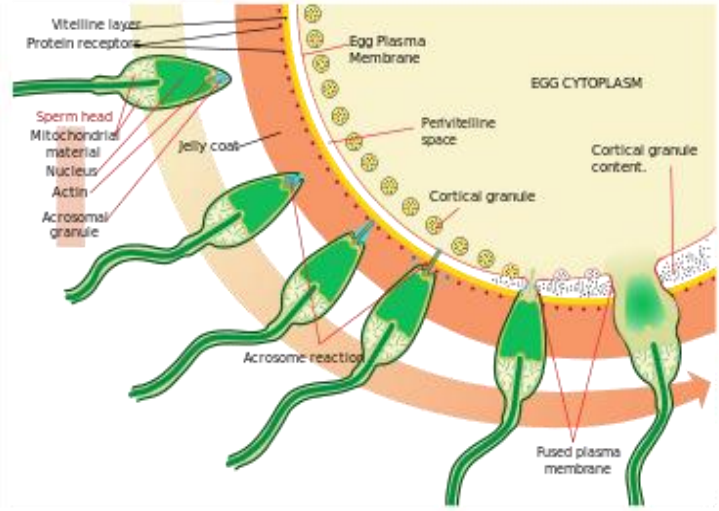
Anti-fertilizin in sperms

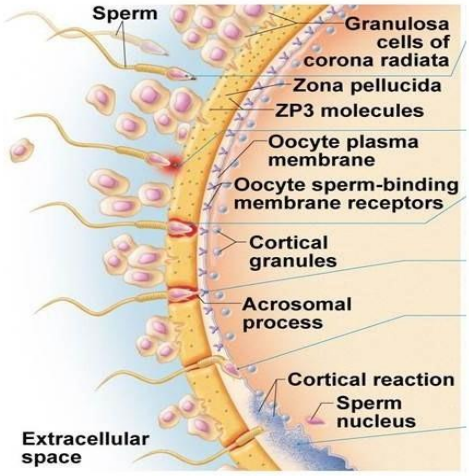
3) Acrosome reaction and penetration

When the acrosome reaction occurs, a number of proteolytic enzymes are exposed or released.

One or more of these enzymes is responsible for digesting the hole through the zona pellucida through which the sperm enters the perivitelline space.


release of enzyme
anterior sperm plasmalemma now consists of the inner acrosomal membrane


Vitelline layer
Protein receptors
Egg Plasma Membrane
EGG CYTOPLASM
Sperm head
Mitochondrial material
Nucleus
Actin
Acrosomal granule
Jelly coat
Perivitelline space
Cortical granule content.
Cortical granule
Acrosome reaction
Fused plasma membrane


Sperm
Granulosa cells of corona radiata
Zona pellucida
ZP3 molecules
Oocyte plasma membrane
Oocyte sperm-binding membrane receptors
Cortical granules
Acrosomal process
Cortical reaction
Sperm nucleus
Extracellular space

When sperm arrives at zona pellucida with the acrosome still intact. This time the sperm has **hyaluronidase** activity. **Events when the sperm gets to the zona pellucida?**

1. Attachment - loose association

2. Binding - strong attachment

3. Acrosome reaction - release of enzymes

4. Penetration of the zona pellucida by the sperm

Zona pellucida is composed of 3 glycoproteins ZP1, ZP2, ZP3

Repeating subunits of ZP2 and ZP3 form filaments that are bound together by ZP1

4) **Activation of Ovum**. Constitutes seven events

1.**Release of Ca++** (calcium) stored in the egg endoplasmic reticulum a critical step in the process.

2.**Cortical reaction** - rupture of cortical granules that occurs concurrently with the Ca++ release. Contents of granules are released into perivitelline space and cause "hardening" of the vitelline membrane or zona pellucida. Causes vitelline/fertilization membrane to rise away from surface of egg in some species.

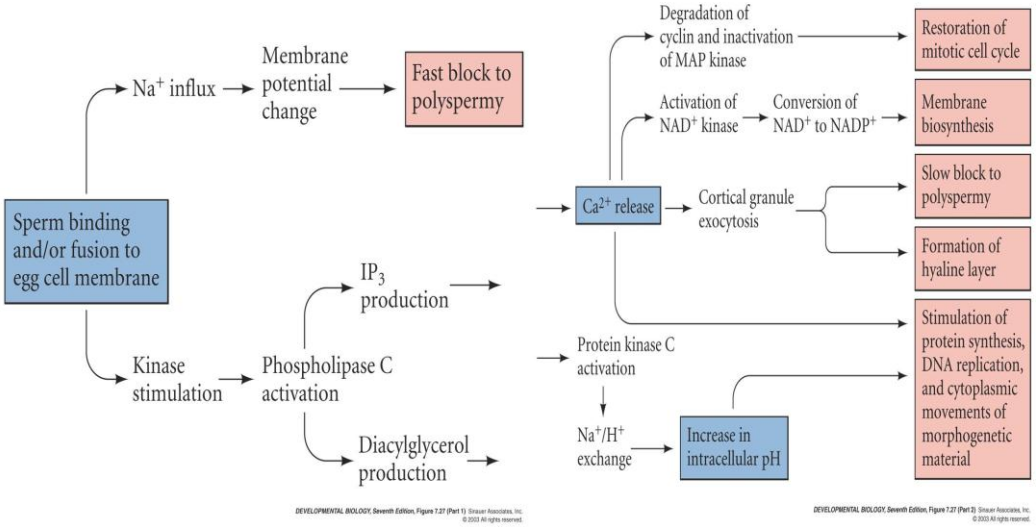
3. A**n influx of Na^+ (sodium) into the egg cytoplasm** causes a change in membrane potential - block to polyspermy.

4. In some species a **reorganization of the egg cytoplasm**.

5. In most cases, **completion of meiosis by the egg**.

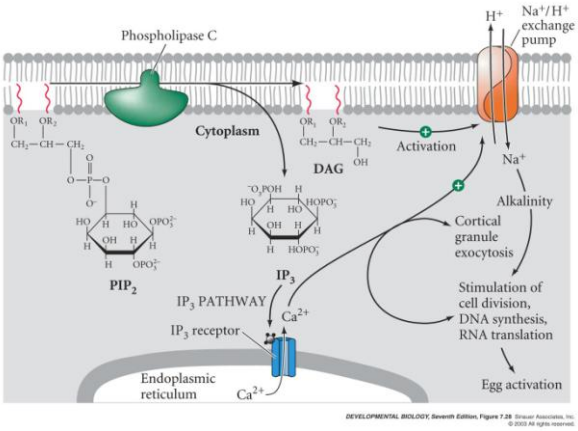
6. An **efflux of H^+ (hydrogen) ions** causing an increase in cytoplasmic pH - this activates previously inhibited synthetic pathways.

7. **Increase in metabolism** - zygote gears up for development



A. B.

Cascade for Egg activation



Signaling Pathway during Egg activation resulting Intracellular Release of Ca^{++}

5) Migration of pronuclei and amphimixis

Events that occur soon <u>after</u> egg activation:

a.DNA replication as male and female pronuclei approach each other

b.Male and female pronuclei merge

c.Preparation for first cleavage

The male nucleus enters the egg cytoplasm and becomes the male pronucleus.

2.As a result of the sperm fusing with the egg plasmalemma, the oocyte nucleus, which is at metaphase of the second meiotic division, completes that division giving rise to another polar body.

3. Following the second meiotic division, what is now the nucleus of the ovum becomes the female pronucleus.

4.The haploid male and female pronuclei move toward one and other, meet, and fuse to form the diploid nucleus of the zygote.

Q. No. 9). Give a detail account on the brain and sexual differentiation in mammals.

Sexual differentiation is the process of development of the differences between males and females from an undifferentiated zygote(fertilized egg). As male and female individuals develop from zygotes into fetuses, into infants, children, adolescents, and eventually into adults, sex and gender differences at many levels develop: genes, chromosomes, gonads, hormones, anatomy, psyche, and social behaviors.

- Sex differences range from nearly absolute to simply statistical. Sex-dichotomous differences are developments which are wholly characteristic of one sex only. Examples of sex-dichotomous differences include aspects of the sex-specific genital organs such as ovaries, a uterus or a phallic urethra. In contrast, sex-dimorphic differences are matters of degree (e.g., size of phallus). Some of these (e.g., stature, behaviors) are mainly statistical, with much overlap between male and female populations.
- Sex differences may be induced by specific genes, by hormones, by anatomy, or by social learning. Some of the differences are entirely physical (e.g., presence of a uterus) and some differences are just as obviously purely a matter of social learning and custom (e.g., relative hair length).
- The early stages of human differentiation appear to be quite similar to the same biological processes in other mammals and the interaction of genes, hormones and body structures is fairly well understood. In the first weeks of life, a fetus has no anatomic or hormonal sex, and only akaryotype distinguishes male from female. Specific genes induce gonadal differences, which produce hormonal differences, which cause anatomic differences, leading to psychological and behavioral differences, some of which are innate and some induced by the social environment.
- The various ways that genes, hormones, and upbringing affect different human behaviors and mental traits are difficult to test experimentally and charged with political conflict.

Chromosomal sex differences

- Humans have forty-six chromosomes, including two sex chromosomes, XX in females and XY in males. It is obvious that the Y chromosomemust carry at least one essential gene which determines testicular formation (originally termed *TDF*).
- A gene in the sex-determining region of the short arm of the Y, now referred to as *SRY*, has been found to direct production of a protein which binds to DNA, inducing differentiation of cells derived from the genital ridges into testes. In transgenic XX mice (and some human XX males), *SRY* alone is sufficient to induce male differentiation.

- Investigation of other cases of human sex reversal (XX males, XY females) has led to discovery of other genes crucial to testicular differentiation on autosomes (e.g., *WT-1*, *SOX9*, *SF-1*), and the short arm of X (*DSS*).

Human prenatal sexual differentiation

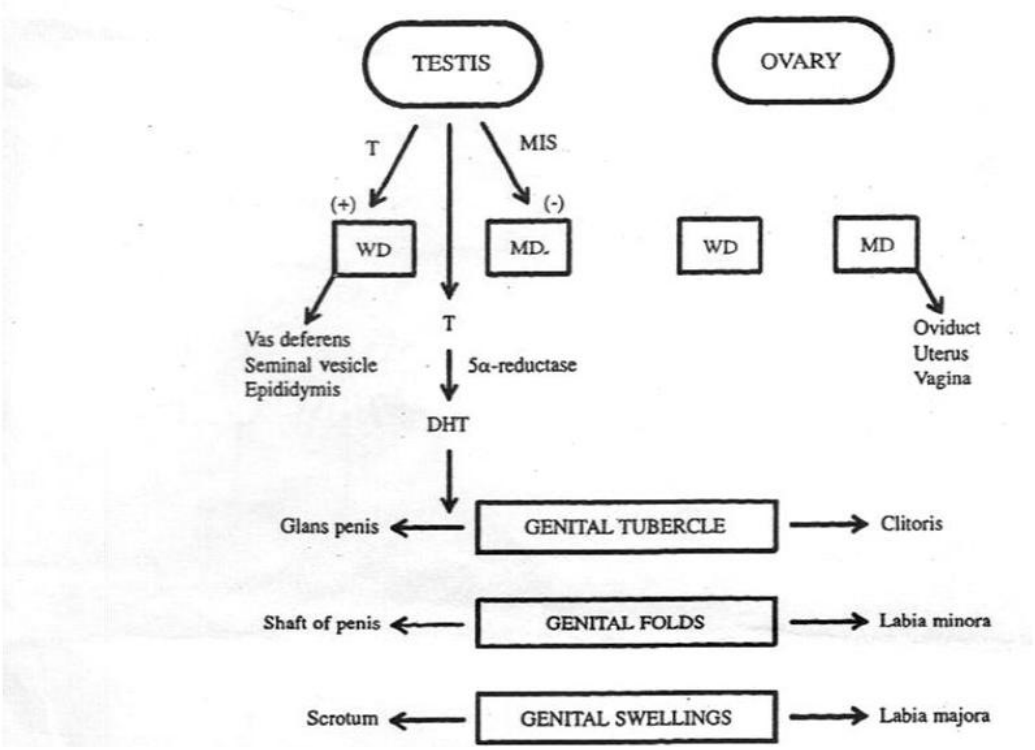
Fetal age (weeks)	Crown-rump length (mm)	Sex differentiating events
0	blastocyst	Inactivation of one X chromosome
4	2-3	Development of wolffian ducts
5	7	Migration of primordial germ cells in the undifferentiated gonad
6	10-15	Development of müllerian ducts
7	13-20	Differentiation of seminiferous tubules
8	30	Regression of müllerian ducts in male fetus
8	32-35	Appearance of Leydig cells. First synthesis of testosterone
9	43	Total regression of müllerian ducts. Loss of sensitivity of müllerian ducts in the female fetus
9	43	First meiotic prophase in oogonia
10	43-45	Beginning of masculinization of external genitalia
10	50	Beginning of regression of wolffian ducts in the female fetus
12	70	Fetal testis is in the internal inguinal ring
12-14	70-90	Male penile urethra is completed
14	90	Appearance of first spermatogonia
16	100	Appearance of first ovarian follicles
17	120	Numerous Leydig cells. Peak of testosterone secretion
20	150	Regression of Leydig cells. Diminished testosterone secretion
24	200	First multilayered ovarian follicles. Canalisation of the vagina
28	230	Cessation of oogonia multiplication
28	230	Descent of testis

Gonadal differentiation

Early in fetal life, germ cells migrate from structures known as yolk sacs to the genital ridge. By week 6, undifferentiated gonads consist ofgerm cells, supporting cells, and steroidogenic cells.

In a male, *SRY* and other genes induce differentiation of supporting cells into Sertoli cells and (indirectly) steroidogenic cells into Leydig cellsto form testes, which become microscopically identifiable and begin to produce hormones by week 8. Germ cells become spermatogonia.

Without *SRY*, ovaries form during months 2-6. Failure of ovarian development in 45,X girls (Turner syndrome) implies that two functional copies of several Xp and Xq genes are needed. Germ cells become ovarian follicles. Supporting and steroidogenic cells become theca cells and granulosa cells, respectively.



Genital differentiation

Hormonal differentiation: In a male fetus, testes produce steroid and protein hormones essential for internal and external anatomic differentiation. Leydig cells begin to make testosterone by the end of month 2 of gestation. From then on, male fetuses have higher levels of androgens in their systemic blood than females. The difference is even greater in pelvic and genital tissues. **Antimullerian hormone (AMH) is a protein hormone produced bySertoli cells from the 8th week** on. AMH suppresses development of müllerian ducts in males, preventing development of a uterus.

Fetal ovaries produce estradiol, which supports follicular maturation but plays little part in other aspects of prenatal sexual differentiation, as maternal estrogen floods fetuses of both sexes.

A differentiation of the sex organ can be seen. However, this is only the external genital differentiation. There is also an internal genital differentiation.

Internal genital differentiation

Gonads are histologically distinguishable by 6–8 weeks of gestation. A fetus of that age has both mesonephric (wolffian) and paramesonephric (mullerian) ducts.

Subsequent development of one set and degeneration of the other depends on the presence or absence of two testicular hormones: testosterone and AMH.

Disruption of typical development may result in the development of both, or neither, duct system, which may produce morphologically intersexual individuals.

Local testosterone causes each wolffian duct to develop into epididymis, vas deferens, and seminal vesicles. Without male testosterone levels, wolffian ducts degenerate and disappear.

Müllerian ducts develop into a uterus, fallopian tubes, and upper vagina unless AMH induces degeneration. The presence of a uterus is stronger evidence of absence of testes than the state of the external genitalia.

External genital differentiation

By 7 weeks, a fetus has a genital tubercle, urogenital groove and sinus, and labioscrotal folds. In females, without excess androgens, these become the clitoris, urethra and vagina, and labia.
Males become externally distinct between 8 and 12 weeks, as androgens enlarge the phallus and cause the urogenital groove and sinus to fuse in the midline, producing an unambiguous penis with a phallic urethra, and a thinned, rugated scrotum.
A sufficient amount of any androgen can cause external masculinization. The most potent is dihydrotestosterone (DHT), generated from testosterone in skin and genital tissue by the action of 5α-reductase. A male fetus may be incompletely masculinized if this enzyme isdeficient. In some diseases and circumstances, other androgens may be present in high enough concentrations to cause partial or (rarely) complete masculinization of the external genitalia of a genetically female fetus.
Further sex differentiation of the external genitalia occurs at puberty, when androgen levels again become disparate. Male levels of testosterone directly induce growth of the penis, and indirectly (via DHT) the prostate.

Breast differentiation

Visible differentiation occurs at puberty, when estradiol and other hormones cause breasts to develop in girls. However, fetal or neonatal androgens may modulate later breast development by reducing the capacity of breast tissue to respond to later estrogen.

Hair differentiation

The amount and distribution of body hair differs between the sexes. Males have more terminal hair, especially on the face, chest, abdomenand back, and females have more vellus hair, which is less visible. This may also be linked to neoteny in humans, as vellus hair is a juvenilecharacteristic.

Other body differentiation

The differentiation of other parts of the body than the sex organ creates the secondary sex characteristics.
General habitus and shape of body and face, as well as sex hormone levels, are similar in prepubertal boys and girls. As puberty progresses and sex hormone levels rise, obvious differences appear.
In males, testosterone directly increases size and mass of muscles, vocal cords, and bones, enhancing strength, deepening the voice, and changing the shape of the face and skeleton. Converted into DHT in the skin, it accelerates growth of androgen-responsive facial and body hair. Taller stature is largely a result of later puberty and slower epiphyseal fusion.
In females, in addition to breast differentiation, estrogen also widens the pelvis and increases the amount of body fat in hips, thighs, buttocks, and breasts. Estrogen also induces growth of the uterus, proliferation of the endometrium, and menses.
The difference in adult masculine and feminine faces is largely a result of a more prominent chin, heavier jaw and jaw muscle development and thicker orbital eyebrow bossing. Masculine features on average are slightly thicker and coarser. Androgen-induced recession of the male hairline accentuates these differences by middle adult life.
Sexual dimorphism of skeletal structure develops during childhood, and becomes more pronounced at adolescence. Sexual orientation has been demonstrated to correlate with skeletal characters that become dimorphic during early childhood (such as arm length to stature ratio) but not with characters that become dimorphic during puberty (such as shoulder width) (Martin & Nguyen, 2004).

Brain differentiation

In most animals, differences of exposure of a fetal or infant brain to sex hormones produce significant differences of brain structure and function which correlate with adult reproductive behavior. This seems to be the case in humans as well; sex hormone levels in male and female fetuses and infants differ, and both androgen receptors and estrogen receptors have been identified in brains. Several sex-specific genes not dependent on sex steroids are expressed differently in male and female human brains. Structural sex

differences begin to be recognizable by 2 years of age, and in adult men and women include size and shape of corpus callosum and certain hypothalamic nuclei, and the gonadotropin feedback response to estradiol.[*citation needed*]

Psychological and behavioral differentiation

Human adults and children show many psychological and behavioral sex differences, both dichotomous and dimorphic. Some (e.g., dress) are learned and obviously cultural. Others are demonstrable across cultures and may have both biological and learned determinants. For example, girls are, on average, more verbally fluent than boys, but males, on average, are better at spatial calculation. Because we cannot explore hormonal influences on human behavior experimentally, and because potential political implications are so unwelcome to many factions of society, the relative contributions of biological factors and learning to human psychological and behavioral sex differences (especially gender identity, role, and orientation) remain unsettled and controversial.

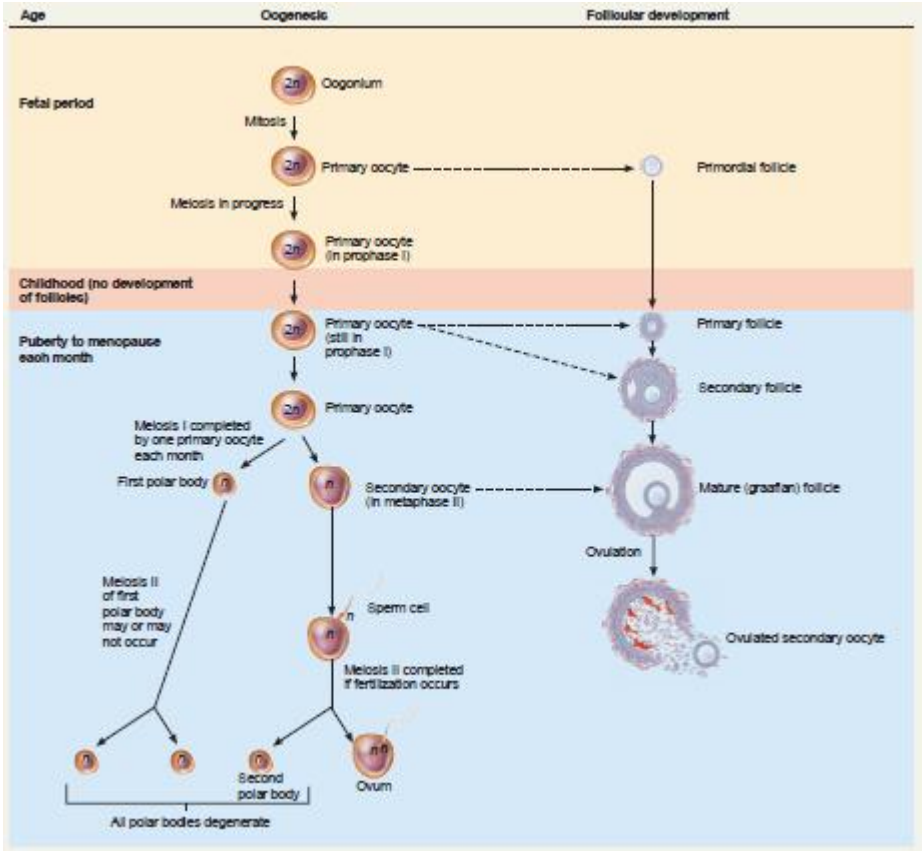
Current theories of mechanisms of sexual differentiation of brain and behaviors in humans are based primarily on three sources of evidence: animal research involving manipulation of hormones in early life, observation of outcomes of small numbers of individuals with disorders of sexual development (intersex conditions or cases of early sex reassignment), and statistical distribution of traits in populations (e.g., rates of homosexuality in twins). Many of these cases suggest some genetic or hormonal effect on sex differentiation of behavior and mental traits[1]; others do not[*citation needed*].

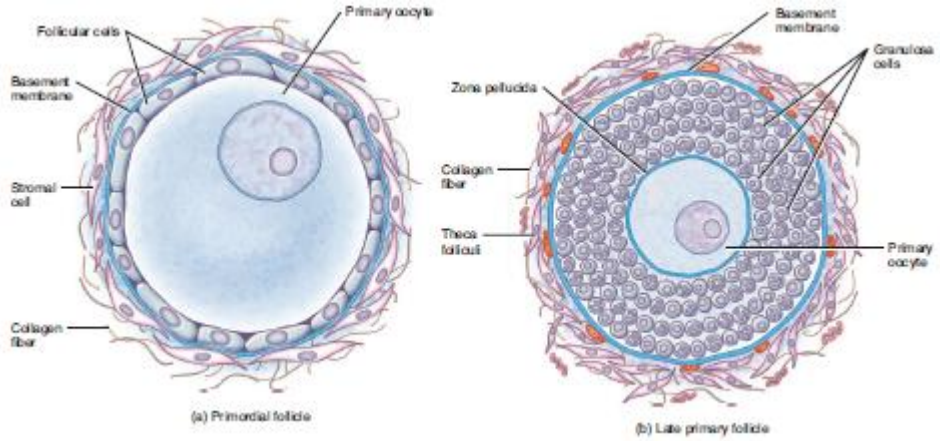
In addition to affecting development, changing hormone levels affect certain behaviors or traits that are gender dimorphic, such as superior verbal fluency among women.[2].

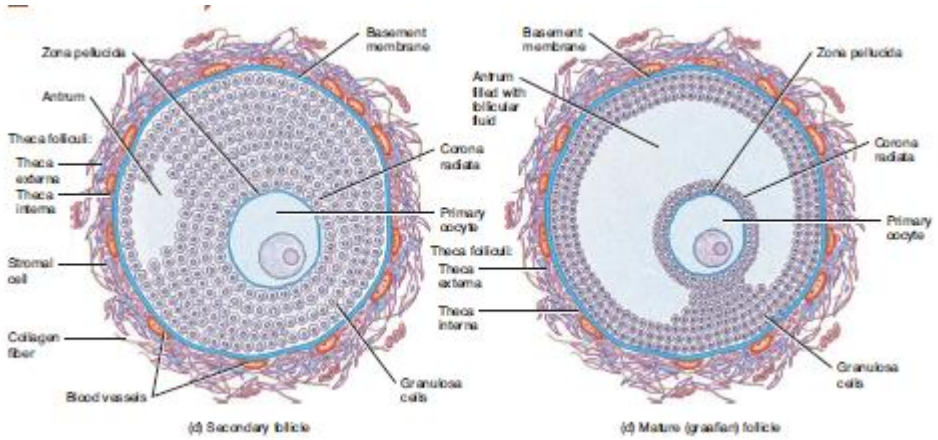
In most mammalian species females are more oriented toward child rearing and males toward competition with other males.

8). Differentiate between (any two)

a. **Primary follicle and Graafian follicle**


Age
Oogenesis
Follicular development
Fetal period
2n
Oogonium
Mitosis
2n
Primary oocyte
Primordial follicle
Meiosis in progress
2n
Primary oocyte
(in prophase I)
Childhood (no development of follicles)
Puberty to menopause each month
2n
Primary oocyte
(still in prophase I)
Primary follicle
Secondary follicle
2n
Primary oocyte
Meiosis I completed by one primary oocyte each month
First polar body
n
n
Secondary oocyte
(in metaphase II)
Mature (graafian) follicle
Ovulation
Meiosis II of first polar body may or may not occur
n
Sperm cell
n
Ovulated secondary oocyte
Meiosis II completed if fertilization occurs
n
n
n
nn
Second polar body
Ovum
All polar bodies degenerate


Follicular cells
Primary oocyte
Basement membrane
Stromal cell
Collagen fiber
(a) Primordial follicle
Basement membrane
Granulosa cells
Zona pellucida
Collagen fiber
Theca folliculi
Primary oocyte
(b) Late primary follicle

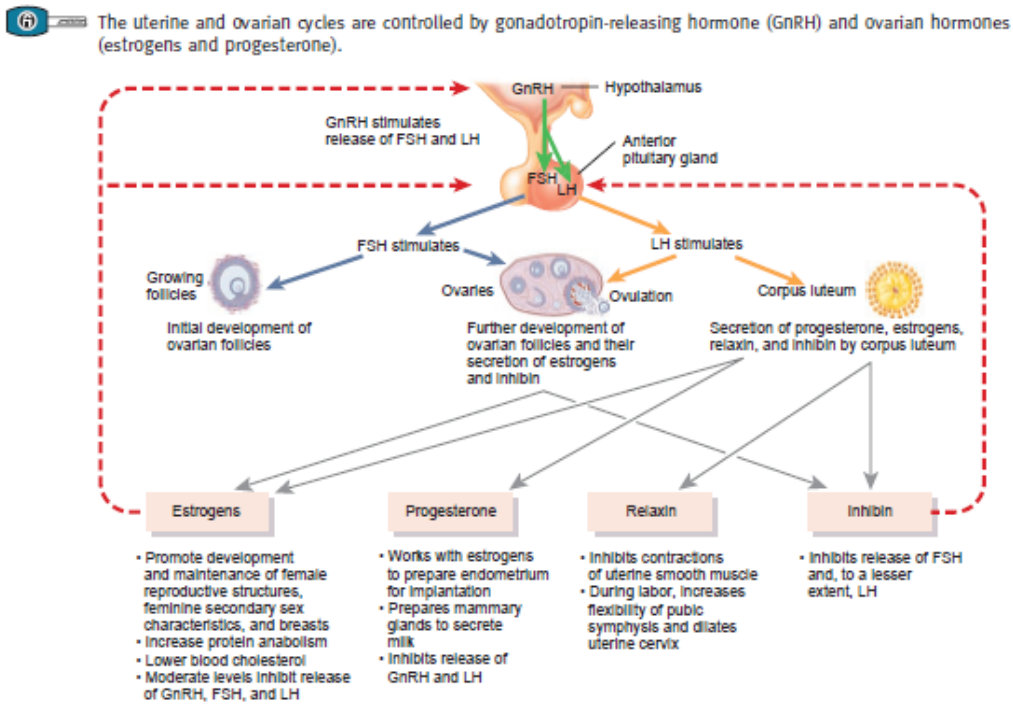


b. Ovarian Cycle and menstrual cycle

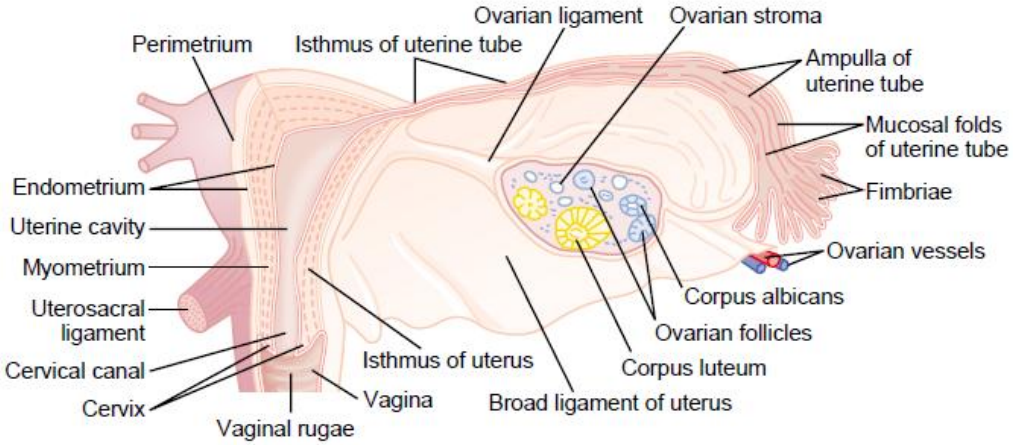
The ovarian cycle ia a series of events that occur during and after the maturation of an oocyte.

The uterine (menstrual) is a concurrent series of changes in the endometrium of the uterus to prepare it for the arrival of a fertilized ovum that will develop there until birth. If fertilization does not occur, ovarian hormone wane (decrease), which causes the stratum functionalis of the endomedtirum to slough off.

The general term female reproductive cycle encompasses the ovarian and uterine cycle. The hormonal changes that regulate them and the related cyclical changes in the breasts of the cervix



c. Corpus luteum and corpus albicans



During the first few hours after expulsion of the ovum from the follicle, the remaining granulosa and theca interna cells change rapidly into *lutein cells*. They enlarge in diameter two or more times and become filled with lipid inclusions that give them a yellowish appearance. This process is called *luteinization,* and the total mass of cells together is called the *corpus luteum,*

In the normal female, the corpus luteum grows to about 1.5 centimeters in diameter, reaching this stage of development 7 to 8 days after ovulation. Then it begins to involute and eventually loses its secretory function as well as its yellowish, lipid characteristic about 12 days after ovulation, becoming the *corpus albicans;* during the ensuing few weeks, this is replaced by connective tissue and over months is absorbed.

d. Follicular rupture and follicular atresia

During early fetal development, primordial (primitive) germ cells migrate from the yolk sac to the ovaries. There, germ cells differentiate within the ovaries into **oogonia.** The ovum surrounded by a single layer of granulosa cells is called a *primordial follicle.* The ovum itself at this stage is still immature,

requiring two more cell divisions before it can be fertilized by a sperm. At this time, the ovum is called a *primary oocyte.*

During all the reproductive years of adult life, between about 13 and 46 years of age, 400 to 500 of the primordial follicles develop enough to expel their ova—one each month; the remainder degenerate (become *atretic*).Throughout a woman's reproductive life, about 400 of the primordial follicles grow into mature follicles and ovulate, and hundreds of thousands of ova degenerate. After a week or more of growth— but before ovulation occurs—one of the follicles begins to outgrow all the others; the remaining 5 to 11 developing follicles in volute (a process called ***atresia***), and these follicles are said to become *atretic.* The cause of the atresia is unknown, but it has been postulated to be the following: The large amounts of estrogen from the most rapidly growing follicle act on the hypothalamus to depress further enhancement of FSH secretion by the anterior pituitary gland, in this way blocking further growth of the less well developed follicles. Therefore, the largest follicle continues to grow because of its intrinsic positive feedback effects, while all the other follicles stop growing and actually involute. This process of atresia is important, because it normally allows only one of the follicles to grow large enough each month to ovulate; this usually prevents more than one child from developing with each pregnancy. The single follicle reaches a diameter of 1 to 1.5 centimeters at the time of ovulation and is called the *mature follicle(Graafian follicle).*

While in this follicle, and just before ovulation, the diploid primary oocyte completes meiosis I, producing two haploid (*n*) cells of unequal size—each with 23 chromosomes. The smaller cell produced by meiosis I, called the **first polar body,** is essentially a packet of discarded nuclear material. The larger cell, known as the **secondary oocyte,** receives most of the cytoplasm. Once a secondary oocyte is formed, it begins meiosis II but then stops in metaphase. The **mature (graafian) follicle soon ruptures a**nd releases its secondary oocyte, a process known as **ovulation.**