Chapter 2: Human Reproduction

Exercises — Chapter-end Exercises

Q1 Fill in the blanks:
(a) Humans reproduce _____ (asexually/sexually)
(b) Humans are _____ (oviparous, viviparous, ovoviviparous)
(c) Fertilisation is _____ in humans (external/internal)
(d) Male and female gametes are _____ (diploid/haploid)
(e) Zygote is _____ (diploid/haploid)
(f) The process of release of ovum from a mature follicle is called _____
(g) Ovulation is induced by a hormone called _____
(h) The fusion of male and female gametes is called _____
(i) Fertilisation takes place in _____
(j) Zygote divides to form _____ which is implanted in uterus.
(k) The structure which provides vascular connection between foetus and uterus is called _____

SOLUTION

(a) sexually — humans are sexually reproducing organisms; two parents contribute gametes.
(b) viviparous — the embryo develops inside the mother's body and the young one is born directly (not from an egg).
(c) internal — sperms are deposited inside the female reproductive tract and fertilisation occurs inside the body.
(d) haploid — gametes (sperms and ova) are produced by meiosis and contain the haploid (n = 23) chromosome number.
(e) diploid — after fusion of the two haploid gametes, the zygote restores the diploid (2n = 46) number.
(f) ovulation — the Graafian follicle ruptures and releases the secondary oocyte (ovum) during ovulation.
(g) LH (Luteinising Hormone) — the LH surge at mid-cycle (around day 14) induces rupture of the Graafian follicle and ovulation.
(h) fertilisation — the process of fusion of the sperm nucleus with the ovum nucleus to form a diploid zygote.
(i) the ampullary region of the fallopian tube (oviduct) — sperms travel through the cervix and uterus to reach the ampulla where the ovum is also transported.
(j) blastocyst — the zygote undergoes repeated mitotic divisions (cleavage) to form a morula, then a blastocyst, which implants in the endometrium.
(k) placenta — the placenta is formed from chorionic villi (trophoblast) and uterine tissue; it provides the vascular connection for exchange of nutrients, gases, and waste between the foetus and the mother.

Answer: (a) sexually (b) viviparous (c) internal (d) haploid (e) diploid (f) ovulation (g) LH (Luteinising Hormone) (h) fertilisation (i) ampullary region of the fallopian tube (j) blastocyst (k)

placenta

Q2 Draw a labelled diagram of male reproductive system.

SOLUTION

The male reproductive system (diagrammatic sectional view of the male pelvis) should show the following structures, properly labelled:

External structures:
• Scrotum — the pouch of skin housing the testes outside the abdominal cavity
• Penis — the male external genitalia; composed of erectile tissue; the enlarged end is the glans penis covered by foreskin (prepuce)
• Urethral meatus — the external opening of the urethra at the tip of the penis

Testes and testicular structures:
• Testis (pair) — oval organs, ~4–5 cm long, contained within the scrotum
• Testicular lobules (~250 per testis) — compartments each containing 1–3 seminiferous tubules
• Seminiferous tubules — highly coiled; lined by spermatogonia and Sertoli cells; site of sperm production
• Rete testis — network of channels at the back of the testis into which seminiferous tubules open
• Vasa efferentia — ducts that carry sperm from rete testis to epididymis
• Epididymis — coiled duct along the posterior surface of the testis; site of sperm maturation and storage

Accessory ducts:
• Vas deferens (ductus deferens) — ascends from the epididymis, loops over the urinary bladder
• Ejaculatory duct — formed by the union of vas deferens and the duct of the seminal vesicle; opens into the urethra
• Urethra — originates from the urinary bladder; runs through the penis to the urethral meatus; carries both urine and semen (at different times)

Accessory glands:
• Seminal vesicles (paired) — open into the ejaculatory duct; secrete fructose-rich fluid
• Prostate gland — surrounds the urethra below the bladder; secretes enzymes and calcium-rich fluid
• Bulbourethral glands (Cowper's glands, paired) — open into the urethra below the prostate; secrete lubricating fluid

Other structures to label in the view:
• Urinary bladder
• Ureter
• Rectum (shown in context)

Answer: Diagram labels: scrotum, testis, epididymis, vas deferens, seminal vesicle, ejaculatory duct, prostate, bulbourethral gland, urethra, penis, urethral meatus, urinary bladder.

Q3 Draw a labelled diagram of female reproductive system.

SOLUTION

The female reproductive system (diagrammatic sectional view) should show the following structures, properly labelled:

Ovaries:
• Ovary (pair) — primary female sex organs; ~2–4 cm in length; located one on each side of the lower abdomen; attached to pelvic wall and uterus by ligaments; covered by thin epithelium enclosing the ovarian stroma (cortex + medulla)

Oviducts (Fallopian tubes):
• Infundibulum — funnel-shaped; closest to the ovary; edges bear finger-like fimbriae that collect the ovum after ovulation
• Ampulla — wider middle part; site of fertilisation
• Isthmus — narrow part; joins the uterus

Uterus:
• Body of uterus (womb) — single; inverted pear-shaped; supported by ligaments
• Uterine fundus — uppermost rounded part
• Uterine cavity — inner space
• Cervix — narrow lower part of the uterus opening into the vagina
• Cervical canal — cavity of the cervix
• Layers: perimetrium (outer thin membrane), myometrium (middle thick smooth muscle), endometrium (inner glandular lining)

Vagina:
• Vagina — birth canal; receives sperms during coitus; together with cervical canal forms the birth canal

External genitalia (vulva):
• Mons pubis — fatty tissue covered by skin and pubic hair
• Labia majora — outer fleshy folds
• Labia minora — inner paired folds
• Clitoris — small finger-like structure at the upper junction of labia minora
• Hymen — membrane partially covering the vaginal opening

Other structures to label:
• Urinary bladder
• Urethra
• Rectum (shown in context)
• Fimbriae

Answer: Diagram labels: ovary, infundibulum, fimbriae, ampulla, isthmus, uterus (fundus/body/cervix), endometrium, myometrium, perimetrium, cervical canal, vagina, labia majora, labia minora, clitoris, hymen, mons pubis.

Q4 Write two major functions each of testis and ovary.

SOLUTION

Functions of Testis:

1. Spermatogenesis — the testis produces male gametes (sperms) in the seminiferous tubules by the process of spermatogenesis. The spermatogonia undergo meiotic divisions leading to the formation of spermatozoa.
2. Androgen secretion — the interstitial cells (Leydig cells) present in the spaces outside the seminiferous tubules synthesise and secrete male sex hormones called androgens (e.g., testosterone). Androgens regulate spermatogenesis and the development of male secondary sexual characteristics.

Functions of Ovary:

1. Oogenesis — the ovary produces female gametes (ova) by the process of oogenesis. Primary oocytes develop through follicular stages and ultimately a mature secondary oocyte (ovum) is released at ovulation.
2. Ovarian hormone secretion — the ovary secretes steroid hormones (ovarian hormones): estrogens (secreted by developing follicles) and progesterone (secreted by the corpus luteum). Estrogens regulate the follicular phase and female secondary sexual characteristics; progesterone maintains the endometrium for implantation and supports pregnancy.

Answer: Testis: (1) produces sperms (spermatogenesis); (2) secretes androgens (Leydig cells). Ovary: (1) produces ova (oogenesis); (2) secretes estrogens and progesterone.

Q5 Describe the structure of a seminiferous tubule.

SOLUTION

A seminiferous tubule is the functional unit of the testis where sperm production takes place.

Location and arrangement:

Each testis has about 250 compartments called testicular lobules. Each lobule contains one to three highly coiled seminiferous tubules. The tubules are embedded in connective tissue that contains blood vessels and interstitial (Leydig) cells.

Wall of the seminiferous tubule (from inside outward):

• The inner surface (lumen side) is lined by two types of cells:

— Male germ cells (spermatogonia): these are diploid cells (46 chromosomes) located on the basement membrane. They multiply by mitotic division and some periodically undergo meiosis (spermatogenesis) to eventually produce haploid spermatids, which differentiate into spermatozoa.

— Sertoli cells: large supporting cells that provide nutrition and structural support to the

developing germ cells. They also secrete factors essential for spermiogenesis (stimulated by FSH) and form the blood-testis barrier.

Interstitial spaces (outside the tubule):
• Leydig cells (interstitial cells) are present in the connective tissue between seminiferous tubules. They synthesise and secrete testicular hormones called androgens (e.g., testosterone) under stimulation by LH.
• Small blood vessels and immunologically competent cells are also present in these spaces.

The seminiferous tubules open into the rete testis, from which vasa efferentia carry the sperms to the epididymis.

Answer: Seminiferous tubules are highly coiled, lined inside by spermatogonia (which undergo spermatogenesis) and Sertoli cells (which provide nutrition). The outer interstitial spaces contain Leydig cells (secrete androgens) and blood vessels.

Q6 What is spermatogenesis? Briefly describe the process of spermatogenesis.

SOLUTION

Definition:
Spermatogenesis is the process of formation of mature male gametes (spermatozoa/sperms) from the undifferentiated male germ cells (spermatogonia) in the seminiferous tubules of the testis. It begins at puberty.

Process of Spermatogenesis:

Step 1 — Multiplication phase:
Spermatogonia (diploid, 2n = 46) are present on the inner wall of seminiferous tubules. They multiply by mitotic divisions, increasing in number.

Step 2 — Growth phase:
Some spermatogonia, called primary spermatocytes, grow in size and prepare for meiosis.

Step 3 — First meiotic division (Meiosis I):
Each primary spermatocyte (diploid, 2n = 46) undergoes the first meiotic division (reduction division), producing two equal haploid secondary spermatocytes (n = 23 chromosomes each).

Step 4 — Second meiotic division (Meiosis II):
Each secondary spermatocyte undergoes the second meiotic division, producing two equal haploid spermatids. Thus, one primary spermatocyte gives rise to four haploid spermatids (n = 23).

Step 5 — Spermiogenesis:
The spermatids are transformed into mature spermatozoa (sperms) by a process of differentiation called spermiogenesis. During this, the spermatid develops a head (with an acrosome and haploid nucleus), a neck, a middle piece (with mitochondria), and a tail (flagellum).

Step 6 — Spermiation:

The mature sperm heads become embedded in the Sertoli cells and are finally released from the seminiferous tubules by the process called spermiation.

Hormonal regulation:
Spermatogenesis is initiated at puberty by increased secretion of GnRH (from the hypothalamus), which stimulates the anterior pituitary to release LH and FSH. LH stimulates Leydig cells to secrete androgens (which drive spermatogenesis), and FSH acts on Sertoli cells to stimulate secretion of factors essential for spermiogenesis.

Answer: Spermatogenesis is sperm formation in seminiferous tubules: spermatogonia (2n) → primary spermatocyte (2n) →[Meiosis I]→ two secondary spermatocytes (n) →[Meiosis II]→ four spermatids (n) →[spermiogenesis]→ four spermatozoa.

Q7 Name the hormones involved in regulation of spermatogenesis.

SOLUTION

The following hormones regulate spermatogenesis:

1. GnRH (Gonadotropin Releasing Hormone) — secreted by the hypothalamus at puberty. It acts on the anterior pituitary to stimulate release of LH and FSH.

2. LH (Luteinising Hormone) — secreted by the anterior pituitary. It acts on the Leydig cells (interstitial cells) of the testis, stimulating them to synthesise and secrete androgens.

3. Androgens (primarily Testosterone) — secreted by the Leydig cells. They stimulate the process of spermatogenesis within the seminiferous tubules.

4. FSH (Follicle Stimulating Hormone) — secreted by the anterior pituitary. It acts on the Sertoli cells and stimulates secretion of factors (such as androgen-binding protein) that are essential for spermiogenesis — the differentiation of spermatids into spermatozoa.

Answer: GnRH (hypothalamus), LH and FSH (anterior pituitary), and Androgens/Testosterone (Leydig cells) regulate spermatogenesis. LH → androgens → spermatogenesis; FSH → Sertoli cells → spermiogenesis factors.

Q8 Define spermiogenesis and spermiation.

SOLUTION

Spermiogenesis:
Spermiogenesis is the process by which haploid spermatids (produced after the second meiotic division during spermatogenesis) are transformed into mature, motile spermatozoa (sperms). During spermiogenesis, the round spermatid undergoes extensive morphological changes: the nucleus becomes elongated and condensed, a cap-like acrosome (filled with hydrolytic enzymes) develops over the anterior portion of the nucleus, the middle piece develops with numerous mitochondria (which provide energy), and the tail (flagellum) grows. The excess cytoplasm is shed as a residual body.

Spermiation:
Spermiation is the process by which mature spermatozoa are released from the Sertoli cells (in which the sperm heads had become embedded after spermiogenesis) into the lumen of the seminiferous tubules. After spermiation, sperms are transported by the accessory ducts (rete testis → vasa efferentia → epididymis → vas deferens) to the outside.

Answer: Spermiogenesis: transformation of spermatids into spermatozoa (differentiation). Spermiation: release of mature sperms from Sertoli cells into the lumen of the seminiferous tubule.

Q9 Draw a labelled diagram of sperm.

SOLUTION

A human sperm (spermatozoon) is a microscopic structure with four main regions. The diagram should label the following parts:

Head:
• Acrosome — a cap-like structure covering the anterior portion of the nucleus; filled with hydrolytic enzymes (e.g., hyaluronidase, acrosin) that help the sperm penetrate the zona pellucida and plasma membrane of the ovum during fertilisation
• Nucleus — elongated, haploid (n = 23); contains the condensed chromosomal material; occupies most of the head
• Plasma membrane — envelops the entire sperm

Neck:
• Neck — short connecting region between the head and the middle piece; contains the centriole which gives rise to the axoneme of the flagellum

Middle piece:
• Mitochondria — numerous mitochondria arranged in a spiral around the axoneme; they produce energy (ATP) required for the movement of the tail and sperm motility, which is essential for fertilisation

Tail:
• Tail (flagellum) — long, whip-like; facilitates sperm motility; its beating propels the sperm through the female reproductive tract towards the ovum

Summary of labels to include in the diagram:
Acrosome | Nucleus (head) | Plasma membrane | Neck | Mitochondria (middle piece) | Tail (flagellum)

Answer: Sperm parts (head to tail): Acrosome (enzymes for fertilisation) → Nucleus (haploid) → Neck (centriole) → Middle piece (mitochondria — energy source) → Tail (flagellum — motility). All enclosed by plasma membrane.

Q10 What are the major components of seminal plasma?

SOLUTION

Seminal plasma is the fluid component of semen (excluding the sperms). It is produced by the secretions of the male accessory glands:

1. Fructose — secreted mainly by the seminal vesicles; serves as the primary energy source for sperms.
2. Calcium — present in seminal plasma; important for sperm function and motility.
3. Certain enzymes — secreted by the seminal vesicles and prostate; include proteases and other factors that facilitate liquefaction of semen after ejaculation.
4. Lubricating fluid — secreted by the bulbourethral glands (Cowper's glands); helps in lubrication of the urethra and penis during coitus.

Overall, seminal plasma provides a suitable medium for the transport, nourishment, and activation of sperms. The functions of male sex accessory ducts and glands, including maintenance of seminal plasma composition, are regulated by androgens.

Answer: Major components of seminal plasma: fructose (energy for sperms), calcium, enzymes (from seminal vesicles and prostate), and lubricating secretions from bulbourethral glands.

Q11 What are the major functions of male accessory ducts and glands?

SOLUTION

Male Accessory Ducts (rete testis, vasa efferentia, epididymis, vas deferens, ejaculatory duct, urethra):

1. Transport of sperms — the accessory ducts store and transport sperms from the seminiferous tubules of the testis to the outside through the urethra.
2. Maturation of sperms — the epididymis is the primary site where sperms undergo maturation and acquire motility. Sperms are non-motile when they first enter the epididymis and become motile by the time they leave it.
3. Storage — the epididymis and vas deferens store sperms until ejaculation.

Male Accessory Glands (seminal vesicles, prostate, bulbourethral glands):

1. Seminal vesicles — secrete a fructose-rich alkaline fluid that provides energy (fructose) to sperms and forms the bulk of semen.
2. Prostate gland — secretes a slightly acidic fluid rich in citrate, zinc, calcium and enzymes; contributes to sperm motility and viability; its alkaline component helps neutralise the acidic vaginal environment.
3. Bulbourethral glands (Cowper's glands) — secrete a clear mucus that lubricates the urethra and penis before and during coitus, neutralising any residual urine acidity in the urethra.

Overall: secretions of these glands constitute the seminal plasma, which along with sperms forms semen. These functions are maintained and regulated by testicular hormones (androgens).

Answer: Accessory ducts: transport, maturation (epididymis), and storage of sperms. Accessory glands: seminal vesicles provide fructose and bulk fluid; prostate secretes enzymes and calcium; bulbourethral glands lubricate the urethra. Together they form seminal plasma.

Q12 What is oogenesis? Give a brief account of oogenesis.

SOLUTION

Definition:
Oogenesis is the process of formation of a mature female gamete (ovum/egg) from the oogonia (gamete mother cells) in the ovary. Unlike spermatogenesis, oogenesis begins during embryonic development and is completed only after fertilisation.

Process of Oogenesis:

Step 1 — During embryonic development:
Oogonia (diploid gamete mother cells) are formed within the fetal ovary — about a couple of million per ovary. No new oogonia are added after birth.

Step 2 — Entry into meiosis (fetal stage):
The oogonia start dividing and enter prophase-I of meiosis-I but get temporarily arrested at that stage. At this point they are called primary oocytes.

Step 3 — Primary follicle formation:
Each primary oocyte gets surrounded by a layer of granulosa cells and is called the primary follicle. Many of these follicles degenerate between birth and puberty, leaving only about 60,000–80,000 primary follicles per ovary at puberty.

Step 4 — Secondary follicle formation:
At puberty, primary follicles get surrounded by more granulosa cell layers plus a new theca layer, forming secondary follicles.

Step 5 — Tertiary follicle (Graafian follicle precursor):
The secondary follicle transforms into a tertiary follicle, which is characterised by a fluid-filled cavity called the antrum. The theca is organised into theca interna (inner) and theca externa (outer). At this stage, the primary oocyte completes Meiosis I (which had been arrested since fetal life). This division is unequal: it produces a large haploid secondary oocyte (which retains most of the nutrient-rich cytoplasm) and a tiny first polar body.

Step 6 — Graafian follicle and ovulation:
The tertiary follicle further develops into the mature Graafian follicle. The secondary oocyte forms a new membrane called zona pellucida around it. The Graafian follicle ruptures (triggered by the LH surge) and releases the secondary oocyte — this is ovulation.

Step 7 — Completion of Meiosis II:
Meiosis II (the second meiotic division) is completed only after fertilisation by a sperm. It is again unequal, producing a large haploid ovum (ootid) and a tiny second polar body. The haploid nucleus of the ovum then fuses with the haploid sperm nucleus to form the diploid zygote.

Key difference from spermatogenesis: oogenesis produces only ONE functional gamete (ovum) per primary oocyte (not four), because both meiotic divisions are unequal with polar bodies discarding excess chromosomes.

Answer: Oogenesis is the formation of the mature ovum in the ovary. Oogonia → primary oocyte (arrested in prophase-I) → secondary oocyte + 1st polar body (Meiosis I at puberty/ovulation) → ovum + 2nd polar body (Meiosis II after fertilisation). Only one functional gamete is produced.

Q13 Draw a labelled diagram of a section through ovary.

SOLUTION

A diagrammatic section through the ovary should show the following structures, properly labelled:

Outer covering:
• Germinal epithelium (surface epithelium) — outer thin layer covering the ovary
• Tunica albuginea — fibrous connective tissue layer beneath the epithelium

Stroma regions:
• Cortex — peripheral zone of the ovarian stroma; contains follicles in various stages of development
• Medulla — inner zone; contains blood vessels, nerves, and connective tissue

Follicles at various stages (to be shown in the cortex):
• Primary follicle — primary oocyte surrounded by a single layer of granulosa cells
• Secondary follicle — primary oocyte surrounded by multiple layers of granulosa cells and a theca layer
• Tertiary follicle — characterised by an antrum (fluid-filled cavity); primary oocyte completing Meiosis I; theca interna and theca externa layers visible
• Graafian follicle (mature follicle) — large, with a well-developed antrum; secondary oocyte surrounded by zona pellucida and corona radiata; cumulus oophorus (stalk of granulosa cells); ready for ovulation

Post-ovulation structures:
• Corpus luteum — formed from the ruptured Graafian follicle after ovulation; yellow-coloured; secretes progesterone (and estrogens)
• Corpus albicans — degenerating corpus luteum (if pregnancy does not occur); appears as a white scar
• Atretic follicle — a follicle that has undergone degeneration (atresia) — many degenerate between birth and puberty

Blood vessels in the medulla should also be labelled.

Answer: Labels for ovary section: germinal epithelium, cortex, medulla, primary follicle, secondary follicle, tertiary follicle (antrum), Graafian follicle (zona pellucida, corona radiata, secondary oocyte, antrum, theca interna/externa), corpus luteum, blood vessels.

Q14 Draw a labelled diagram of a Graafian follicle.

SOLUTION

A Graafian follicle is the mature ovarian follicle just before ovulation. The labelled diagram should include the following structures:

Outer layers:
• Theca externa — outermost layer; fibrous connective tissue
• Theca interna — inner vascular layer; secretes estrogens

Granulosa cell layers:
• Granulosa cells (membrana granulosa) — multiple layers of cells lining the follicle; surround the antrum and the oocyte
• Cumulus oophorus — the stalk/mound of granulosa cells that connects the secondary oocyte to the follicle wall and projects into the antrum
• Corona radiata — innermost layer of granulosa cells immediately surrounding the secondary oocyte; remains with the oocyte after ovulation

Fluid-filled cavity:
• Antrum — large, fluid-filled cavity (follicular fluid/liquor folliculi) that occupies most of the follicle

The egg and its membranes:
• Secondary oocyte — the large haploid cell (has completed Meiosis I); positioned eccentrically within the follicle
• First polar body — tiny cell adjacent to the secondary oocyte (produced by the unequal first meiotic division)
• Zona pellucida — thick glycoprotein membrane directly surrounding the secondary oocyte

Summary of labels:
Theca externa → Theca interna → Granulosa cells (membrana granulosa) → Antrum (follicular fluid) → Cumulus oophorus → Corona radiata → Zona pellucida → Secondary oocyte → First polar body

Answer: Graafian follicle labels: theca externa, theca interna, granulosa cells (membrana granulosa), antrum (follicular fluid), cumulus oophorus, corona radiata, zona pellucida, secondary oocyte, first polar body.

Q15 Name the functions of the following:
(a) Corpus luteum
(b) Endometrium
(c) Acrosome
(d) Sperm tail
(e) Fimbriae

SOLUTION

(a) Corpus luteum:

The corpus luteum is formed from the remnants of the ruptured Graafian follicle after ovulation. Its primary function is to secrete large amounts of progesterone (and some estrogens). Progesterone is essential for the maintenance of the endometrium of the uterus, which is necessary for implantation of the fertilised ovum and the maintenance of early pregnancy. If fertilisation does not occur, the corpus luteum degenerates, progesterone levels fall, and menstruation occurs.

(b) Endometrium:
The endometrium is the inner glandular lining of the uterus. Its functions are:
• It undergoes cyclical changes during the menstrual cycle (proliferation in the follicular phase, secretory changes in the luteal phase, and shedding during menstruation).
• It provides the site for implantation of the blastocyst (fertilised ovum) — the blastocyst embeds into the endometrium to establish pregnancy.
• During pregnancy, the endometrium supports the developing embryo and contributes to the formation of the placenta.

(c) Acrosome:
The acrosome is a cap-like structure that covers the anterior portion of the sperm head. It is filled with hydrolytic enzymes (e.g., hyaluronidase, acrosin). During fertilisation, when the sperm contacts the zona pellucida of the ovum, the acrosomal enzymes are released (acrosomal reaction). These enzymes digest the zona pellucida and help the sperm penetrate through it and the plasma membrane of the ovum to achieve fertilisation.

(d) Sperm tail:
The tail (flagellum) of the sperm provides motility. Its beating movement (powered by ATP produced by mitochondria in the middle piece) propels the sperm through the female reproductive tract from the vagina through the cervix, uterus, and into the ampullary region of the fallopian tube where fertilisation occurs. Sperm motility is thus essential for fertilisation.

(e) Fimbriae:
Fimbriae are finger-like projections present at the edges of the infundibulum (the funnel-shaped opening) of the fallopian tube. Their function is to collect the ovum (secondary oocyte) released from the ovary at the time of ovulation and direct it into the infundibulum of the fallopian tube, from where it moves towards the ampulla for possible fertilisation.

Answer: (a) Corpus luteum: secretes progesterone to maintain endometrium for implantation. (b) Endometrium: site of implantation; undergoes menstrual cyclical changes. (c) Acrosome: contains enzymes to penetrate zona pellucida during fertilisation. (d) Sperm tail: provides motility for sperm to reach the ovum. (e) Fimbriae: collect the ovum after ovulation and direct it into the fallopian tube.

Q16 Identify True/False statements. Correct each false statement to make it true.
(a) Androgens are produced by Sertoli cells. (True/False)
(b) Spermatozoa get nutrition from Sertoli cells. (True/False)
(c) Leydig cells are found in ovary. (True/False)
(d) Leydig cells synthesise androgens. (True/False)
(e) Oogenesis takes place in corpus luteum. (True/False)
(f) Menstrual cycle ceases during pregnancy. (True/False)
(g) Presence or absence of hymen is not a reliable indicator of virginity or sexual experience. (True/False)

SOLUTION

(a) Androgens are produced by Sertoli cells. — FALSE
Correction: Androgens are produced by Leydig cells (interstitial cells) located in the interstitial spaces outside the seminiferous tubules. Sertoli cells provide nutrition to the developing germ cells and secrete factors for spermiogenesis, but do NOT produce androgens.

(b) Spermatozoa get nutrition from Sertoli cells. — TRUE
Sertoli cells (also called nurse cells) line the seminiferous tubules and provide structural support, nutrition, and essential factors to the developing male germ cells (spermatogonia → spermatozoa) throughout spermatogenesis and spermiogenesis.

(c) Leydig cells are found in ovary. — FALSE
Correction: Leydig cells (interstitial cells) are found in the testes, specifically in the interstitial spaces between the seminiferous tubules. They are not found in the ovary.

(d) Leydig cells synthesise androgens. — TRUE
Leydig cells (interstitial cells) in the testis synthesise and secrete testicular hormones called androgens (e.g., testosterone) under stimulation by LH from the anterior pituitary.

(e) Oogenesis takes place in corpus luteum. — FALSE
Correction: Oogenesis takes place in the ovary (specifically within the ovarian follicles). The corpus luteum is the structure formed from the ruptured Graafian follicle after ovulation; it secretes progesterone and does not produce ova.

(f) Menstrual cycle ceases during pregnancy. — TRUE
During pregnancy, the corpus luteum persists (maintained by hCG from the placenta) and continuously secretes progesterone, which maintains the endometrium. This prevents the disintegration of the endometrium and hence menstruation does not occur during pregnancy.

(g) Presence or absence of hymen is not a reliable indicator of virginity or sexual experience. — TRUE
The hymen can be torn by reasons other than coitus — such as sudden falls, physical exercise (horseback riding, cycling), or insertion of a vaginal tampon. Moreover, in some women the hymen may persist even after coitus. Therefore, the status of the hymen cannot reliably indicate whether a woman has had sexual intercourse.

Answer: (a) False — androgens produced by Leydig cells, not Sertoli cells. (b) True. (c) False — Leydig cells are in the testis, not ovary. (d) True. (e) False — oogenesis occurs in the ovary (follicles), not corpus luteum. (f) True. (g) True.

Q17 What is menstrual cycle? Which hormones regulate menstrual cycle?

SOLUTION

Menstrual Cycle:

The menstrual cycle is the cyclic reproductive cycle of female primates (monkeys, apes, and human beings). In humans, it begins at puberty (the first menstruation is called menarche) and repeats at an average interval of about 28–29 days. The cycle of events starting from one menstruation till the next is the menstrual cycle. It ceases around the age of 50 years (menopause). One ovum is released per cycle (during ovulation).

Phases of the menstrual cycle:

1. Menstrual phase (days 1–5): breakdown and shedding of the endometrial lining along with blood and tissue fluid through the vagina. Occurs when the ovum is not fertilised.
2. Follicular/Proliferative phase (days 6–13): the primary follicle grows to become a Graafian follicle; the endometrium regenerates (proliferates). Rising estrogen levels characterise this phase.
3. Ovulatory phase (day 14): LH surge triggers rupture of the Graafian follicle and release of the secondary oocyte (ovulation).
4. Luteal/Secretory phase (days 15–28): the ruptured follicle forms the corpus luteum, which secretes progesterone. The endometrium becomes thick and secretory, ready for implantation. If fertilisation does not occur, the corpus luteum degenerates and the cycle restarts.

Hormones that regulate the menstrual cycle:

• GnRH (Gonadotropin Releasing Hormone) from the hypothalamus — stimulates the pituitary to release LH and FSH.
• FSH (Follicle Stimulating Hormone) from the anterior pituitary — stimulates follicular development and secretion of estrogens by the growing follicles.
• LH (Luteinising Hormone) from the anterior pituitary — gradually increases during the follicular phase; the LH surge at mid-cycle (day ~14) triggers ovulation; LH also supports the development of the corpus luteum.
• Estrogens (from the developing follicles, mainly) — cause proliferation of the endometrium; rising estrogen levels trigger the LH surge (positive feedback).
• Progesterone (from the corpus luteum) — maintains the thickened, secretory endometrium during the luteal phase; essential for potential implantation; falling progesterone triggers menstruation.

Answer: Menstrual cycle: ~28-day reproductive cycle in female primates from menarche to menopause, comprising menstrual, follicular, ovulatory, and luteal phases. Regulated by GnRH (hypothalamus), FSH and LH (anterior pituitary), estrogens (follicles), and progesterone (corpus luteum).

Q18 What is parturition? Which hormones are involved in induction of parturition?

SOLUTION

Parturition:
Parturition is the process of delivery of the fully developed foetus (childbirth) at the end of the gestation period (approximately 9 months). It involves vigorous contraction of the uterine muscles leading to expulsion of the baby through the birth canal. Soon after the infant is delivered, the placenta is also expelled.

Mechanism and hormones involved in induction of parturition:
Parturition is induced by a complex neuroendocrine mechanism:

1. Foetal ejection reflex — signals for parturition originate from the fully developed foetus and the placenta. These signals induce mild uterine contractions called the foetal ejection reflex.

2. Oxytocin — the foetal ejection reflex triggers release of oxytocin from the posterior pituitary of the mother. Oxytocin acts on the uterine (myometrium) smooth muscle and causes stronger uterine contractions. Stronger contractions in turn stimulate further secretion of oxytocin (a positive feedback loop). This cycle of uterine contraction → oxytocin secretion → stronger contractions continues, resulting in increasingly powerful contractions that ultimately expel the baby.

3. Estrogens — during late pregnancy, rising estrogen levels increase the sensitivity (responsiveness) of the uterine muscles to oxytocin and play a role in initiating parturition.

4. Cortisol — fetal cortisol levels rise toward the end of pregnancy and contribute to triggering the neuroendocrine cascade that initiates parturition.

5. Relaxin — secreted by the ovary in the later phase of pregnancy; helps in relaxation (widening) of the pubic symphysis and softening of the cervix, facilitating delivery.

Note: Doctors can inject oxytocin synthetically (e.g., Pitocin) to induce or augment labour when medically necessary.

Answer: Parturition is the process of childbirth (delivery of the foetus) at the end of gestation. Hormones involved: oxytocin (main driver — positive feedback uterine contractions), estrogens (uterine sensitivity), cortisol (fetal signal), and relaxin (cervical softening/pubic relaxation).

Q19 In our society the women are often blamed for giving birth to daughters. Can you explain why this is not correct?

SOLUTION

This social belief is scientifically incorrect. The sex of the baby is determined by the father (the male parent), not the mother.

Scientific explanation:
• Human females have the sex chromosome pattern XX. Therefore, ALL ova (eggs) produced by the female carry only the X chromosome. The female contributes nothing but an X chromosome with respect to sex determination.

• Human males have the sex chromosome pattern XY. Therefore, 50% of sperms carry the X chromosome and 50% carry the Y chromosome.

• During fertilisation:
— If an X-bearing sperm fertilises the ovum → the zygote is XX → develops into a female (daughter).
— If a Y-bearing sperm fertilises the ovum → the zygote is XY → develops into a male (son).

• Since the ovum always contributes an X chromosome, the sex of the child depends entirely on which type of sperm (X or Y) fertilises the ovum. This is determined by the father's sperm.

Conclusion: The mother has no role in determining the sex of the baby because all her gametes carry only X chromosomes. It is the father's sperm that determines whether the child will be a daughter (XX) or a son (XY). Blaming the mother for the birth of a daughter is therefore completely scientifically unfounded.

Answer: The sex of the baby is determined by the sperm (father), not the egg (mother). All ova carry only X; sperms carry either X or Y. X-sperm → daughter (XX); Y-sperm → son (XY). The mother has no role in sex determination.

Q20 How many eggs are released by a human ovary in a month? How many eggs do you think would have been released if the mother gave birth to identical twins? Would your answer change if the twins born were fraternal?

SOLUTION

Eggs released per month:
A human ovary releases only ONE egg (secondary oocyte) per menstrual cycle per month. Ovulation of one ovum per cycle is the norm in humans.

Identical (monozygotic) twins:
Identical twins arise from a single fertilised egg (one zygote) that splits into two during early embryonic development (at the 2-cell or early blastocyst stage). Both embryos have identical genetic material.
Therefore, if identical twins were born, only ONE egg would have been released from the ovary (just as in any normal pregnancy).
The twinning happens after fertilisation, not as a result of releasing two eggs.

Fraternal (dizygotic) twins:
Fraternal twins arise from two separate eggs that are released in the same cycle, each fertilised by a different sperm. The two embryos have different genetic makeups (like ordinary siblings).
Therefore, if fraternal twins were born, TWO eggs would have been released by the ovary in that cycle (simultaneous ovulation of two ova — one from each ovary, or two from the same ovary).

Summary:
• Normal: 1 egg per month

- Identical twins: 1 egg released (split after fertilisation)
- Fraternal twins: 2 eggs released (two separate fertilisation events)

Answer: Normally 1 egg per month. Identical twins: still 1 egg (the zygote splits after fertilisation). Fraternal twins: 2 eggs released and fertilised separately.

Q21 How many eggs do you think were released by the ovary of a female dog which gave birth to 6 puppies?

SOLUTION

Unlike humans, dogs are polytocous animals — they typically give birth to multiple offspring (a litter) in one reproductive cycle.

Each puppy in a litter arises from a separate egg fertilised by a separate sperm (similar to fraternal twins in humans). Dogs undergo multiple ovulations in a single reproductive cycle.

Therefore, if a female dog gave birth to 6 puppies, at least 6 eggs would have been released by her ovaries during that reproductive cycle — one egg corresponding to each puppy.

This contrasts sharply with humans, where normally only one egg is released per cycle, giving rise to a single offspring (or, rarely, fraternal twins if two eggs are released simultaneously).

Answer: At least 6 eggs were released — one for each puppy, since each puppy arises from a separately fertilised egg (dogs are polytocous and undergo multiple ovulations per cycle).