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Introduction

Overview

- Humans reproduce sexually and are viviparous.
- Reproductive events: gametogenesis, insemination, fertilisation, zygote formation, blastocyst development, implantation, gestation, and parturition.
- Events occur after puberty with distinct male and female reproductive processes.
- Reproductive organs: primary (produce gametes and hormones) and secondary (conduct gametes, no gamete/hormone production).
- Secondary sexual characters are external features distinguishing sexes.

Memory Aids

- Primary = Produce gametes + hormones; Secondary = Conduct gametes only.
- Secondary sexual characters = External sex differences.

Quick Checkpoints

- What are the main reproductive events in humans?
- Define primary and secondary sex organs.
- What are secondary sexual characters?

Male Reproductive System

Structure and Location

- Located in the pelvis region.
- Includes paired testes, accessory ducts, accessory glands, and external genitalia.
- Testes are outside the abdominal cavity in the scrotum.

Memory Aids

- Testes in scrotum = outside abdomen for temperature control.

Quick Checkpoints

- Where is the male reproductive system located?
- What are the main components of the male reproductive system?
- Why are testes located outside the abdomen?

Scrotum

Function and Structure

- Connected to abdomen/pelvis by inguinal canals.
- Spermatic cord (artery, vein, nerve) passes through inguinal canal to testes.
- Maintains testes temperature at $\sim 34^{\circ}\text{C}$, $2\text{--}2.5^{\circ}\text{C}$ below body temperature.
- Temperature regulation via cremaster and dartos muscles adjusting scrotal position.
- Temperature receptors in scrotum control movement of testes towards/away from pelvis.

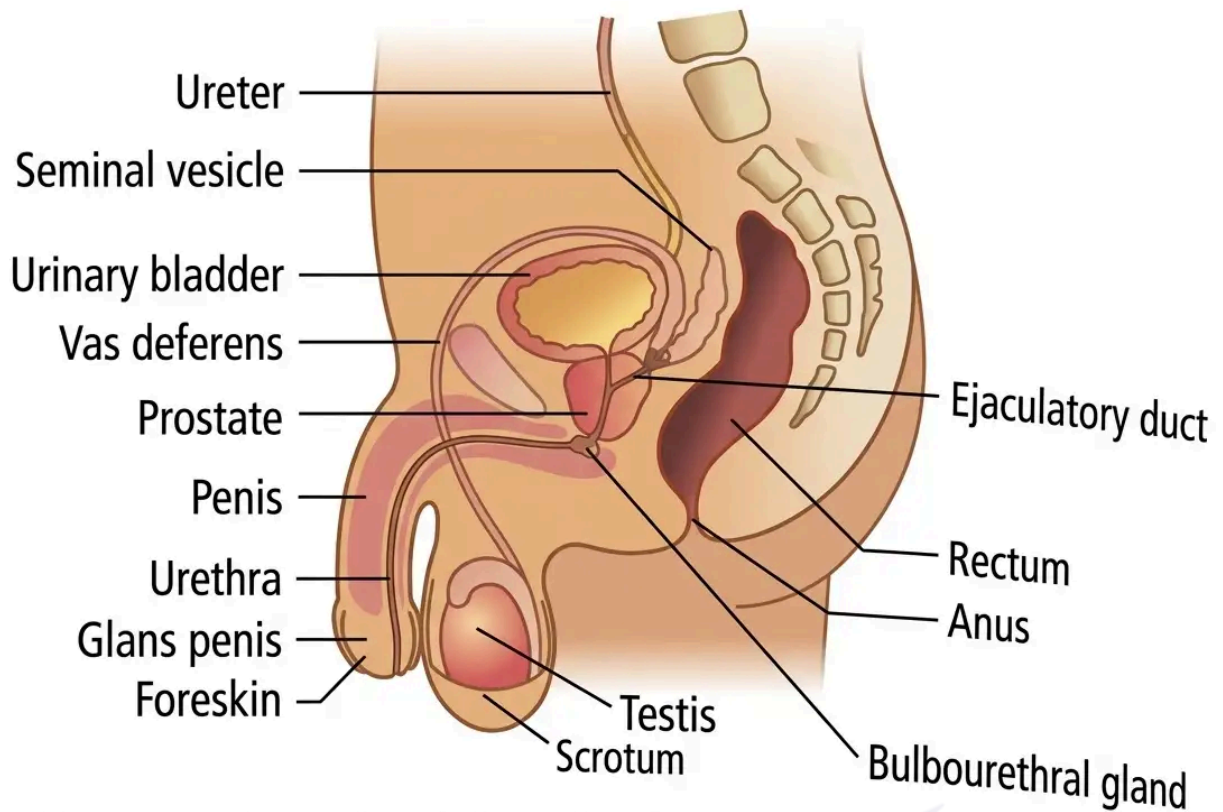


Fig.: Diagrammatic sectional view of male pelvis showing reproductive system

Memory Aids

- Scrotum = Temperature regulator for sperm production.
- Cremaster + Dartos muscles = Adjust testes position for heat control.

Quick Checkpoints

- How does the scrotum regulate testes temperature?
- What is the role of the spermatic cord?
- Why is testes temperature lower than body temperature?

Testis and Seminiferous Tubules

Structure and Function

- Testis: oval, 4-5 cm long, 2-3 cm wide; covered by tunica vaginalis, tunica albuginea, tunica vasculosa.
- Contains ~250 testicular lobules; each has 1-3 seminiferous tubules.
- Seminiferous tubules: site of spermatogenesis; lined by spermatogonia (male germ cells) and Sertoli cells (nutrition).
- Interstitial spaces contain blood vessels and Leydig (interstitial) cells producing androgens.
- Functions: sperm production and androgen secretion.
- Other immune cells present: lymphocytes, macrophages, mast cells.

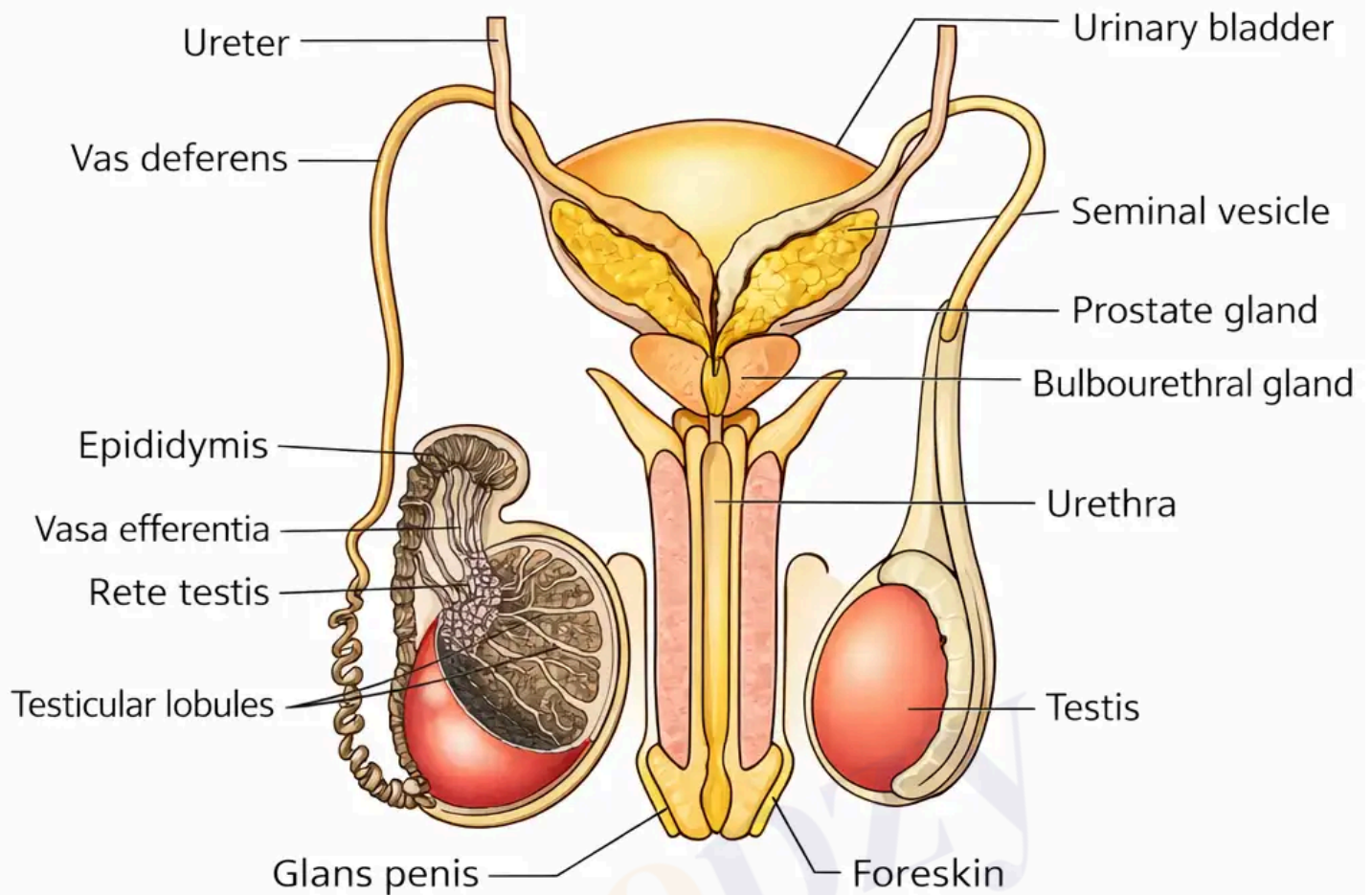


Fig.: Diagrammatic view of male reproductive system
(part of testis is open to show inner details)

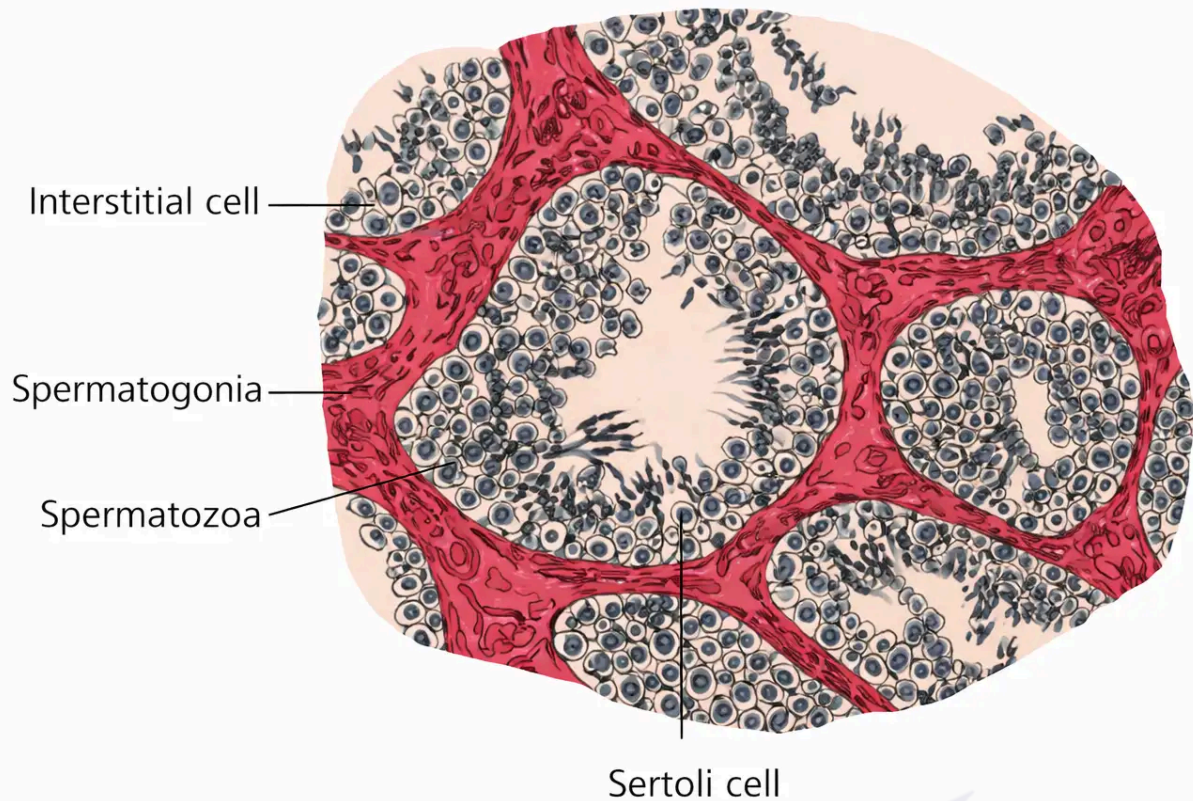


Fig.: Diagrammatic sectional view of seminiferous tubule

Memory Aids

- Seminiferous tubules = Sperm production site.
- Sertoli cells = Support and nourish sperm cells.
- Leydig cells = Produce testosterone.

Quick Checkpoints

- What are the layers covering the testis?
- Where does spermatogenesis occur?
- What cells produce testosterone?

Male Accessory Ducts

Components and Functions

- Include rete testis, vasa efferentia, epididymis, and vas deferens.
- Seminiferous tubules open into vasa efferentia via rete testis.
- Vasa efferentia lead to epididymis (posterior testis surface), where sperm mature and are stored.
- Epididymis divided into caput, corpus, and cauda regions.
- Vas deferens ascends to abdomen, loops over bladder, receives seminal vesicle duct, and opens into urethra as ejaculatory duct.
- Urethra extends from bladder through penis to urethral meatus (external opening).

Memory Aids

- Epididymis = Sperm maturation and storage.
- Vas deferens = Sperm transport to urethra.

Quick Checkpoints

- What is the path of sperm from seminiferous tubules to urethra?
- What are the parts of the epididymis?
- Where does the vas deferens open?

External Genitalia (Penis)

Structure and Function

- Penis: male copulatory organ and urinal duct.
- Contains three erectile tissues: two dorsal corpora cavernosa and one ventral corpus spongiosum.
- Corpus spongiosum surrounds penile urethra and forms glans penis at tip.
- Glans penis covered by prepuce (foreskin).

Memory Aids

- Corpora cavernosa = Erectile tissue for erection.
- Corpus spongiosum = Protects urethra during erection.
- Prepuce = Covers glans penis.

Quick Checkpoints

- What erectile tissues are present in the penis?
- What is the function of the corpus spongiosum?
- What is the prepuce?

Male Accessory Glands

Types and Secretions

- Include paired seminal vesicles, prostate gland, and paired bulbourethral (Cowper's) glands.
- Seminal vesicles: sac-like, near bladder base; ducts join vas deferens to form ejaculatory duct.
- Seminal vesicle secretion (60-70% semen volume): alkaline, contains fructose (energy), prostaglandins (stimulate uterine contractions), clotting proteins, and calcium.
- Prostate gland: chestnut-shaped, surrounds urethra; secretes alkaline milky fluid (20-30% semen volume) with citric acid (nutrient), enzymes, and prostaglandins (activate sperm motility).
- Bulbourethral glands: pea-sized, on either side of membranous urethra; secrete alkaline fluid to neutralize urine acidity and mucus to lubricate penis and urethra.

Memory Aids

- Seminal vesicles = Energy + uterine stimulation.
- Prostate = Nutrients + sperm activation.
- Bulbourethral glands = Neutralize acidity + lubrication.

Quick Checkpoints

- What are the main male accessory glands?
- What does seminal vesicle secretion contain?
- What is the function of bulbourethral glands?

Semen

Composition and Function

- Mixture of secretions from seminal vesicles, prostate, bulbourethral glands, and sperm from testes.
- Ejected during ejaculation; contains 200-300 million sperms per ejaculation.
- Alkaline pH (7.35-7.50) to protect sperm and neutralize urine acidity.
- Provides fluid medium for sperm transport and nourishment.

Memory Aids

- Semen = Sperm + gland secretions for protection and nourishment.

Quick Checkpoints

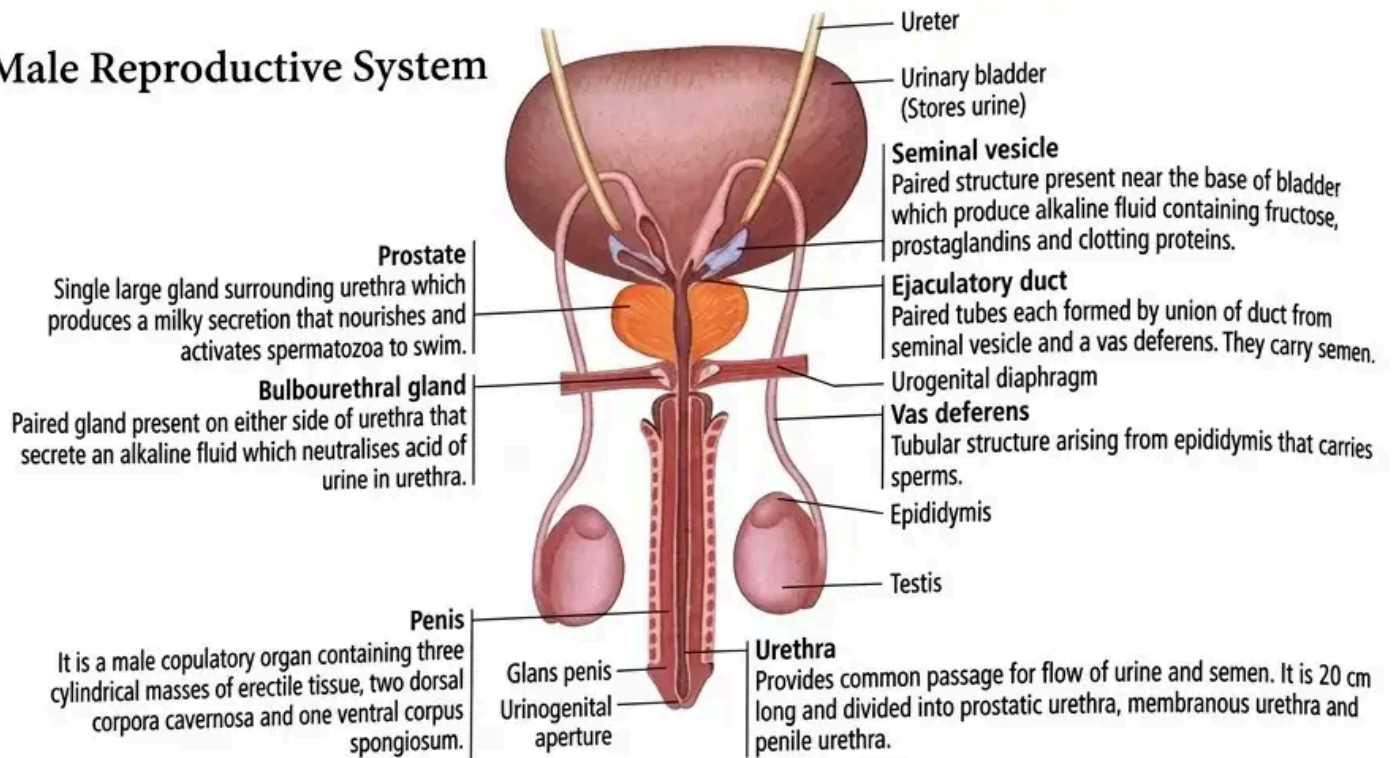
- What is semen composed of?
- Why is semen alkaline?
- How many sperms are typically in one ejaculation?

Common Male Reproductive Disorders

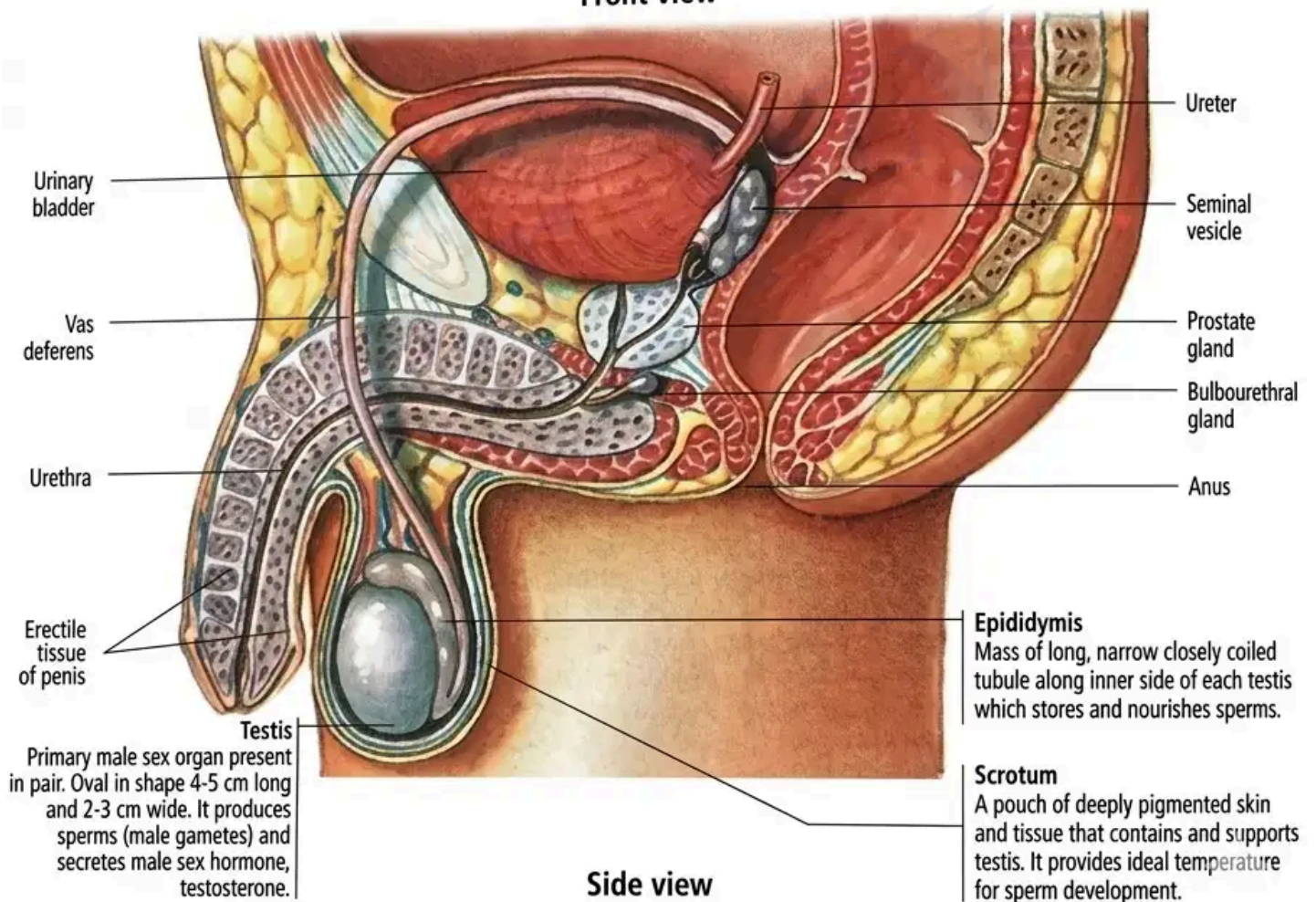
Cryptorchidism and Inguinal Hernia

- Cryptorchidism: failure of testis descent into scrotum due to low fetal testosterone.
- Inguinal hernia: intestine protrudes into scrotum due to torn inguinal tissue.

Male Reproductive System



Front view



Side view

Memory Aids

- Cryptorchidism = Undescended testis.
- Inguinal hernia = Intestine in scrotum.

Quick Checkpoints

- What causes cryptorchidism?
- What is inguinal hernia?

Gametogenesis

Overview

- Primary sex organs (testis in males, ovaries in females) produce gametes (sperms and ova).
- Process of formation of male and female gametes is called gametogenesis.

Memory Aids

- Gametogenesis = formation of gametes (sperm + ovum).

Quick Checkpoints

- What organs produce gametes?
- Define gametogenesis.

Spermatogenesis

Phases and Process

- Occurs in seminiferous tubules of testes, starts at puberty.
- **Multiplication phase:** Spermatogonia divide mitotically to form many spermatogonia.
- **Growth phase:** Spermatogonium grows into primary spermatocyte (diploid, 46 chromosomes).
- **Maturation phase:** Primary spermatocyte undergoes meiosis I to form two secondary spermatocytes (haploid, 23 chromosomes each).
- Secondary spermatocytes undergo meiosis II to form spermatids.
- Each primary spermatocyte produces four spermatids (haploid).

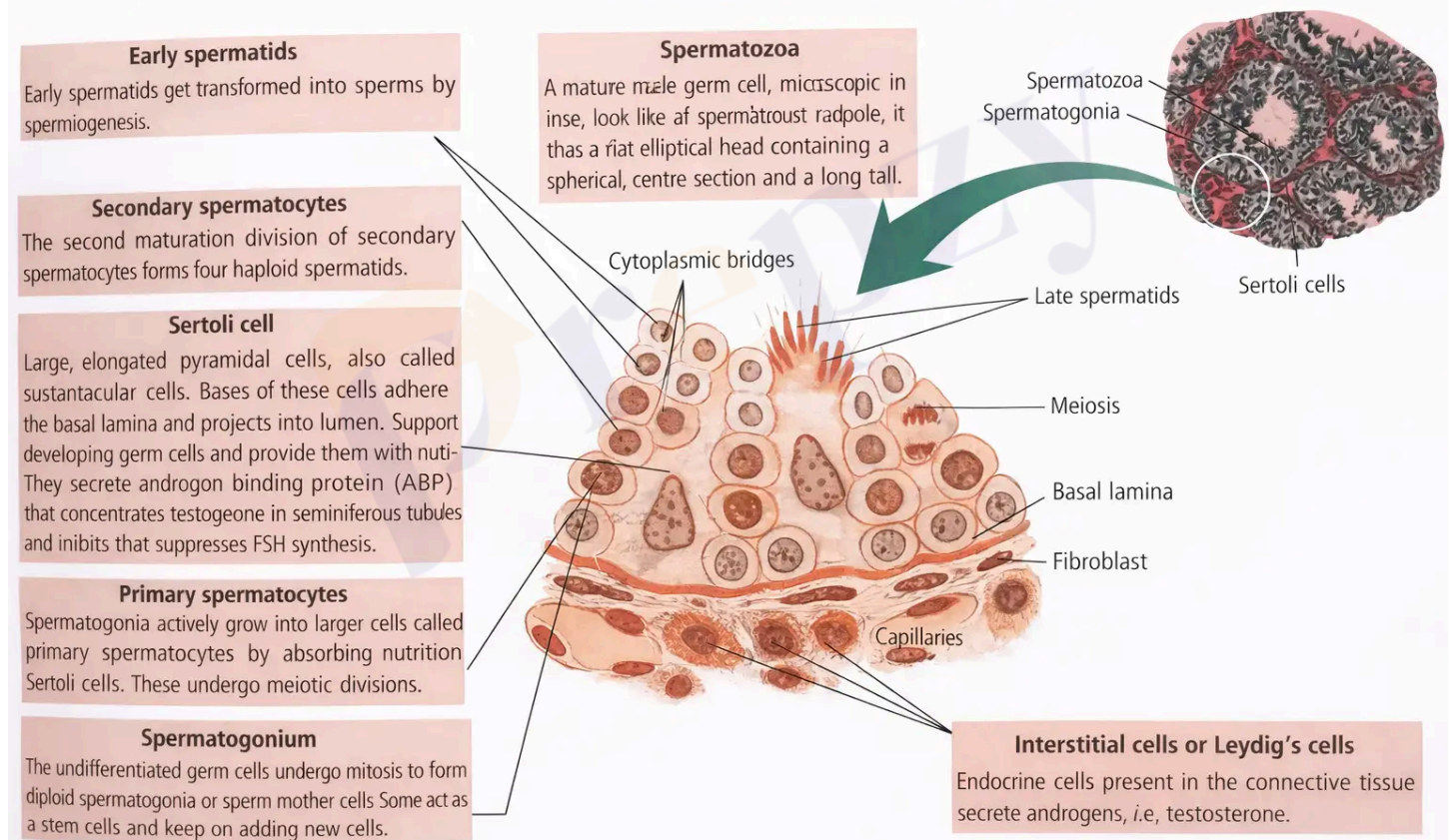


Fig.: Section of seminiferous tubule showing its cells at various stages

Memory Aids

- Spermatogenesis phases: Multiply, Grow, Mature.
- 1 primary spermatocyte → 4 spermatids.

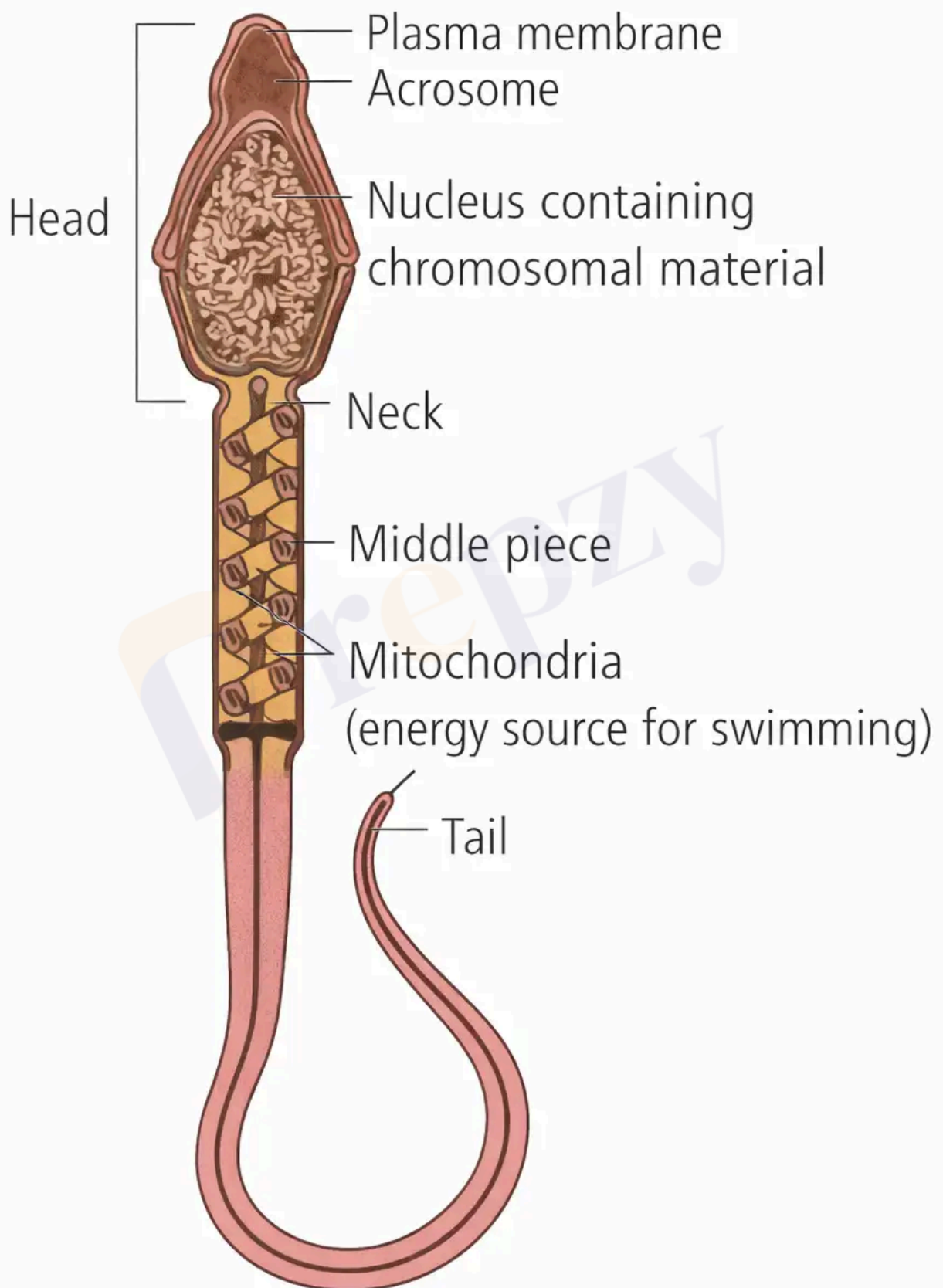
Quick Checkpoints

- Where does spermatogenesis occur?
- What are the phases of spermatogenesis?
- How many spermatids are formed from one primary spermatocyte?

Formation of Spermatozoa

Structure and Process

- Transformation of spermatids into spermatozoa is called spermiogenesis or spermateliosis.
- Sperm parts: head, neck, middle piece, tail.
- Head contains haploid nucleus with acrosome (enzymes for fertilisation).
- Middle piece has mitochondria for energy; tail has 9+2 microtubule arrangement for motility.
- About 200-300 million sperms ejaculated per coitus.
- Spermiation: release of spermatozoa from seminiferous tubules.
- Semen = sperm + seminal plasma from accessory glands.



Fia.: Structure of a sperm

Memory Aids

- Spermiogenesis = spermatids to spermatozoa.
- Sperm structure: Head (nucleus + acrosome), Middle (mitochondria), Tail (movement).

Quick Checkpoints

- What is spermiogenesis?
- Name the parts of a sperm.
- What is spermiation?

Hormonal Control of Male Reproductive System

Hormonal Regulation

- Puberty triggers GnRH secretion from hypothalamus.
- GnRH stimulates anterior pituitary to release LH and FSH.
- LH stimulates Leydig cells to produce testosterone.
- FSH stimulates Sertoli cells to secrete androgen binding protein (ABP) and inhibin.
- Testosterone and inhibin provide negative feedback on LH and FSH secretion.

Memory Aids

- GnRH → LH + FSH → Testosterone + ABP + Inhibin.
- Negative feedback controls hormone levels.

Quick Checkpoints

- What hormones regulate spermatogenesis?
- Role of LH and FSH in male reproduction?

- What feedback controls hormone secretion?

Oogenesis

Process and Stages

- Formation of mature female gamete (ovum).
- Begins during embryonic development with oogonia formation; no new oogonia after birth.
- Oogonia enter prophase I of meiosis and arrest at diplotene stage (primary oocyte).
- Primary oocyte surrounded by granulosa cells forms primary follicle.
- Many follicles degenerate; 60,000-80,000 remain at puberty.
- Primary follicles develop into secondary follicles, then tertiary follicles with fluid-filled antrum.
- Primary oocyte completes meiosis I forming large secondary oocyte and small first polar body.
- Secondary oocyte surrounded by zona pellucida; undergoes meiosis II after fertilisation.
- One oogonium produces one ovum and three polar bodies.
- Ovulation: release of secondary oocyte from Graafian follicle.

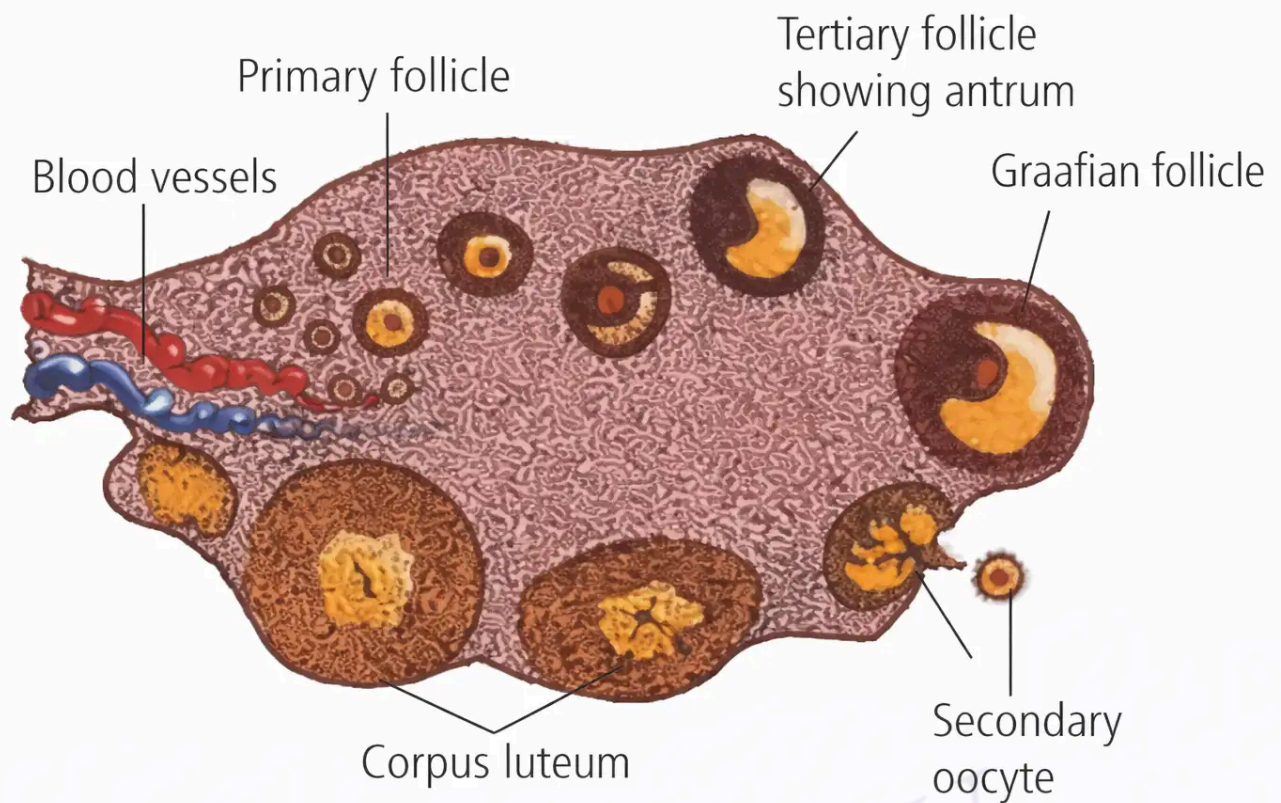


Fig.: Diagrammatic section view of ovary

Memory Aids

- Oogenesis stages: Oogonia → Primary oocyte → Secondary oocyte → Ovum.
- One oogonium → 1 ovum + 3 polar bodies.
- Ovulation releases secondary oocyte.

Quick Checkpoints

- When does oogenesis start?
- What is the fate of primary oocytes before puberty?
- What cells are released during ovulation?

Hormonal Control of Female Reproductive System

Hormonal Regulation

- GnRH from hypothalamus stimulates anterior pituitary to secrete LH and FSH.
- FSH promotes follicle growth and estrogen production; completes meiosis I in oocyte.
- LH stimulates corpus luteum to secrete progesterone.
- High progesterone inhibits GnRH, reducing LH, FSH, and progesterone secretion (negative feedback).

Memory Aids

- GnRH → LH + FSH → Estrogen + Progesterone.
- Progesterone inhibits GnRH and gonadotropins.

Quick Checkpoints

- Which hormones regulate female reproduction?
- Role of FSH and LH in oogenesis?
- How does progesterone regulate hormone levels?

Additional Notes

Key Points

- Vitellogenesis: yolk deposition in primary oocyte during prophase I.
- Mature ovum is spherical, contains nucleus, and is the largest cell in the body.

Memory Aids

- Vitellogenesis = yolk formation in oocyte.
- Ovum = largest cell, spherical with nucleus.

Quick Checkpoints

- What is vitellogenesis?
- Describe the mature ovum.

Menstrual Cycle

Phases and Overview

- Reproductive cycle in female primates (monkeys, apes, humans).
- First menstruation at puberty called menarche.
- Cycle repeats every 28/29 days on average.
- Cycle from one menstruation to next is menstrual cycle.
- Four phases: menstrual, follicular, ovulatory, luteal.

Memory Aids

- Menstrual cycle phases: M-F-O-L (Menstrual, Follicular, Ovulatory, Luteal).
- Menarche = first menstruation at puberty.

Quick Checkpoints

- What triggers the start of the menstrual cycle?
- How long is the average menstrual cycle?
- What are the four phases of the menstrual cycle?

Menstrual Phase

Key Features

- Marks cycle start; lasts 3-5 days.
- Day 1 of menstruation = day 1 of cycle.

- LH production drops, corpus luteum degenerates.
- Progesterone and estrogen levels fall rapidly.
- Endometrium breaks down; uterine tissues and blood shed via vagina (menstruation).
- Hygiene during menstruation is crucial.

Memory Aids

- Menstruation = shedding of uterine lining.
- Low LH → corpus luteum degeneration → hormone drop → menstruation.

Quick Checkpoints

- What hormone changes cause menstruation?
- How long does the menstrual phase last?
- What marks day 1 of the menstrual cycle?

Follicular Phase or Proliferative Phase

Key Features

- Occurs days 6-13/14 in 28-day cycle.
- Primary follicles mature into Graafian follicle.
- Gradual rise in LH and FSH secretion.
- FSH stimulates follicle growth and estrogen secretion.
- Estrogen causes endometrium proliferation.

Memory Aids

- Follicle grows → estrogen rises → endometrium thickens.
- FSH and LH increase gradually.

Quick Checkpoints

- Which hormones rise during follicular phase?
- What happens to ovarian follicles in this phase?
- How does estrogen affect the uterus?

Ovulatory Phase

Key Features

- Occurs around day 14 of cycle.
- LH and FSH peak simultaneously.
- LH surge causes rupture of Graafian follicle.
- Ovulation: release of ovum from follicle.

Memory Aids

- LH surge = trigger for ovulation.
- Ovulation occurs mid-cycle (~day 14).

Quick Checkpoints

- What hormone surge triggers ovulation?
- When does ovulation occur in the cycle?
- What is released during ovulation?

Luteal Phase or Secretory Phase

Key Features

- Occurs days 15-28 in 28-day cycle.
- Time between ovulation and next menstruation.

- LH transforms ovulated follicle into corpus luteum.
- Corpus luteum secretes progesterone.
- Progesterone thickens endometrium for implantation.
- Uterine glands produce watery mucus.
- Uterine wall prepared to nourish blastocyst if fertilization occurs.
- No menstruation during pregnancy; cycle stops.
- Without fertilization, corpus luteum degenerates → endometrium breaks down → menstruation starts new cycle.
- Menstrual cycles cease around age 50 (menopause).
- Cyclic menstruation occurs between menarche and menopause.

Memory Aids

- Corpus luteum = progesterone source post-ovulation.
- Progesterone prepares uterus for pregnancy.
- Menopause = end of menstrual cycles (~50 years).

Quick Checkpoints

- What hormone does corpus luteum secrete?
- What happens to the endometrium during luteal phase?
- When does menstruation resume if no fertilization occurs?

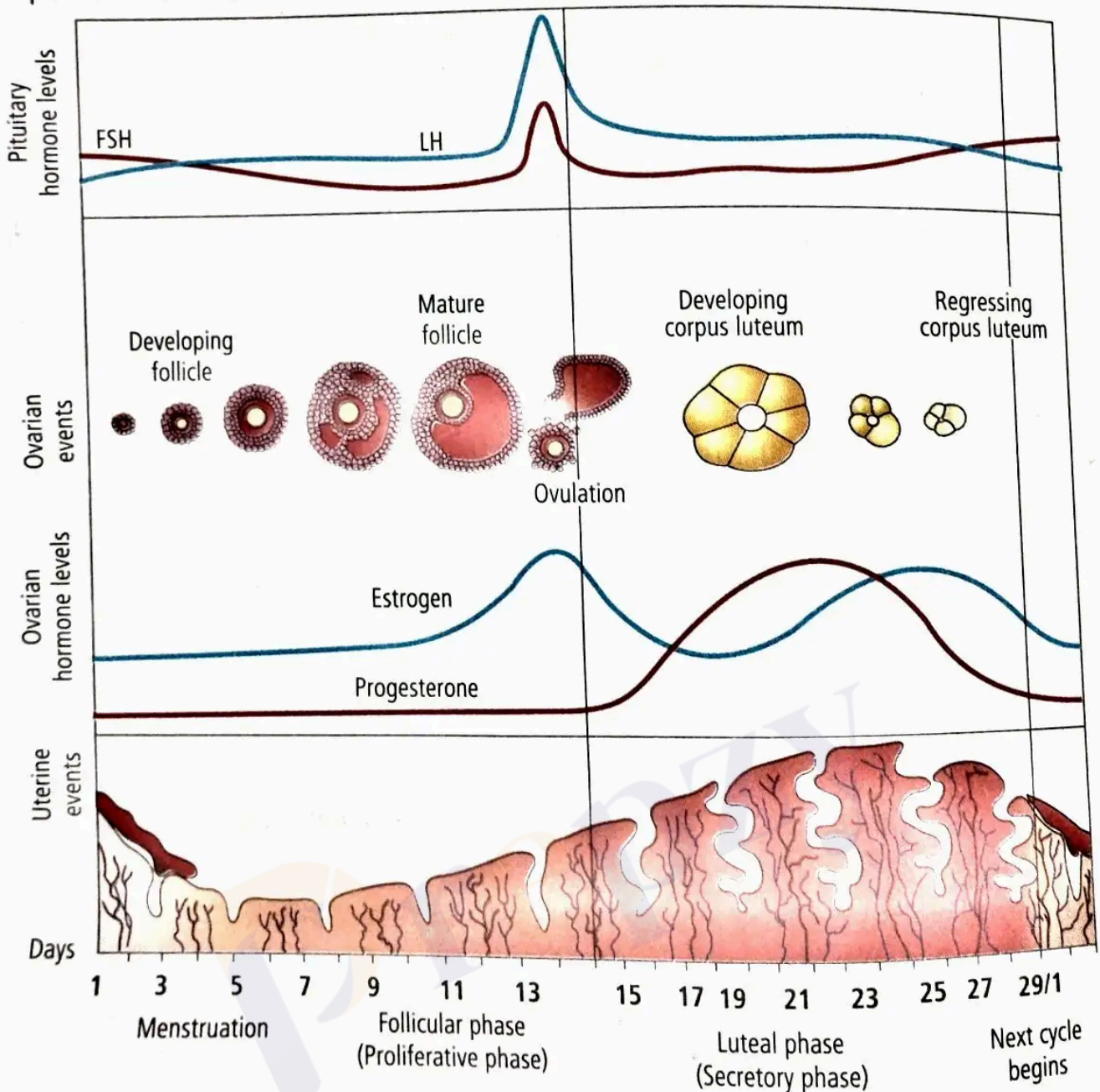


Fig.: Diagrammatic representation of various events during a menstrual cycle

Estrous Cycle

Phases and Overview

- Sexual cycle in mammals other than primates (no menstruation).
- Four phases: anestrus, proestrus, estrus, metestrus.
- Anestrus: resting phase, no sexual cycle.
- Proestrus: follicle development, endometrium starts developing under estrogen.
- Estrus: period of heat, Graafian follicle develops under gonadotropins.
- Metestrus: corpus luteum active, produces progesterone; regresses if no pregnancy.

Memory Aids

- Estrous phases: A-P-E-M (Anestrous, Proestrous, Estrous, Metestrous).
- No menstruation in estrous cycle.

Quick Checkpoints

- What is the resting phase in estrous cycle?
- Which phase is called the period of heat?
- What hormone does corpus luteum produce in metestrous?

Fertilisation and Implantation

Process and Site of Fertilisation

- Insemination: Semen released into female vagina during copulation.
- Secondary oocyte released from mature Graafian follicle enters fallopian tube.
- Ciliated cells in infundibulum propel oocyte to ampulla.
- Ampullary-isthmic junction is fertilisation site.
- Fertilisation requires simultaneous arrival of sperm and ovum at ampulla.
- Sperm aided by uterine and tube contractions, then swim at 1.5-3 mm/min.

Capacitation and Acrosomal Reaction

- Capacitation: Activation of sperm by female tract secretions removing surface coatings.
- Exposes sperm receptors; takes 5-6 hours.
- Acrosomal reaction releases lysins: hyaluronidase, corona penetrating enzymes, acrosin.
- Enzymes digest follicle cells, corona radiata, and zona pellucida.
- Plasma membranes of sperm acrosome and oocyte fuse.
- Cortical reaction blocks entry of additional sperms, ensuring monospermy.

Fertilisation and Zygote Formation

- Sperm entry triggers completion of secondary oocyte meiosis II.
- Produces second polar body and haploid ovum (ootid).
- Fusion of haploid sperm and ovum nuclei forms diploid zygote.
- Secondary oocyte viable for fertilisation only 24 hours post-ovulation.
- Fertilizin (egg) and antifertilizin (sperm) interaction causes species-specific sperm adhesion (agglutination).

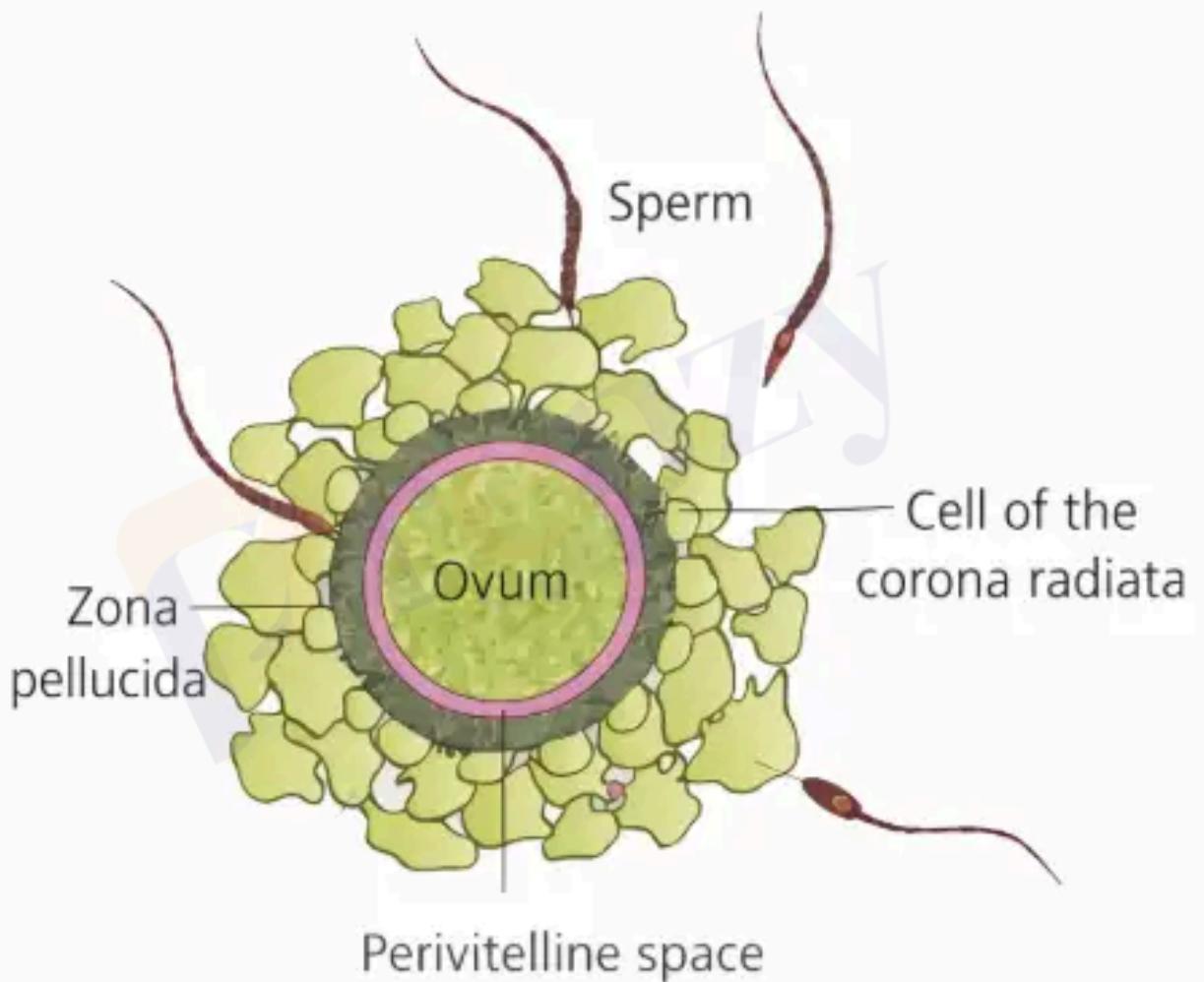


Fig.: Ovum surrounded by few sperms

Sex Determination and Cleavage

- Female gametes carry X chromosome; male gametes carry X or Y (50% each).

- Fusion determines zygote sex: XX female, XY male.
- Zygote undergoes repeated mitotic divisions (cleavage) without volume increase.
- Cleavage forms 2, 4, 8, 16 blastomeres; 8-16 cell stage called morula.
- Morula develops into blastocyst with outer trophoblast and inner cell mass.
- Trophoblast attaches to endometrium; inner cell mass forms embryo.
- Implantation: blastocyst embeds in uterine lining, initiating pregnancy.

Cleavage Significance and Types

- Cleavage distributes cytoplasm among blastomeres.
- Increases protoplasm mobility for cell differentiation and germ layer formation.
- Restores cell size and nucleocytoplasmic ratio.
- Converts unicellular zygote into multicellular embryo.
- Human cleavage is holoblastic (complete division).
- Trophoblast cells near inner cell mass called Rauber cells; form extraembryonic membranes.
- Rauber cells do not form embryo but provide nutrition.
- Inner cell mass is embryo precursor.

Implantation and Zona Hatching

- Implantation occurs ~7 days after fertilisation.
- Zona pellucida prevents premature implantation and exposure of trophoblast cells.
- Blastocyst sheds zona pellucida via zona hatching before implantation.
- Blastocyst inner cell mass faces endometrium for implantation.
- Uterine cells cover blastocyst post-attachment, embedding it in endometrium.

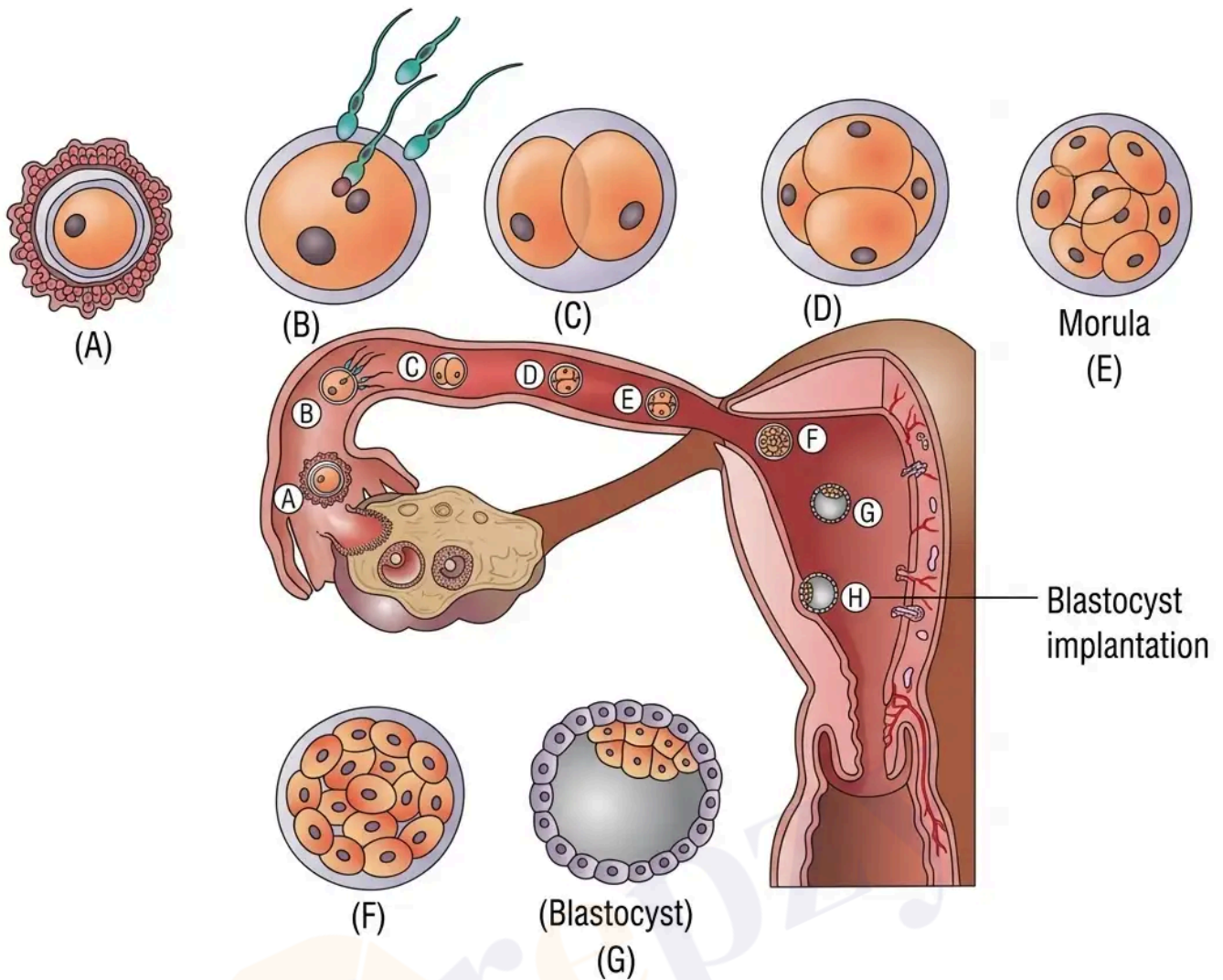


Fig.: Transport of ovum, fertilisation and passage of growing embryo through fallopian tube

Memory Aids

- Insemination = semen into vagina.
- Capacitation = sperm activation by female secretions.
- Acrosomal reaction = enzyme release to penetrate ovum layers.
- Cortical reaction = blocks polyspermy.
- Cleavage = mitotic division without growth.
- Morula = solid ball; blastocyst = hollow ball.
- Zona hatching = blastocyst escapes zona pellucida for implantation.
- Rauber cells = trophoblast cells near inner cell mass, form membranes.

Quick Checkpoints

- What is the site of fertilisation in the female reproductive tract?
- Define capacitation and its significance.
- Which enzymes are involved in the acrosomal reaction?
- What triggers the completion of meiosis II in the oocyte?
- How is sex determined at fertilisation?
- Describe the stages from zygote to blastocyst.
- What is the role of the trophoblast in implantation?
- Explain the function of zona pellucida during early embryo development.
- What is zona hatching and why is it important?

Pregnancy and Embryonic Development

Implantation and Placenta Formation

- Implantation initiates pregnancy.
- Trophoblast forms finger-like chorionic villi surrounded by uterine tissue and maternal blood.
- Chorionic villi and uterine tissue interdigitate to form the placenta.
- Placenta supplies oxygen and nutrients, removes wastes, and connects to embryo via umbilical cord.
- Placenta acts as endocrine tissue producing hCG, hPL, estrogens, progestogens, and relaxin (later stage).
- Pregnancy increases maternal blood levels of estrogens, progestogens, cortisol, prolactin, and thyroxine.

Memory Aids

- Placenta = Nutrient + Waste exchange + Hormone production.
- hCG, hPL, relaxin only during pregnancy.

Quick Checkpoints

- What forms the placenta?
- Which hormones are produced by the placenta?
- Role of umbilical cord?

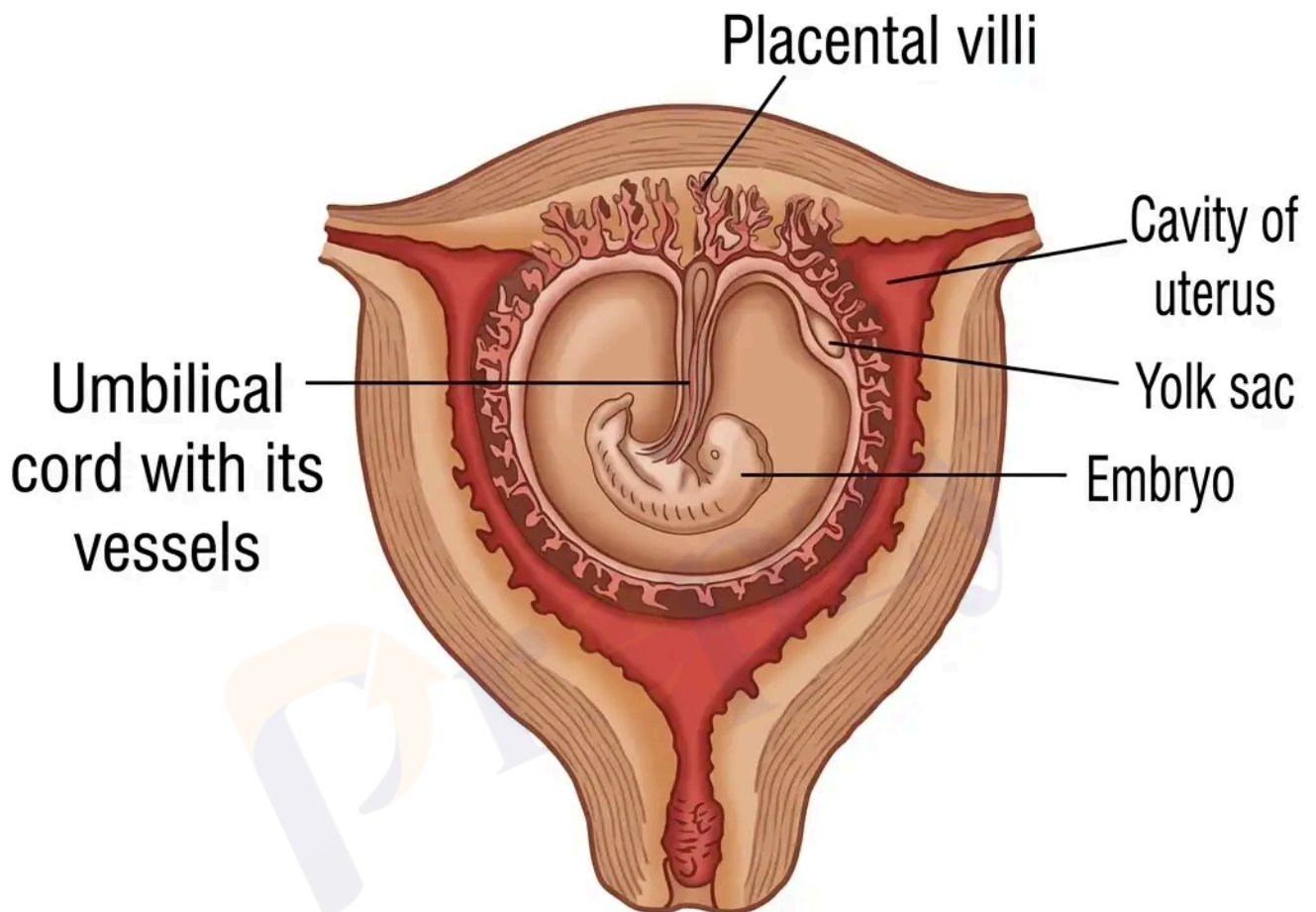


Fig.: The human fetus within the uterus

Embryonic Layers and Development

- 8 days post-fertilization, trophoblast splits into syncytiotrophoblast and cytotrophoblast.
- Inner cell mass contains stem cells forming all tissues and organs.
- Inner cell mass differentiates into epiblast and hypoblast forming embryonic disc.
- Gastrulation transforms blastocyst into gastrula with three germ layers: ectoderm, mesoderm, endoderm.
- Epiblast and trophoblast differentiation forms amniotic cavity with amniotic fluid.

- Trophoblast forms extra-embryonic mesoderm, which splits into somatopleuric and splanchnopleuric layers enclosing extraembryonic coelom.
- Chorion formed by somatopleuric mesoderm and trophoblast; main embryonic placenta part and hCG producer.

Memory Aids

- Gastrulation = Formation of 3 germ layers.
- Chorion = Placenta + hCG source.

Quick Checkpoints

- What are the two layers of trophoblast?
- What forms the embryonic disc?
- Function of chorion?

Amnion and Yolk Sac

- Amnion formed by amniogenic cells and somatopleuric membrane.
- Amniotic fluid acts as shock absorber.
- Hypoblast cells line blastocoel forming primary yolk sac (endodermal cells).
- Extraembryonic mesoderm and coelom reduce yolk sac to secondary yolk sac.
- Three germ layers (ectoderm, mesoderm, endoderm) form by cell movements in triploblastic animals.

Memory Aids

- Amniotic fluid = Shock absorber.
- Yolk sac shrinks from primary to secondary.

Quick Checkpoints

- What forms the amnion?

- Role of amniotic fluid?
- Difference between primary and secondary yolk sac?

Gastrulation and Germ Layers

- Primitive streak is a faint groove on epiblast dorsal surface during gastrulation.
- It defines embryo's head-tail and right-left sides.
- Epiblast cells invaginate below primitive streak (invagination).
- Invaginated cells displace hypoblast to form endoderm.
- Cells between epiblast and endoderm form mesoderm.
- Remaining epiblast cells form ectoderm.
- Three germ layers give rise to all tissues and organs with conserved fate across animals.

Memory Aids

- Primitive streak = Body axis + germ layer formation.
- Invagination = Epiblast cells move inward.
- Germ layers: Ectoderm (outer), Mesoderm (middle), Endoderm (inner).

Quick Checkpoints

- What is the primitive streak?
- Which germ layer forms first?
- What is invagination?

Fate of three germ layers

Ectoderm derivatives

Epidermis of skin, hair, nails, etc. Enamel of teeth, salivary glands, nervous system, mammary glands, parts of eye, ear, pituitary, pineal and mammary glands, etc.

Mesoderm derivatives

Connective tissues like adipose tissue, ligaments, tendons, etc. Dentine of teeth. Heart, kidneys, coelomic epithelium, notochord, mesenteries, reproductive system, except prostate, etc.

Endoderm derivatives

Epithelium of mouth, stomach, Eustachian tube, middle ear, prostate, vagina, thyroid, parathyroid, thymus gland, etc.

Germ Layer Derivatives

- Ectoderm forms skin, hair, nails, nervous system, parts of eyes and ears.
- Mesoderm forms muscles, bones, connective tissue, heart, kidneys, reproductive organs.
- Endoderm forms lining of mouth, stomach, glands, parts of ear and reproductive system.
- All major body structures arise from these three layers.

Memory Aids

- Ectoderm = External structures + nervous system.
- Mesoderm = Muscles + skeleton + organs.
- Endoderm = Internal linings + glands.

Quick Checkpoints

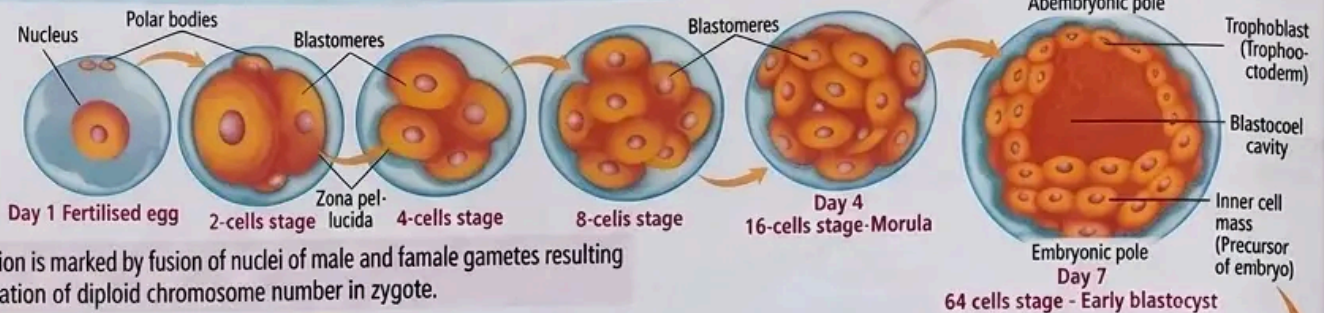
- Which germ layer forms the nervous system?
- What does mesoderm develop into?
- Endoderm gives rise to which organs?

Early Embryonic Development in Humans

Embryonic development in humans begins after conception and formation of zygote. The developing organism from conception until approximately the end of **eight weeks** (second month) is called **embryo**. Various stages of human embryonic development from zygote till the end of second month of pregnancy, have been summarised as follows:

Cleavage : Series of rapid mitotic divisions of the zygote convert single-celled zygote into a multicellular structure called **blastocyst**.

At the end of fourth day embryo reaches uterus. It has 8-16 blastomeres and this solid mass of cells is known as **morula**.

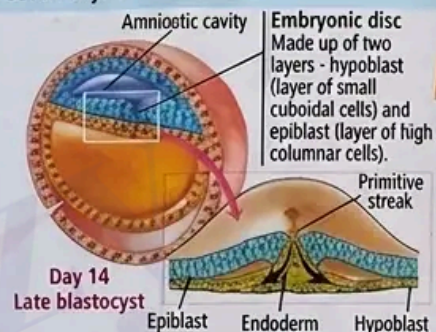


Fertilisation is marked by fusion of nuclei of male and female gametes resulting in restoration of diploid chromosome number in zygote.

Implantation : It is the attachment of blastocyst to the uterine wall which occurs after seven days of fertilisation.

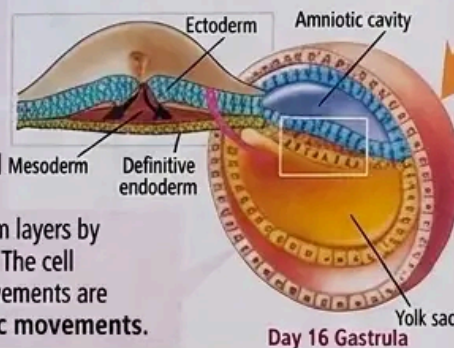
Late blastocyst

It is the pre-embryo in which trophoblast develops into two layers (syncytiotrophoblast and cytotrophoblast) in the region of contact between the blastocyst and endometrium. It sinks into a pit formed in endometrium and gets completely buried in it.

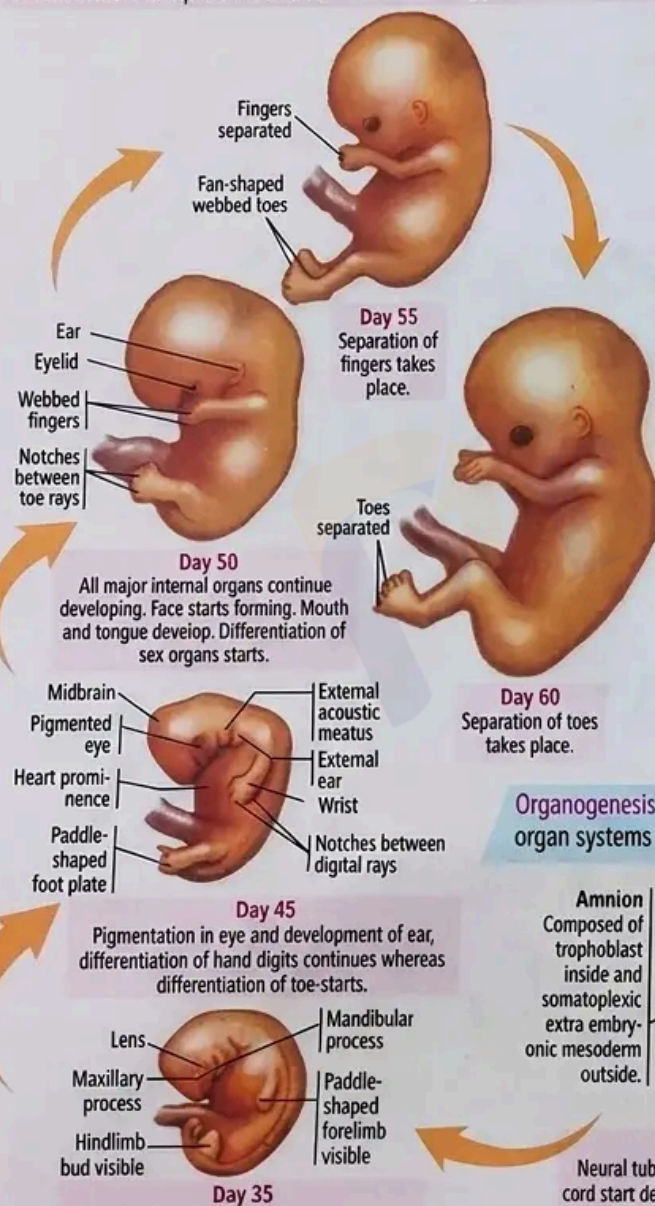


Gastrula

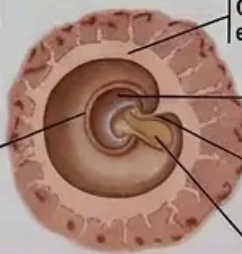
Blastocyst is transformed into **gastrula** with three primary germ layers by rearrangement of cells. The cell rearrangements or movements are called **morphogenetic movements**.



Organogenesis : Following gastrulation, umbilical cord starts developing and various organ systems start differentiating.



Amnion
Composed of trophoblast inside and somatopleuric extra embryonic mesoderm outside.



Day 25

Neural tube develops, brain and spinal cord start developing. Heart, blood vessels

Chorion : Embryonic membrane formed from the somatopleuric extra embryonic mesoderm inside and trophoblast outside.

Amniotic cavity : Space between epiblast and trophoblast, filled with amniotic fluid. Its roof is formed by amniogenic cells derived from trophoblast.

Allantois : Composed of endoderm inside and splanchnopleuric extraembryonic mesoderm outside. Small and non-functional in humans except for furnishing blood vessels to placenta.

Yolk sac
It functions as the site of early blood cell formation.

Early Embryonic Development Stages

- Fertilization: Fusion of male and female gametes forming zygote.

- Cleavage: Rapid cell division forming morula (solid ball) by day 4.
- Blastocyst: Hollow structure with inner cell mass and cavity by day 7.
- Implantation: Blastocyst attaches to uterine wall around day 7.
- Late blastocyst: Trophoblast cells develop for implantation.
- Gastrulation (day 16): Formation of three germ layers.
- Organogenesis: Organs develop, umbilical cord forms, systems differentiate.
- Embryo growth (days 35-60): Development of eyes, ears, limbs, fingers, and toes.
- Transforms single cell into complex embryo.

Memory Aids

- Fertilization → Cleavage → Blastocyst → Implantation → Gastrulation → Organogenesis.
- Day 7: Blastocyst and implantation.
- Day 16: Gastrulation starts.

Quick Checkpoints

- What is the sequence of early embryonic stages?
- When does implantation occur?
- What happens during gastrulation?

Parturition and Lactation

Parturition

- Parturition is the expulsion of the full-term baby from the uterus at the end of gestation.
- Signals originate from the fully developed fetus and placenta, causing mild uterine contractions called fetal ejection reflex.
- Fetal ejection reflex triggers oxytocin release from maternal pituitary.
- Oxytocin stimulates strong uterine contractions to expel the baby.
- Relaxin hormone increases flexibility of pubic symphysis and ligaments.
- Relaxin also helps dilate the uterine cervix during labour.
- Forceful uterine contractions during birth are called labour.
- After birth, placenta and umbilical cord remnants are expelled by uterine contractions, called after birth.

Lactation

- Lactation is milk production from mammary glands.
- Mammary glands differentiate during pregnancy and start milk production near term.
- Initial milk produced for 2-3 days is colostrum.
- Colostrum contains antibodies essential for newborn immunity.

Memory Aids

- Fetal ejection reflex = fetus triggers oxytocin release.
- Relaxin = relaxes ligaments and dilates cervix.
- Labour = strong uterine contractions for birth.
- Colostrum = first milk rich in antibodies.

Quick Checkpoints

- What triggers parturition signals?
- Role of oxytocin in birth?
- Function of relaxin during labour?
- What is colostrum and its importance?
- Define after birth.