

Chapter 2: Human Reproduction

Class XII Biology — Comprehensive Study Notes & Diagrams

1. Introduction to Human Reproduction

Reproduction is a biological process in which an organism produces new, similar offspring for the continuity of the species from generation to generation.

- **Human beings** are unisexual (gonochoric), meaning male and female reproductive organs are found in separate individuals. They exhibit distinct *sexual dimorphism*.
- Human beings are **sexually reproducing** and **viviparous** (they give birth to completely developed young ones).

Key Events in Human Reproduction:

1. **Gametogenesis:** Formation of gametes (sperm in males and ovum in females).
2. **Insemination:** Transfer of male gamete (sperm) into the female genital tract (vagina).
3. **Fertilisation:** Fusion of male and female gametes to form a zygote.
4. **Implantation:** Attachment of the blastocyst to the uterine wall.
5. **Gestation:** The duration between fertilisation and parturition (embryonic development phase).
6. **Parturition:** Delivery/birth of the baby.
7. **Lactation:** Breastfeeding period following childbirth.

Note: Reproductive events occur after **puberty** in human beings. Sperm formation continues even in old men, but ovum formation in women ceases around the age of 50 years (menopause).

2. The Male Reproductive System

Located in the pelvic region, the male reproductive system comprises:

Primary & Secondary Reproductive Organs

- **Primary Organ:** Pair of Testes (produce sperms and male sex hormones).
- **Secondary Organs & Ducts:** Epididymis, Vas Deferens, Ejaculatory Duct, Urethra, Penis (external genitalia).
- **Accessory Glands:** Prostate gland, Bulbourethral (Cowper's) glands, Seminal vesicles.

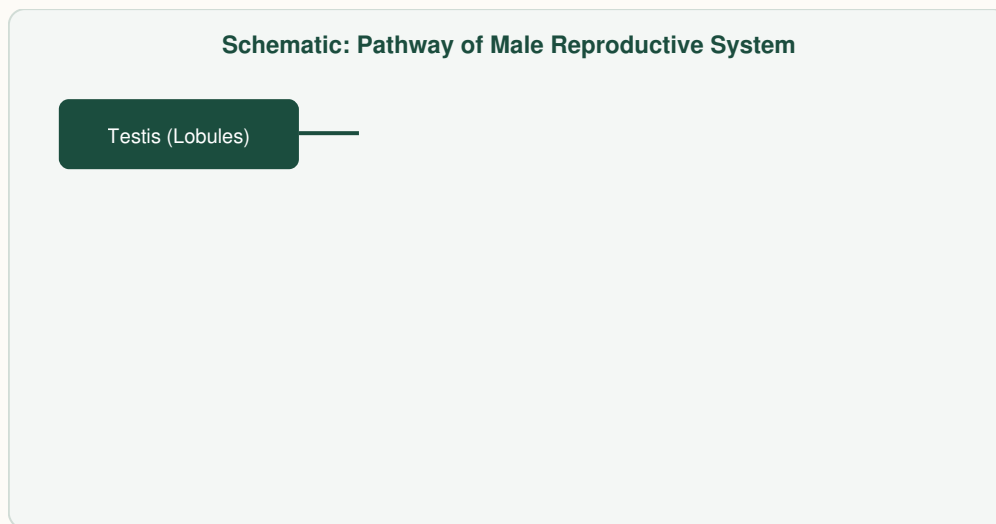


Figure 2.1: Flow diagram representing the male reproductive duct system.

Structure of Testis

A pair of testes is situated outside the abdominal cavity within a pouch called the **scrotum**. The scrotum maintains a lower temperature ($2 - 2.5^{\circ}\text{C}$ below normal body temperature) necessary for spermatogenesis.

Dimensions: Oval shape, length $4-5\text{ cm}$, width $2-3\text{ cm}$.

Each testis contains about **250 compartments** called *testicular lobules*.

Each lobule contains 1 to 3 highly coiled **seminiferous tubules** in which sperms are produced.

Cell Types in Seminiferous Tubules:

Male Germ Cells (Spermatogonia): Undergo meiotic division to form sperms.

Sertoli Cells: Provide nutrition and support to the germ cells/sperms.

Interstitial Space: The region outside seminiferous tubules contains blood vessels and **Leydig cells (interstitial cells)**, which synthesize and secrete male sex hormones (androgens / testosterone).

Testicular Capsules: Two protective layers envelope the testis — outer *Tunica Vaginalis* and inner *Tunica Albuginea*. Connected to scrotum wall via *Gubernaculum*.

Detailed Organs & Accessory Glands

Epididymis: Divided into 3 parts: *Caput* (head), *Corpus* (body), and *Cauda* (tail). Site of sperm maturation and storage.

Vas Deferens: Ascends into the abdomen, loops over the urinary bladder, and connects with the duct of the seminal vesicle.

Seminal Vesicle: Sac-like glandular structure producing alkaline seminal fluid rich in fructose, calcium, and enzymes.

Ejaculatory Duct: Formed by the union of vas deferens and seminal vesicle duct; conveys sperms and secretions into urethra.

Urethra: Originates from urinary bladder/ejaculatory duct through penis to *urethral meatus*. Has 3 parts: Prostatic, Membranous, and Penile Urethra.

Penis: Male copulatory organ composed of erectile tissue (two dorsolateral *Corpora Cavernosa* and one ventral *Corpus Spongiosum*). Enlarged end is *Glans Penis* covered by *Foreskin (prepuce)*.

Prostate Gland & Bulbourethral (Cowper's) Gland: Secrete alkaline fluids that neutralize urethral acidity and provide lubrication during sexual intercourse.

3. The Female Reproductive System

Located in the pelvic region, the female reproductive system includes primary/secondary organs and external genitalia.

Structure of Ovary

- Pair of ovaries, length **2-4 cm**, attached to pelvic wall and uterus by ligaments.
- Covered by thin epithelium enclosing the **ovarian stroma**, divided into peripheral **cortex** and inner **medulla**.
- **Follicular Development:**
 - Primary oocytes formed during embryonic stage get surrounded by granulosa cells forming **Primary Follicles**.
 - At puberty, only **60,000 to 80,000** primary follicles remain in each ovary (many degenerate).
 - Primary follicle → Secondary follicle → Tertiary follicle (characterized by a fluid-filled cavity called **Antrum**).
 - Tertiary follicle matures into **Graafian Follicle** containing the secondary oocyte. Upon rupture, ovum is released (**Ovulation**).
 - Ruptured Graafian follicle transforms into yellow endocrine structure called **Corpus Luteum** (secretes *Progesterone*).

Secondary Reproductive Organs & External Genitalia

- **Oviduct (Fallopian Tube):** **10-12 cm** long. Consists of *Infundibulum* (funnel-shaped with finger-like projections called *fimbriae*), *Ampulla* (site of fertilisation), and *Isthmus*.
- **Uterus (Womb):** Inverted pear-shaped organ. Opens into vagina via *cervix* (cervical canal + vagina = birth canal).
Uterine Wall Layers:
 1. **Perimetrium:** External thin membrane.
 2. **Myometrium:** Middle thick smooth muscle layer (strong contractions during birth).
 3. **Endometrium:** Inner glandular layer that undergoes cyclic changes during menstrual cycle.
- **Vulva (External Genitalia):** Includes *Mons Pubis*, *Labia Majora*, *Labia Minora*, *Clitoris*, *Vestibule*, and *Hymen*.

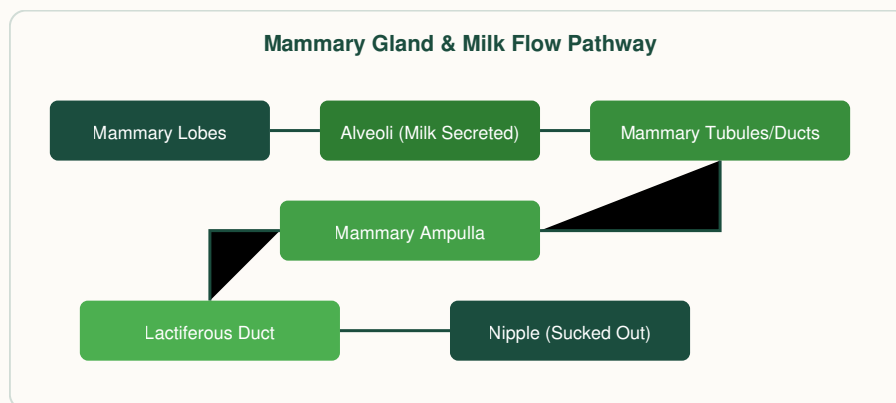


Figure 3.1: Pathway of milk secretion and conduction in Mammary Glands.

4. Gametogenesis

The process of formation of haploid male gametes (sperms) and female gametes (ovum) in testes and ovaries respectively.

A. Spermatogenesis

Process of sperm formation in testes. Consists of two stages: **Formation of Spermatids** and **Spermiogenesis**.

Phase	Ploidy & Chromosome No.	Process Description
Multiplication Phase	Diploid ($2n = 46$)	Primordial germ cells undergo repeated mitosis to produce <i>Spermatogonia</i> .
Growth Phase	Diploid ($2n = 46$)	Spermatogonia accumulate nutrition and enlarge to become <i>Primary Spermatocytes</i> .
Maturation Phase	Meiosis I: Haploid ($n = 23$) Meiosis II: Haploid ($n = 23$)	Primary spermatocyte undergoes Meiosis I → 2 <i>Secondary Spermatocytes</i> → Meiosis II → 4 equal <i>Spermatids</i> .
Spermiogenesis	Haploid ($n = 23$)	Transformation of non-motile <i>Spermatids</i> into functional motile <i>Spermatozoa (Sperms)</i> .

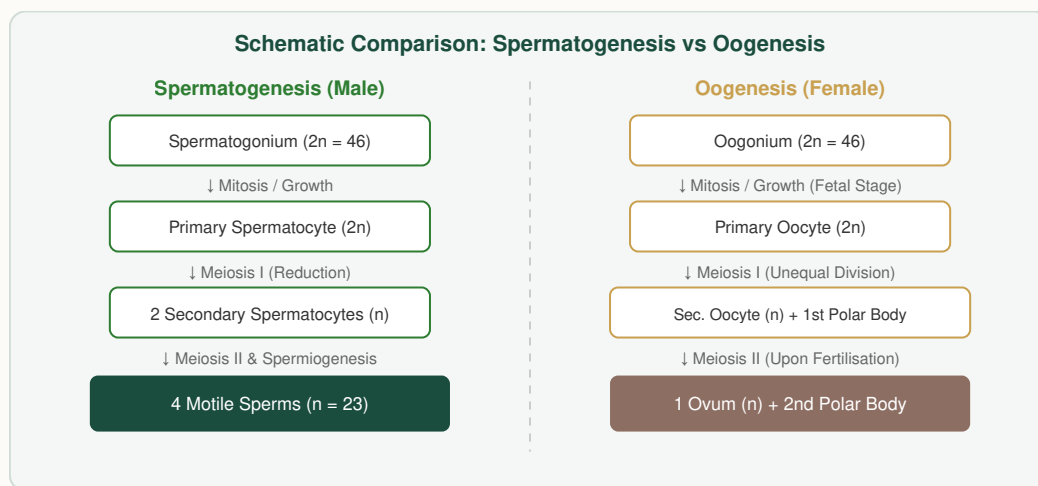


Figure 4.1: Comparative cellular stages of Spermatogenesis and Oogenesis.

Structure of Sperm

- **Head:** Contains elongated haploid nucleus. Front is covered by cap-like **Acrosome** filled with lytic enzymes (*Hyaluronidase, Acrosin, Zona lysin*) to penetrate ovum outer layers.
- **Neck:** Connects head and middle piece; contains centrioles.
- **Middle Piece:** Contains numerous spiral mitochondria (*Nebenkern*) that generate ATP/energy for motility.
- **Tail:** Long axial filament facilitating whip-like movement.

Hormonal Control of Spermatogenesis

Hypothalamus secretes **GnRH** → Anterior Pituitary releases **LH** and **FSH**.

- **LH:** Acts on Leydig cells → stimulates synthesis/secretion of *Androgens (Testosterone)* → stimulates Spermatogenesis.
- **FSH:** Acts on Sertoli cells → secretes factors essential for *Spermiogenesis*.

B. Oogenesis

The process of formation of a mature female gamete (ovum). Initiated during **embryonic development** (fetal stage). No oogonia are added after birth.

- Primary oocytes remain arrested at **Prophase-I** of meiotic division until puberty.

- **Meiosis I (Unequal):** Produces a large haploid *Secondary Oocyte* and a tiny *1st Polar Body*.
- **Meiosis II:** Occurs after sperm entry, producing 1 functional *Ovum (Ootid)* and a *2nd Polar Body*.

5. Menstrual Cycle

Reproductive cycle in female primates (monkeys, apes, humans) lasting approximately **28-30 days**.

- **Menarche:** The first menstruation beginning at puberty (11-13 years).
- **Menopause:** Cessation of menstruation around 50 years of age.

Phases of Menstrual Cycle

1. **Menstrual Phase (Days 1-5):** Breakdown of endometrial lining and uterine blood vessels resulting in menstrual flow through vagina. Occurs when released ovum is not fertilised.
2. **Follicular / Proliferative Phase (Days 6-13):** FSH stimulates primary follicles to grow into mature Graafian follicles. Graafian follicles secrete *Estrogen*, causing proliferation and thickening of the endometrium.
3. **Ovulatory Phase (Day 14):** Rapid surge of LH (*LH Surge*) reaches peak level, causing rupture of Graafian follicle and release of ovum (**Ovulation**).
4. **Luteal / Secretory Phase (Days 15-28):** Ruptured follicle converts to **Corpus Luteum**, which secretes high levels of *Progesterone* (essential for endometrial maintenance and implantation). In absence of fertilisation, Corpus Luteum degenerates into *Corpus Albicans*, triggering a new cycle.

6. Fertilisation, Implantation & Sex Determination

- **Fertilisation:** Occurs in the **Ampulla** of the fallopian tube. Sperm acrosomal enzymes dissolve *Zona Pellucida* to allow nuclear entry, inducing block to polyspermy.
- **Zygote & Cleavage:** Mitotic cleavage transforms zygote $\rightarrow 2 \rightarrow 4 \rightarrow 8 \rightarrow 16$ cells (*Blastomeres*). Solid 8-16 cell ball is **Morula**.
- **Blastocyst & Implantation:** Morula develops into **Blastocyst** (32-64 cells) with outer layer *Trophoblast* and inner mass *Inner Cell Mass*. Trophoblast attaches to endometrium (*Implantation*), leading to pregnancy.
- **Sex Determination:** Female is homogametic (**44 + XX**), Male is heterogametic (**44 + XY**). Sperm carrying either X or Y chromosome determines sex:
 - $22 + X \text{ ext{ sperm}} + 22 + X \text{ ext{ ovum}} \rightarrow 44 + XX \text{ ext{ (Female 50\%)}}$
 - $22 + Y \text{ ext{ sperm}} + 22 + X \text{ ext{ ovum}} \rightarrow 44 + XY \text{ ext{ (Male 50\%)}}$

7. Pregnancy, Embryonic Development & Parturition

- **Placenta:** Structural and functional unit formed by *Chorionic villi* and maternal uterine tissue.
Functions: Provides **ext{O}_2** and nutrients to fetus, removes **ext{CO}_2** and metabolic waste. Acts as temporary endocrine gland secreting **hCG, hPL, Estrogen, Progesterone, and Relaxin**.
- **Embryonic Milestones:**
 - *1st Month: Heart is formed (detected via stethoscope).*
 - *2nd Month: Limbs and digits develop.*
 - *12 Weeks (1st Trimester): Major organ systems formed, external genitalia visible.*
 - *5th Month: First fetal movements and head hair appearance.*
 - *24 Weeks (2nd Trimester): Eye-lids separate, eyelashes form, fine body hair.*
 - *9 Months: Fetus fully developed.*

- **Parturition:** Complex neuroendocrine mechanism. Mild uterine contractions (Foetal Ejection Reflex) trigger release of **Oxytocin** from maternal pituitary, inducing strong uterine contractions to expel baby through birth canal.
- **Lactation:** Mammary glands produce milk post-delivery. Initial milk produced is **Colostrum**, rich in antibodies (IgA), nutrients, and vitamins that provide passive immunity to the newborn.