LECTURE 10: REPRODUCTIVE SYSTEMS

INTRODUCTION
The only system not essential for life, but ensures continued human existence. However all living organisms must reproduce in order to continue their species. Humans reproduce by sexual reproduction with internal fertilization, where a flagellated sperm (gamete) fertilizes an ovum (gamete) producing a zygote. These two gametes meet within the female's uterine tubes located one on each side of the upper pelvic cavity. In sexual reproduction, the genetic information is contributed by both parents, and therefore a unique combination of genetic information results in each zygote.

ORGANS OF REPRODUCTIVE SYSTEM
Both male and female reproductive system consists of:
1. Gonads (ovaries and testes) = reproductive organs which are responsible for production of gametes (sperm and egg) and sex hormones
   a. Testes (male gonads) secrete sex hormones (androgen = primarily testosterone) and produce about 1.5 billion gametes (spermatozoa) per day.
   b. Females ovaries (gonads) release one immature gamete (oocyte) per month
2. Ducts and tubes - transport sperm and egg and connect to passageways that opens to exterior
3. Accessory Glands and organs that secrete fluid and provide support
   a. In male accessory glands such as Prostate gland and Seminal vesicle produce secretion that mixes with sperm prior to ejaculation and bulbourethral gland produce an alkaline lubricant to lubricate penis and prepare it for intercourse.
   b. In female uterus provide support and protection to the growing embryo and fetus
   c. Oocyte travels along uterine tube to uterus
4. Perineal structures (external genitalia)

THE FUNCTIONS OF THE REPRODUCTIVE SYSTEMS
The various reproductive organs work together to: produce gametes (egg and sperm cells); transport and sustain these cells; nurture and maintain the developing zygote/fetus (female only); produce sex hormones (male = testosterone, female = estrogens and progesterone). These functions are divided between the primary and secondary, or accessory, reproductive organs. The primary reproductive organs, or gonads, consist of the ovaries and testes. These organs are responsible for production of gametes, and sex hormones. Functions of sex hormones include: maturation of the reproductive system; development of secondary sexual characteristics (e.g. growth of breasts in female and deepening voice in and facial hair growth in male); and regulating the normal physiology of the reproductive system. All other organs (accessory or secondary reproductive organs such as ducts, and glands) are responsible for transporting and sustaining the gametes and nurturing the developing offspring (in female).

SIMILARITIES BETWEEN MALE AND FEMALE REPRODUCTIVE SYSTEMS
The reproductive systems of the male and female have some basic similarities and some specialized differences. They are the same in that most of the reproductive organs of both sexes develop from similar embryonic tissue, meaning they are homologous. Both systems have gonads (male have testes and female have ovaries) that produce gametes (testes produce sperm and ovaries produce egg or ovum) and sex organs. And both systems experience maturation of their reproductive organs, which become functional during puberty as a result of the gonads secreting sex hormones. The testis and ovary share several similarities. A connective tissue capsule, the tunica albuginea, surrounds both. Both rely on mitosis and meiosis to produce gametes. Both respond to follicle stimulating hormone (FSH) and leutinizing hormone (LH). Both produce sex steroids. But differences abound as well. The testis produces spermatozoa almost without limit whereas the number of ova is fixed before birth i.e. a female is born with a predetermined number of oocytes and cannot produce new ones, whereas male continuously produces sperm. Oocytes are ovulated (released one ova per menstrual cycle) from puberty to menopause. Also, although gametogenesis involves two meiotic divisions in both, each primary oocyte yields a
single ovum rather than four spermatozoa i.e. meiosis in male produces four sperm, whereas meiosis in female produce one function egg and 3 polar bodies (non-functional eggs).

MEIOSIS

Introduction: The genetic information of living organisms is DNA (deoxyribonucleic acid) that is carried on the genes of chromosomes. Think of chromosome as a cook book and gene as a recipe. A cook book may have thousands of recipes; a chromosome may have thousands of genes. Each recipe is instruction for preparing one dish, each gene is a chemical code (instruction) for making one protein. A recipe is a step by step instruction on how to prepare a dish using the available material in the kitchen; a gene is a chemical code that has step by step instruction on how to make a specific protein using the available amino acids in the cell. Different dishes are made by addition different ingredients in different combinations; different proteins are made by creating a polymer of amino acids in different sequences. For example as an analogy let’s assume that in the following sentences the three letter words are different amino acids. FAT CAT EATS THE RED BUG; RED BUG EATS THE FAT CAT; RED CAT EAT THE FAT BUG. As you could see by changing the sequences of words (amino acids) different sentences (proteins) are made.

In humans, each somatic (body) cell is diploid, which means the cell contains 46 chromosomes or 23 pairs. A diploid cell means the cell have two sets of chromosomes (one from each parent) i.e. we have two set of chromosome number one (one from our dad and one from our mom), two sets of chromosome number two and so one we have 23 pairs of chromosome. Human sex cells or gametes, however, are haploid, which means the cell contains only 23 chromosomes i.e. sperm and egg contain only one set of chromosome. Meiosis is the type of cell division that results in gametes that possess half the chromosome number of the parent cell (i.e. meiosis reduces the chromosome number by one-half).

1. Male sperm (haploid) = 23 chromosomes (1 set).
2. Female egg (haploid) = 23 chromosomes (1 set).
3. Fertilization (fusion of egg and sperm) = (zygote diploid) = 46 chromosome (2 sets: one from sperm and one from egg) i.e. 50% of genes from mother and 50% of genes from fate
4. Meiosis is called spermatogenesis in the male. It occurs in testes (to be more specific it occurs in seminiferous tubes which are located inside testes).
5. Meiosis is called oogenesis in the female (it occurs ovaries).
6. Meiosis consist of two round of nuclear divisions (meiosis I and meiosis II), and each round of nuclear division consist of four phases.
   a. First Meiotic Division/Meiosis I: Prophase I; Metaphase I; Anaphase I; Telophase I
   b. Second Meiotic Division/Meiosis II: Prophase II; Metaphase II; Anaphase II; Anaphase II; Telophase II
      i. At the end of meiosis II 4 gametes with 23 chromosomes are produced.
         1. During spermatogenesis, 4 sperm result.
         2. During oogenesis, only 1 ovum results due to unequal cytokinesis (i.e. polar bodies result; discussed later). Why? Because at the end of 1st meiotic division one ovum gets all the cytoplasm and the other ovum gets no cytoplasm and then again at the end of 2nd meiotic division one ovum gets all the cytoplasm and the other ovum gets no cytoplasm. This ensures that at least one egg should have enough cytoplasm (more cytoplasm means more food storage to support the zygote for 4-7 days until placenta is formed).

ORGANS OF THE MALE REPRODUCTIVE SYSTEM

The purpose of the organs of the male reproductive system is to: produce, maintain, and transport spermatozoa and protective fluid (semen); discharge sperm within the female reproductive tract during sex; produce and secrete male sex hormones responsible for maintaining the male reproductive system. Organs of reproductive system include:

1. Testes – testes is responsible for sperm production and production of hormones such as Testosterone.
2. Tube/Ductules – tubes and ductules store spermatozoa and transport spermatozoa to deposit it in female vagina during intercourse.
3. **Accessory Glands** – accessory gland secrete enzymes, alkaline fluid to buffer the acidic vaginal fluid and prevent damage to the spermatozoa by acid, fructose that can be used by the spermatozoa for energy, antimicrobial agent to kill any microorganism, and lubricant to smoothen and lubricate the penis prior to intercourse.

4. **External genitals** – deposit sperm into the female reproductive organs

**TESTES**
Tests is the primary male sex organs which produce sperm and male sex hormones. Testes are suspended outside the abdominal cavity by the scrotum, a pouch of skin that keeps the testes close or far from the body at an optimal temperature for sperm development i.e. scrotum has a built-in thermostat to maintain temperature of the testes at about thirty-five degrees Celsius (ninety-five degrees Fahrenheit. NOTE: body temperature is thirty-seven degrees Celsius (ninety-eight point six degrees Fahrenheit)). If it becomes too cool on the outside, the scrotum will contract to bring the testes closer to the body for warmth (scrotum appears tightly wrinkled), and when is becomes too hot, scrotum will relax to keep testes away from the body. Scrotum is divided internally into two halves (two chambers) where each chamber contains a testis. Seminiferous tubules are inside each testis, and are where sperm are produced by meiosis. Seminiferous tubules are packed into each testis. Spermatocytes inside the tubules divide by meiosis to produce spermatids that in turn develop into mature sperm.

1. **Descent of the Testes**
   a. Originate as retroperitoneal masses of tissue near adult kidney location and at 7-8 months gestation testes move through abdominal wall to scrotum.
   b. Descent is stimulated by testosterone.

2. **Structure of the Testes:**
   a. Ovoid structures held within the scrotum, outside the male body
   b. Each testis is divided into a series of **lobules. Each lobule is separated by projections** of the tunica albuginea called septa.
   c. Each lobule contains:
      i. **Seminiferous tubules** are tightly packed tubules located within lobules of the testes. The seminiferous tubules are the functional units of the testis, where spermatogenesis takes place i.e. sperm production occurs in seminiferous tubule.
      ii. Spermatozoa are produced by the process of spermatogenesis at the outermost layer of cells in the seminiferous tubules and proceeds toward the lumen of seminiferous tubules.
      iii. Each seminiferous tubule forms a loop and is connected to rete testes (maze looking network of tubular passageways) by afferent ducts.
      iv. Large efferent ductules connect the rete testis to the epididymis (this duct is outside the testes) that is connected to rete testis i.e. efferent ductules connect ducts located inside the testes to ducts located outside the testes.
      v. Overall pathway of sperms are as follow (red = inside the testes, blue = outside the testes): Seminiferous tubes → Afferent tubes → Rete testes → Efferent tubes → epididymis → duct deferens → ejaculatory duct → urethra → outside (vagina)
vi. **Interstitial cells** (of Leydig) - In between the seminiferous tubules within the testes, are interstitial cells, or, Cells of Leyden. They are responsible for secreting the male sex hormones (testosterone).

**FORMATION OF SPERM CELLS**

1. The **seminiferous tubules** are lined by stratified **epithelium**.
2. This germinal epithelium consists of **two types of cells**: Spermatogonium and Sustentacular cells
   a. **Spermatogenic cells** give rise to sperm cells.
   b. **Sustentacular cells** (Sertoli cells) support and nourish the spermatogenic cells, secrete androgen-binding protein, secrete inhibin, maintain the blood-testis barrier.
3. **Spermatogenesis**: Males produce sperm from puberty and then throughout life.
   a. The sperm is produced in the germinal epithelium of the seminiferous tubules.
   b. Sperm cells are produced from **spermatogonia cells**.
   c. First stem cells (spermatogonia which contain 23 pairs (or 46) of chromosomes) divide by mitosis to produce two daughter cells. One of the daughter cell differentiate into primary spermatocytes, and the other daughter cell stays as spermatogonia cell. This maintains the population of spermatogonia cell, and ensures the continuous production of sperm throughout the life (beginning from puberty)
   d. Primary spermatocytes undergo through the process of meiosis and produce 4 spermatids.
   e. Each spermatid goes through the process of spermiogenesis and differentiate into spermatozoa i.e. spermatid (without flagella) becomes spermatozoa (with flagella). Following spermiogenesis, the structure of a mature sperm cell consists of a head, a body, and a flagellum. Spermiogenesis involves major changes in a spermatid’s internal and external structures.
      i. The **head** contains nucleus (23 chromosomes). It is covered by a helmet like structure called an **acrosome** which contains enzymes hyalurodinaze (modified lysosome that is packed with zona-digesting enzymes called hyalurodinaze) to help penetrate the oocyte i.e. hyalurodinaze break down the outer membrane of the ovum, called the zona pellucida, allowing one of the sperms penetrate the ovum.
      ii. The **body** (mid-piece) contains many mitochondria needed to produce ATP for energy for the sperm cell to complete its long journey
      iii. The **flagellum** is a **tail** that provides locomotion for the sperm cell
   f. Overall sequence of spermatogenesis include: Mitosis, Meiosis, Spermiogenesis
i. One spermatogonium undergoes through the process of mitosis and gives rise to two spermatocytes.
ii. One primary spermatocyte undergoes meiosis I. This gives rise to
iii. Two secondary spermatocytes, which undergo meiosis II. This gives rise to
iv. Four spermatids. These cells mature into
v. Four sperm cells (spermatozoa through a maturation process called, spermiogenesis. The sperm cells collect in the lumen of the seminiferous tubule and then move up the tubules to the rete testes and then to epididymis where they are stored.

MALE REPRODUCTIVE TRACTS (TUBES/DUCTULES)
1. Epididymes (s); epididymis (pl):
   a. Tightly coiled tube on the outside of testes leading to ductus or vas deferens
   b. Spermatozoa are produced in the seminiferous tubes, and as they physically mature fluid currents, created by cilia transport the immobile spermatozoa into the epididymis (the start of the male reproductive tract)
   c. epididymis is the primary site of storage of sperm cells i.e. as spermatozoa are transported into the epididymis, they are stored there
   d. Function:
      i. It monitors and adjusts the composition of the fluid produced by the seminiferous tubules.
      ii. It acts as a recycling center for damaged spermatozoa.
      iii. It stores and protects spermatozoa and facilitates their functional maturation. NOTE: Although spermatozoa leaving the epididymis are physically mature, but they are functionally immature (they remain immobile and they cannot fertilize an egg).
iv. To become motile (actively swimming) and fully functional, they undergo **capacitation**: (1) mixed with secretions of the seminal vesicles,(become mobile); (2) exposed to conditions in the female reproductive tract(become capable of fertilization)

v. Capacitation involves removal of steroid (e.g. cholesterol) and seminal glycoproteins from the head of the sperm by the vaginal fluid. This exposes the acrosomal head of the sperm and allows greater binding between sperm and oocyte

2. **Ductus** (or Vasa) **Deferentia (s); ductus (or vas) deferens** (pl):
   a. A muscular tube which passes upward from testis passes through parietal peritoneum (inguinal canal) and into abdominal cavity. Just before it reaches prostate gland and seminal vesicles, its lumen enlarges (This expanded portion is known as the **ampulla**)
   b. **Ampulla** fuses with duct from seminal vesicle to form **ejaculatory duct** (within prostate gland).
      The junction of the ampulla with the duct of the seminal vesicle marks the start of the **ejaculatory duct** (short passageway penetrates the muscular wall of the prostate gland and empties into the urethra).
   c. Peristaltic contractions propel spermatozoa and fluid along the duct deferens during ejaculation.

3. The **Urethra**
   a. Extends 18–20 cm from the urinary bladder to the tip of the penis and it is shared by both reproductive and urinary systems i.e. both sperm and urine passes through this passageway.
   b. It is divided into prostatic, membranous, and penile regions

**MALE ACCESSORY GLANDS**

1. Seminiferous tubules and the epididymis fluid account for only about 5 percent of the volume of semen ejaculated. The rest of the volume of ejaculated semen is produced by male reproductive glands. Important glands include the seminal vesicles, the prostate gland, and the bulbourethral glands.

2. **Seminal Vesicles**:
   a. The ductus deferens on each side ends at the junction between the ampulla and the duct that drains the seminal vesicle
   b. Each seminal vesicle is a tubular sac-like structure attached to vas deferens
   c. Seminal vesicles are active secretory glands and they contribute about 60-70 % of semen volume i.e. about 60 to 70 percent of semen that is ejaculated are produced by the seminal vesicles.
   d. Secretion of the seminal vesicles contains fructose, prostaglandins and fibrinogen
      i. Fructose is used (metabolized) by the spermatozoa for energy (ATP). NOTE: sperm has a very small body, and this means less amount of cytoplasm, and it also means less storage of energy. Yet sperm has to travel a long distance to reach the egg, therefore it need nutrient that can be metabolized and used for energy.
      ii. Prostaglandin stimulate contraction of smooth muscle along the reproductive tracts, and the contraction helps (pushes) the sperms and make their travel easier (because they receive an extra push as they swim)
      iii. Fibrinogen forms a temporary clot after ejaculation (within the vagina) to protect sperms from the acidic environment in vagina i.e. the sperms on the surface of the clot will be exposed to the acidic environment of vagina and will die, but the sperms in the core (center) of the clot will be protected.
   e. Seminal vesicle secretion are discharged into ejaculatory duct at emission (during ejaculation) and mixed with spermatozoa
   f. Spermatozoa become mobile after mixing with seminal vesicles secretion

3. **Prostate Gland**:
   a. Small, muscular, rounded organ that encircles the proximal portion of the urethra as it leaves the urinary bladder
   b. Produces prostatic fluid which accounts for about 20–30 % of semen volume
   c. Secretion of prostate gland contain
      i. **Seminalplasmin**, (antibiotic that prevent urinary tract infections)
ii. A milky, **alkaline fluid**, which enhances sperm motility and neutralizes acidic pH of vagina.

4. **Bulbourethral Glands:**
   a. Two small exocrine structures beneath prostate (at the base of the penis)
   b. Secrete a mucous like lubricant for penis
   c. Secretion of bulbourethral gland not only lubricates the penis prior to intercourse, it also helps to neutralize any urinary acids (droplets of urine that can be in the urethra)

5. **Semen**
   a. A typical ejaculation releases 2–5 ml of semen that contain:
      i. Spermatozoa. 20 million to 100 million per milliliter.
      ii. Seminal fluid is a mixture of glandular secretions with a distinct ionic and nutrient composition.
      iii. Enzymes. (1) protease (help dissolve mucous secretions in the vagina); (2) seminalplasmin, (antibiotic enzyme kills a variety of bacteria) (3) prostatic enzyme (converts fibrinogen to fibrin after ejaculation) (4) fibrinolysin, (liquefies the clotted semen)
      iv. Semen = sperm cells (from testes); alkaline fluids and enzymes (from prostate); fructose, prostaglandin, and fibrinogen (from seminal vesicles) and lubricant (from bulbourethra).

**MALE EXTERNAL REPRODUCTIVE EXTERNAL GENITALS**

1. **Scrotum:**
   a. A pouch of skin and subcutaneous tissue that encloses the testes (see testes for more details)

2. **Penis:**
   a. It is a tubular male excitatory organ through which the distal portion of the urethra passes
   b. Penis is divided into three regions: (1) the root, (2) the body, and (3) the glans (prepuce, or foreskin, surrounds the tip of the penis and covers the glans)
   c. Specialized to become erect for insertion into vagina during sexual intercourse
   d. The penis is composed of three cylindrical columns of **erectile tissue:**
      i. A pair of parallel spongy columns called the corpora cavernosum i.e. Pair of dorsally located **corpora cavernosa** and
      ii. Single **corpus spongiosum**,
   e. **Erection, Orgasm, and Ejaculation**
      i. **Erection** = enlargement, and stiffening of the penis result from the engorgement of the erectile tissues when a man becomes aroused, and parasympathetic nerve induces (relax the smooth muscles in the penis), allowing blood to flow into the tiny pool-like sinuses and flood the penis i.e. vascular spaces within erectile tissue become engorged with blood when male becomes sexually stimulated.
         1. Erection is caused by increased arterial flow filling the erectile tissues and compression of veins, thus trapping blood in the penis.
         2. In resting state arterial branches constricted and muscular partitions are tense to restrict blood flow into the erectile tissue.
         3. In activity parasympathetic nervous system release neurotransmitter that dilate blood vessels: 1) vessels dilate, 2) blood flow to the erectile tissue increases 3) the vascular channels become engorged with blood, 4) **erection** of the penis occurs
      ii. **Emission** = movement of semen from epididymis into urethra.
      iii. **Ejaculaion** = forceful movement of semen from urethra to outside caused by sympathetic nervous system.
      iv. **Orgasm** = culmination of sexual stimulation accompanied by involuntary rhythmic contractions of the epididymis causing emission and ejaculation of semen, resulting in a sense of psychological and physiological release.
HORMONAL CONTROL OF THE MALE REPRODUCTIVE SYSTEM

1. Hypothalamic and Pituitary Hormones
   a. At puberty, the hypothalamus secretes gonadotropin releasing hormone (GnRH) that targets the male’s anterior pituitary gland.
   b. The anterior pituitary gland then secretes two gonadotropins when stimulated by GnRH: FSH and LH
      i. Follicle stimulating hormone (FSH), stimulates sustentacular cells in the testes and initiates spermatogenesis in the germinal epithelium of seminiferous tubules
      ii. Luteinizing hormone (LH) stimulates the interstitial cells to produce male sex hormones (testosterone).
   c. Male Sex Hormones = Androgens (Testosterone)
      i. Testosterone is the major androgen whose production begins at puberty.
      ii. Testosterone stimulates development of secondary sex organs of the male:
         1. Facial, axillary, pectoral, and inguinal hair follicles i.e. increased growth of body hair
         2. Increases bone and muscle growth
         3. Thickening of vocal cords of larynx i.e. lower-pitched voice
         4. Increase metabolism
         5. Stimulates spermatogenesis
         6. Increases/enhances sex drive

2. Regulation of Male Sex Hormones
   a. Negative feedback mechanism regulates testosterone concentration and keeps is at relatively stable day-to-day levels.
   b. As [testosterone] increases, the hypothalamus and pituitary gland is inhibited, decreasing anterior pituitary secretion of gonadotropins. FSH and LH secretion decreases and decreased FSH means decreased sperm production, and decreased LH means testosterone secretion decreases.
   c. As [testosterone] decreases, the hypothalamus signals anterior pituitary to secrete gonadotropins (FSH and LH). FSH means sperm production starts again.

ORGANS OF THE FEMALE REPRODUCTIVE SYSTEM
The ovaries are the main reproductive organs of a woman. The two ovaries, which are about the size and shape of almonds, produce female hormones (estrogens and progesterone) and eggs (ova). All the other female reproductive organs (fallopian tubes, the uterus, the vagina and external genitals) are there to transport, nurture and otherwise meet the needs of the egg or developing fetus. The female gonads, ovaries, are located within the lower abdominal cavity.

OVARIES
1. Primary female sex organs which produce ova (eggs) and female sex hormones
2. Broad ligament – fold in peritoneum that attaches to ovary, uterus, and uterine tubes
3. Ovary Structure
   a. Solid ovoid structures that are located (one on each side) on the posterior wall of the pelvic cavity
4. Primordial Follicles
   a. During prenatal development, oogonia divide by mitosis to produce more oogonia that develop into primary oocytes.
   b. Each primordial follicle contains a primary oocyte and a layer of flattened epithelial cells.
   c. The primary oocyte begins to undergo meiosis, but the process soon halts and does not resume until puberty i.e. female is born with about 1 million eggs and all the eggs are at the prophase of meiosis I. All the eggs will stop the process of meiosis and this process will halt until puberty.
   d. The number of oocytes steadily declines throughout the life of a female.
   e. By the age of puberty there will be about 400 thousand eggs left and all the eggs will be still at
prophase of meiosis I.

f. At puberty, once each month, FSH stimulates about dozen primary oocyte (eggs that are in prophase of meiosis I) to start Meiosis I. Dozen of eggs start the process of meiosis from prophase of meiosis I, and only one of the eggs will proceed as far as metaphase of meiosis II (Secondary oocyte) and then the process of meiosis will halts (stops) again. The secondary oocyte is then ovulated from the ovary (under influence of LH) i.e. a surge in LH hormone stimulates ovulation. The ovulated egg is in metaphase of meiosis II.

g. The secondary egg enters the uterine tube, and if there is sperm to fertilize the egg, the process of meiosis will be completed, however if there is no sperm, the process of meiosis will never be completed and the egg will degrade.

h. The process will start again with the next cycle (next month) i.e. ovulation occurs once a month

i. During child bearing years, each month FSH stimulates about dozen primordial follicle to mature and only one will mature to secondary follicle:

5. Ovulation:
   a. Oogenesis (meiosis I) is complete as the follicle matures to secondary follicle right before ovulation
   b. Upon maturation, luteinizing hormone (LH) causes the follicle to burst, releasing a secondary oocyte and leaving behind cells (the layer of cells left behind called corpus luteum).
   c. After ovulation, the oocyte is drawn into the uterine (fallopian) tube, via fimbriae.
   d. Uterine Tubes (Fallopian Tubes, Oviducts) - Fertilization typically occurs in fallopian tube.

UTERUS

A muscular organ that receives embryo and sustains its life during development. The uterine wall has three layers: endometrium, myometrium and perimetrium.

1. **Endometrium** = inner lining i.e. endometrium is the inner layer of the uterine wall.
   a. Site of implantation of blastocyst

2. **Myometrium** = bundles of smooth muscle; bulk of uterus.

3. **Perimetrium** = visceral covering.

4. Lower one-third (inferior portion) of uterus narrows to form cervix i.e. cervix is the tubular part of the uterus that extends downward into the upper vagina. Pap smears are taken from cervical tissue.

VAGINA

Passageway from cervix to outside, its function is to: receive erect penis, convey uterine secretions, and to transport offspring during birth. The **hymen** is a membrane composed of epithelium and connective tissue, which partially closes the vaginal orifice.

EXTERNAL GENITALS

The external genitalia, also called the vulva or pudendum, include the mons pubis, labia, clitoris, and structures associated with the vestibule.

1. **Labia majora** are external rounded folds of adipose tissue and skin that enclose and protect underlying organs and tissues.

2. **Labia minora** are flattened, longitudinal folds between labia majora and they are well supplied with blood vessels

3. **Clitoris** is an excitatory organ that resembles male penis. It is a small projection at the anterior end of the labia, and it is composed of two columns of erectile tissue

4. **Vestibule** is space between labia minora that encloses vaginal and urethral openings. Vestibular glands secrete mucus into the vestibule during sexual stimulation.
ERECTION, LUBRICATION, AND ORGASM

1. **Erection** = erectile tissues of clitoris and vestibular bulbs become engorged with blood and swell during sexual stimulation.

2. **Lubrication** = vestibular glands secrete mucus into the vestibule and vagina during sexual stimulation.

3. **Orgasm** = rhythmic contraction of muscles of perineum, uterine wall and fallopian tubes, which result in a feeling of psychological and physiological release.

HORMONAL CONTROL OF THE FEMALE REPRODUCTIVE SYSTEM

Hormones from the hypothalamus, anterior pituitary, and ovaries play an important role in control of sex cell maturation, development and maintenance of the female secondary sex characteristics, and changes that occur during the monthly reproductive cycle.

1. **Female Sex Hormones**
   a. The female body remains reproductively immature until about eight years of age when secretion of **gonadotropins** (FSH and LH) from the anterior pituitary gland increases i.e. at puberty hypothalamus releases GnRH, and GnRH stimulates pituitary gland to secrete FSH and LH.
   b. The most important female sex hormones are estrogens and progesterone.
      i. Estrogens are responsible for the development and maintenance of the female secondary sex characteristics.
      ii. Progesterone prepares the endometrium of the uterus for pregnancy.

2. **Female Reproductive Cycle**
   a. The female reproductive cycle is approximately **28 days** in length and involves the interaction between several glands, hormones, and target sites.
   b. Beginning at **puberty**, on Day 0, the hypothalamus secretes gonadotropin releasing hormone, GnRH, which targets the anterior pituitary gland to secrete follicle stimulating hormone (FSH).
   c. **Follicle Stimulating Hormone (FSH)**
      i. FSH is secreted from Day 0 through 14 of the reproductive cycle and causes the primary oocyte (primary follicle) to mature and develop into secondary oocyte (secondary follicle). Follicle = egg + epithelial cells (granulosa cells) that surround the egg.
      ii. The developing follicle secretes estrogen i.e. estrogen secretion increases beginning with day 0 of the reproductive cycle until day 14. During this period the level of estrogen in blood is high.
   d. **Estrogen**
      i. Is produced by the maturing follicle (of the ovary) on Days 1-14.
      ii. Estrogen is responsible for the development of female secondary sexual characteristics at puberty, and then maintains them throughout life
         1. Secondary sexual characteristics include: development of breasts and mammary glands; increased fat deposition in breasts, thighs, and buttocks; priming of endometrium (i.e. baseline thickening).
   e. **Luteinizing Hormone (LH)**
      i. On Day 14, the hypothalamus secretes GnRH that targets the anterior pituitary gland to secrete a surge of **luteinizing hormone (LH)**.
      ii. A surge in LH causes ovulation and the secondary oocyte is released into a fallopian tube. The follicle that is left in the ovaries after ovulation becomes the corpus luteum, which secretes progesterone i.e. secretion of progesterone increase after ovulation. At the same time secretion of estrogen decreases because estrogen was produced by the developing follicle.
   f. **Progesterone**
      i. Is secreted from Days 14-24 by corpus luteum.
      ii. Progesterone targets the uterine endometrium to prepare for implantation i.e. after ovulation your body thinks what if the ovulated egg is fertilized! If it is fertilized then the...
uterus (uterine endometrium) should be prepare for it.

iii. Progesterone causes the endometrium to become thick, glandular, and vascular.

iv. If implantation does not occur by Day 24, the corpus luteum degenerates (becoming the corpus albicans), and levels of progesterone (and estrogen) decline dramatically.

v. This decline occurs from Days 24-28.

   1. Decreases level of estrogen and progesterone starts menses (menstruation cycle)

vi. The hypothalamus detects the marked decrease in progesterone (and estrogen) by Day 28 and initiates a new cycle by secreting GnRH that targets the anterior pituitary gland to secrete FSH on Day 0.

   1. FSH begins a new cycle by targeting a primordial follicle to mature.

vii. If implantation does occur, the corpus luteum continues to secrete progesterone to maintain the developing embryo, until the placenta is formed (end of month 3). The level of progesterone and estrogen does not decline = no menstruation.

viii. During this cycle, estrogen and progesterone inhibit the release of LH and FSH.

   1. As the anterior pituitary senses the fall in the concentrations of these hormones, it secretes them again (negative feedback), initiating a new menstrual cycle.

g. The ovarian cycle is the monthly series of events associated with the maturation of the egg.

   i. The follicular phase is the period of follicle growth typically lasting from days 1 to 14.

   ii. Ovulation occurs when the ovary wall ruptures and the secondary oocyte is expelled.

   iii. The luteal phase is the period of corpus luteum activity, days 14 – 28

3. Menstrual Cycle

   a. The uterine (menstrual) cycle is a series of cyclic changes that the uterine endometrium goes through each month in response to changing levels of ovarian hormones in the blood

   b. The menstrual phase takes place on days 1–5 typically, and is the time when the endometrium is shed from the uterus i.e. the old functional layer is sloughed off.

   c. The proliferation phase (days 6–14) is the time in which the endometrium is rebuilt, once again becoming velvety, thick, and well vascularized i.e. a new functional layer is formed in the uterus.

   d. The secretory phase (days 15–28) is the phase in which the endometrium prepares for implantation of an embryo.

4. Menopause

   a. Eventually the ovaries stop responding to FSH and cycling ceases.

   b. Menopause is characterized by a low concentration of estrogens and continuous secretion of FSH and LH.

   c. The female reproductive organs regress.

**BIRTH CONTROL**

Birth control is the voluntary regulation of the number of children produced and the time they are conceived. This usually involves some method of contraception.
### Male Reproductive Organ Summary Table

<table>
<thead>
<tr>
<th>Name of Organ (s)</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teste</strong></td>
<td>Solid ovoid structure held in scrotum; lobules of seminiferous tubules separated by interstitial cells</td>
<td>production of sperm (seminiferous tubules/FSH); secretion of testosterone (interstitial cells, LH)</td>
</tr>
<tr>
<td><strong>Epididymis</strong></td>
<td>Tightly coiled tubule superior to testes; leads to vas deferens</td>
<td>storage of sperm</td>
</tr>
<tr>
<td><strong>Vas Deferens</strong></td>
<td>Muscular tube leading from epididymis into abdominal cavity</td>
<td>Movement of sperm</td>
</tr>
<tr>
<td><strong>Seminal Vesicles</strong></td>
<td>Sac-like structure attached to vas deferens</td>
<td>Addition of fructose (energy source) to sperm/semen</td>
</tr>
<tr>
<td><strong>Prostate Gland</strong></td>
<td>Sponge-like structure below bladder and surrounding urethra</td>
<td>Addition of milky alkaline fluid to semen for sperm motility</td>
</tr>
<tr>
<td><strong>Bulbourethral Glands</strong></td>
<td>Two pea-shaped structures below prostate</td>
<td>addition of penis lubricant to sperm/semen</td>
</tr>
<tr>
<td><strong>Urethra</strong></td>
<td>Tube leading from bladder/prostate to outside held within penis</td>
<td>Transport of sperm and urine to outside</td>
</tr>
<tr>
<td><strong>Penis</strong></td>
<td>Male excitatory organ; vascular columns fill with blood causing erection</td>
<td>Is held in female vagina during intercourse for transfer of sperm</td>
</tr>
<tr>
<td><strong>Scrotum</strong></td>
<td>Pouch of skin and fat that holds testes</td>
<td>Hold testes at cooler temperature to insure optimum sperm production</td>
</tr>
</tbody>
</table>

### Female Reproductive Organs Summary Table

<table>
<thead>
<tr>
<th>Name of Organ(s)</th>
<th>Structure</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ovaries</strong></td>
<td>Solid, ovoid structures on posterior pelvic cavity; cortex of ovarian follicles</td>
<td>Production of secondary oocytes for fertilization production of estrogen for development of 2° sex organs production of progesterone to prepare endometrium for implantation</td>
</tr>
<tr>
<td><strong>Uterine Tubes (Fallopian Tubes; Oviducts)</strong></td>
<td>Tubes that pass medially from ovaries to uterus lined with cilia, expanded ends (fimbriae) over ovary</td>
<td>Site of fertilization transportation of fertilized egg to uterus</td>
</tr>
<tr>
<td><strong>Uterus</strong></td>
<td>Muscular (smooth) organ that houses developing embryo, fetus; 3 layers</td>
<td>Houses and protects developing embryo/fetus</td>
</tr>
<tr>
<td><strong>Cervix</strong></td>
<td>Lower (inferior portion) one-third of uterus</td>
<td>Pap smear location</td>
</tr>
<tr>
<td><strong>Vagina</strong></td>
<td>Passageway from cervix to outside</td>
<td>Birth canal; houses erect penis during intercourse</td>
</tr>
<tr>
<td><strong>Labia Major</strong></td>
<td>external reproductive organs</td>
<td>protect underlying organs</td>
</tr>
<tr>
<td><strong>Labia Minora</strong></td>
<td>Folds between labia majora</td>
<td>Well supplied with blood vessels which engorge during sexual stimulation</td>
</tr>
<tr>
<td><strong>Clitoris</strong></td>
<td>Small projection at anterior end of labia; two columns of vascular tissue</td>
<td>Female excitatory organ</td>
</tr>
<tr>
<td><strong>Vestibular glands</strong></td>
<td>Glands within space between labia minora</td>
<td>Provide lubrication during sexual stimulation</td>
</tr>
</tbody>
</table>

### Summary of Female Reproductive Cycle

<table>
<thead>
<tr>
<th>Secreted by what organ or gland?</th>
<th>FSH</th>
<th>LH</th>
<th>estrogen</th>
<th>progesterone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior pituitary gland</strong></td>
<td>Anterior pituitary gland</td>
<td>Anterior pituitary gland</td>
<td>Maturing ovarian follicle</td>
<td>Corpus luteum (of follicle)</td>
</tr>
<tr>
<td><strong>Days of secretion</strong></td>
<td>days 0-14</td>
<td>day 14</td>
<td>days 1-14</td>
<td>days 14-24</td>
</tr>
<tr>
<td><strong>Target(s) of hormone</strong></td>
<td>Primordial ovarian follicle</td>
<td>Secondary (mature) ovarian follicle</td>
<td>Secondary sex organs (mammary glands and breasts, adipose tissue in buttocks and thigh region)</td>
<td>Endometrium of uterus</td>
</tr>
<tr>
<td><strong>response</strong></td>
<td>maturation of ovarian follicle and oocyte (Meiosis I)</td>
<td>bursting of ovarian follicle ovulation = release of secondary oocyte</td>
<td>development at puberty maintenance throughout life until menopause</td>
<td>causes endometrium to thicken, become vascular and glandular preparation for implantation</td>
</tr>
</tbody>
</table>