Lecture Outline: The Reproductive System

I. **Introduction to Reproductive Systems**

A. The reproductive system is the only organ system with different versions for male and female.

B. **Primary Sex Organs (Gonads)**

1. Defined as structures that produce gametes (sex cells).
2. In humans, gametes are sperm (male) and eggs (female).
3. For males, the primary sex organs are the testes.
4. For females, the primary sex organs are the ovaries.

C. **Secondary Sex Organs**

1. These are delivery devices rather than gamete producers.
2. Examples include the penis and vagina.

II. **Male Reproductive Anatomy**

A. **Testes (Male Gonads)**

1. Plural of testicle.
2. Unlike female gonads, male gonads lie outside the abdominal pelvic cavity once sexual maturity is reached.
3. They start development in the abdominal pelvic cavity but descend into the scrotum, a sack-like structure.
4. The testis is a whitish, egg-shaped structure.
5. Each testis is covered by a tough outer coat called the tunica albuginea.
6. The interior of the testis is primarily made up of seminiferous tubules.

B. **Epididymis**

1. Closely associated with each testis.
2. Sperm produced by the testis mature in the epididymis for about two

weeks.

3. It is a network of very long, convoluted tubes that allow sperm to mature.

C. **Ductus Deferens (Vas Deferens)**

1. A tube that transports sperm from the epididymis.
2. It loops around the ureter (part of the urinary system) into the abdominal pelvic cavity.
3. It ends in a bag-like structure called an ampulla.
4. Cutting this tube as a form of contraception is called a vasectomy.

D. **Semen**

1. A complex mixture, including sperm and secretions from accessory glands.

E. **Accessory Glands Contributing to Semen**

1. **Seminal Vesicles**
    a. There are two seminal vesicles.
    b. They produce components of the semen, which mix with sperm from the ductus deferens in the ampulla.
2. **Prostate Gland**
    a. A walnut-sized gland found only in males.
    b. It surrounds the tubing where the seminal vesicle and ductus deferens meet.
    c. It produces its own secretions that become part of the semen.
3. **Bulbourethral Glands**
    a. There are two of these glands, located at the root of the penis.
    b. They produce mucus, which is added as the final component of semen just before ejaculation.

F. **Urethra (Male)**

1. Longer in males than in females, extending through the penis.
2. In males, it serves as a delivery device for both urine and semen.
3. **Three Major Parts**

a. Prostatic urethra: The first part, located within the prostate gland.
b. Membranous urethra: The shortest part, it penetrates through the floor of the abdominal pelvic cavity.
c. Spongy urethra: The third and final part, officially starts inside the penis and runs down its length, surrounded by erectile tissue.

G. **Penis Structure**

1. Consists of the root (deepest part, not externally visible), the shaft (visible part), and the glans (the head of the penis).
2. The glans penis is covered by skin called the prepuce (foreskin), which can be cut during circumcision.

H. **Erectile Tissues**

1. The penis contains three columns of erectile tissue: two corpora cavernosa and one corpus spongiosum.
2. The spongy urethra runs through the corpus spongiosum.
3. During erection, these tissues become engorged with blood due to increased blood flow, causing hydrostatic pressure.

I. **Spermatic Cord**

1. Includes blood vessels (veins and arteries) and nerves.
2. There is a spermatic cord for each of the two testes.

III. **Spermatogenesis (Sperm Production)**

A. **Seminiferous Tubules**

1. Make up the bulk of the interior of each testis.
2. They are arranged into subsections called lobules, partially separated by septa.
3. This is where sperm are released.

B. **Rete Testis**

1. A network of tubules that receive young, immature sperm from the seminiferous tubules.

C. **Cell Types in the Body**

1. **Somatic Cells**

a. Make up the vast majority of cells in the body.

b. They are diploid (2n) and undergo only mitosis, producing genetically identical cells.

2. **Germline Cells (Spermatogonia in Males)**
    a. A tiny minority of cells found only in the gonads.
    b. They are diploid (2n) and can undergo both mitosis (to replenish themselves) and meiosis (to produce gametes).

D. **Ploidy (Degree of Chromosome Sets)**
1. Refers to how many of each type of chromosome a cell has.
2. For humans, there are 23 different types of chromosomes (n=23).
3. **Haploid (n)**
    a. Cells containing just one of each of the 23 types of chromosomes.
    b. Human gametes (sperm and eggs) are haploid.
4. **Diploid (2n)**
    a. Cells containing two of each type of chromosome (e.g., two number ones, two number twos, etc.).
    b. Human somatic cells and germline cells are diploid, having 2 * 23 = 46 chromosomes.

E. **Cell Division Processes**
1. **Mitosis**
    a. A type of cell division that creates genetically identical cells with the same ploidy.
2. **Meiosis**
    a. A different type of cell division that produces genetically non-identical cells.
    b. It cuts the ploidy in half (e.g., diploid to haploid).
    c. A diploid cell undergoing complete meiosis produces four haploid cells.

F. **Stages of Sperm Development**
1. Spermatogonia (germline stem cells) undergo mitosis and then meiosis.
2. Meiosis produces early, immature forms called spermatids.

3. Spermatids mature into fully viable sperm within the epididymis through a process called spermiogenesis.

G. **Sperm Structure**

1. A unicellular organism representing the haploid stage of the human life cycle.
2. **Head**
    a. Houses the cell's nucleus, which contains the DNA (chromosomes).
3. **Midpiece**
    a. Located just before the tail, it contains many mitochondria responsible for producing ATP (energy) for swimming.
4. **Flagellum (Tail)**
    a. A long, whip-like tail that propels the sperm forward through liquid.

IV. **Hypothalamo-Pituitary-Gonadal (HPG) Axis (Male)**

A. A complex signaling pathway involving the hypothalamus, anterior pituitary, and testes.

B. **Hypothalamus**

1. Releases Gonadotropin-Releasing Hormone (GnRH).

C. **Anterior Pituitary**

1. Cells in the anterior pituitary are stimulated by GnRH to release two gonadotropins: Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH).
2. These hormones are named for their functions in females but also occur in males.

D. **Testes (Gonads)**

1. LH stimulates interstitial cells (located in spaces between structures) within the testes to produce testosterone.
2. FSH acts on different cells called supporting cells, which assist the spermatogonia in sperm production.

E. **Testosterone (Male Hormone)**

1. Controls many functions, including sperm production.
2. Exhibits negative feedback: High testosterone levels act on both the

hypothalamus and anterior pituitary to turn down their production of GnRH, FSH, and LH, maintaining balance.

V. **Female Reproductive Anatomy**

A. **Ovaries (Female Gonads)**

1. The primary sex organs in females, responsible for producing gametes (eggs or ova).
2. Unlike male gonads, ovaries remain within the abdominal pelvic cavity throughout life.

B. **Uterine Tubes (Fallopian Tubes)**

1. Closely associated with each ovary.
2. **Infundibulum**
    a. A funnel-shaped structure with fringes called fimbriae.
    b. It helps catch the egg released during ovulation.
3. The infundibulum narrows to become the uterine tube, which leads to the uterus.
4. Fertilization usually occurs in the uterine tube.

C. **Uterus**

1. A highly muscular, hollow organ.
2. Its interior is a potential space that can expand significantly during pregnancy.
3. **Parts of the Uterus**
    a. Fundus: The superior, blind (dead) end of the uterus.
    b. Cervix: The narrowed, neck-like part of the uterus that opens into the vagina.
4. **Layers of the Uterine Wall**
    a. Endometrium: The inner lining, which undergoes drastic changes in thickness and is the site of embryo implantation.
    b. Myometrium: The thickest layer, composed of smooth muscle, responsible for contractions during childbirth.
    c. Parametrium: The outer covering of the uterus.
5. Supported in place by ligaments, including the broad ligament, round

ligament, and ovarian ligament.

D. **Vagina**

1. A word meaning "sheath," describing its function in accepting the penis.
2. It is a secondary sex organ, serving as a delivery device for the fetus during childbirth and for receiving the penis and sperm.
3. Its interior is highly folded, which aids in stimulating the penis during intercourse.

E. **External Genitalia (Vulva)**

1. **Labia Majora**
    a. The larger, outer lips that guard the external opening of the vagina.
    b. They are dry and feature hair.
2. **Labia Minora**
    a. The smaller, inner lips, located between the labia majora.
    b. They are moist epithelium and become engorged with blood during sexual arousal.
3. **Clitoris**
    a. Develops in the same way as the penis (homologous structure).
    b. Much shorter than a penis, with a highly sensitive glans (head) that can lead to orgasm when stimulated.
    c. The glans of the clitoris is also covered by a prepuce (hood-like skin covering).
4. **Vestibular Glands**
    a. Located on either side, they produce secretions that moisten the labia minora and act as a lubricant during intercourse.

F. **Perineum**

1. The region outlined by bony landmarks, superficially defined as the area between the vagina (or scrotum in males) and the anus.

VI. **Oogenesis (Egg Production) and Ovarian Cycle**

A. **Egg Production Process (Oogenesis)**

1. Production of female gametes starts before a female is even born,

while she is a fetus.

2. Millions of potential eggs (primordial follicles) begin the process of meiosis but then pause for almost two decades until sexual maturity.
3. Most potential eggs die before birth, but thousands remain.
4. Unlike males who produce millions of fresh sperm daily, females normally release only one egg per ovarian cycle (roughly every 28 days).
5. The ovulated egg is an "old cell" as its development began in the fetal stage.

B. **Follicle Development in the Ovary**

1. Primordial follicles are the earliest stage.
2. Each cycle, some primordial follicles are chosen to develop into primary follicles, which then grow larger into growing follicles.
3. Normally, only one growing follicle fully matures to produce an egg for release.

C. **Ovulation**

1. The process where a mature egg ruptures out of the wall of the ovary.
2. If successful, the egg is caught by the funnel-like infundibulum of the uterine tube.

D. **Corpus Luteum**

1. After ovulation, the ruptured follicle is renamed a corpus luteum ("yellow body").
2. The corpus luteum continues to produce hormones, particularly progesterone.
3. If no pregnancy occurs, it degenerates.
4. If pregnancy occurs, it is called a corpus luteum of pregnancy and persists longer, producing hormones until the placenta develops sufficiently.

E. **Meiosis in Females (Distinct from Males)**

1. While meiosis in males produces four viable sperm from one germline cell, in females, it produces one large viable egg cell and three tiny

"polar bodies."

2. The polar bodies are discarded, allowing the egg to conserve as much cytoplasm as possible.
3. This conservation is crucial because the egg (and subsequent zygote) needs to be large for survival, as the sperm primarily delivers only DNA.
4. Biologically, the female is defined as the sex that produces the larger of the two gametes.

F. **Phases of the Ovarian Cycle**

1. Follicular Phase: The period during which follicles are developing in the ovary.
2. Luteal Phase: Begins immediately after ovulation, characterized by the formation and activity of the corpus luteum.

VII. **Female Hormonal Control and Uterine Cycle**

A. **Key Hormones in Females**

1. LH (Luteinizing Hormone) and FSH (Follicle-Stimulating Hormone): Released by the anterior pituitary, their surge (especially LH) causes ovulation.
2. Estrogens: Released by developing follicles; increasing estrogen levels during the follicular phase lead to the LH surge.
3. Progesterone: Primarily produced by the corpus luteum after ovulation. It prepares the uterus for potential pregnancy by making the endometrial lining thick and moist. Its name means "promotes gestation."

B. **Uterine Cycle (Menstrual Cycle)**

1. Occurs simultaneously with the ovarian cycle, describing changes in the endometrium (inner lining of the uterus).
2. Day one of both cycles is defined as the first appearance of menstrual blood.
3. **Phases of the Uterine Cycle**
    a. Menstrual Phase: The shedding of the previous endometrial lining if pregnancy did not occur, resulting in menstrual flow (menses),

typically lasting about 5 days.

b. Proliferative Phase: Following menstruation, the endometrium grows fresh and thickens again, with its cells proliferating (increasing in number), stimulated by estrogens.

c. Secretory Phase: After the endometrium has thickened, endometrial glands begin secreting substances to make the lining moist and chemically suitable for an embryo to implant. This thickness is maintained by progesterone.

4. If no pregnancy occurs, the progesterone level drastically dips, signaling the uterus to undo this preparation and degrade the endometrial lining, leading to the beginning of the next menstrual phase.

VIII. **Mammary Glands (Breasts)**

A. Mammary glands are located within the breasts and are responsible for producing milk.

B. This is why humans are classified as mammals, as true milk is produced only by mammals.

C. **Lactation (Milk Production)**

1. Occurs in sack-like structures called alveoli, which are arranged in lobules within the mammary glands.
2. Milk is produced and stored continuously in these lobules in pregnant or nursing women.

D. **Milk Ejection**

1. After production, milk is delivered into lactiferous ducts, which widen into lactiferous sinuses, all converging at the nipple.
2. Milk is ejected through the nipple in response to suckling by an infant or by a suction pump. This is a distinct process from milk production and involves a different hormone.

E. **Nipple and Areola**

1. The nipple is a rounded mound of tissue with openings for milk ejection.
2. It is surrounded by a darkened circular area called the areola, which

likely serves as a visual target for the infant.

F. The bulk of the breast in non-pregnant and non-nursing females is primarily made up of adipose (fat) tissue, as the mammary glands are very small when not actively producing milk.

IX. **Human Sexual Life Cycle and Development**

A. **Fertilization**

1. The fusion of two unicellular gametes (a haploid sperm and a haploid egg) to produce one unicellular zygote.
2. This is the defining moment of sexual reproduction, as it mixes genetic material from two parents.
3. Fertilization usually occurs in the uterine tube.
4. While many sperm attempt to fertilize an egg, only one is successful, and its entry prevents others from doing the same.

B. **Ploidy Alternation in the Life Cycle**

1. Fertilization doubles the ploidy (combining two haploid gametes to form a diploid zygote).
2. Meiosis, occurring in the gonads, halves the ploidy (producing haploid gametes from diploid germline cells).
3. This alternation between fertilization and meiosis ensures that the chromosome number remains constant from one generation to the next.
4. Human individuals exist as the diploid stage, while gametes represent the short-lived haploid stage.

C. **Stages of Development After Fertilization**

1. **Zygote**
    a. The single, diploid cell that marks the official beginning of a new human life.
    b. It typically forms in the uterine tube and then moves toward the uterus.
2. **Embryo (Conceptus)**
    a. The zygote undergoes mitosis to become a multicellular organism,

initially appearing as a mass of cells.

b. This early embryo implants into the endometrium of the uterus.

3. **Fetus**

a. The embryo develops into a fetus around 12 weeks of gestation, at which point it looks much more like a human.

b. Development continues as a fetus until birth, typically around 9 months after fertilization.

D. **Placenta**

1. An organ that develops between the new organism (embryo and then fetus) and the mother's uterus.
2. It is unique in that it is partly derived from the mother and partly from the fetus.
3. The placenta eventually takes over the hormone-producing functions of the corpus luteum during pregnancy.

E. **Parturition (Childbirth)**

1. An excellent example of a positive feedback mechanism, which is much rarer than negative feedback in the body.
2. As the fetus, typically head-down, stretches the cervix of the uterus, stretch receptors in the cervix send signals to the hypothalamus in the brain.
3. The hypothalamus signals the posterior pituitary to release oxytocin into the bloodstream.
4. Oxytocin travels to the uterus, stimulating contractions of the myometrium (the muscular layer), particularly in the fundus.
5. These contractions push the fetus further down, causing even greater stretching of the cervix, which in turn leads to the release of even more oxytocin, intensifying the contractions.
6. This positive feedback loop continues to build in intensity until the fetus is expelled through the vagina.

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