Human Reproductive System

I. The male reproductive anatomy is a delivery system for sperm.

A. The male's external reproductive organs consist of the scrotum and penis.

1. The **penis** is the external organ for depositing sperm in the vagina of the female.

a. During sexual excitement, the nervous system causes the arteries leading to the penis to dilate, increasing blood flow.

b. This blood flow squeezes veins leading away from the penis, restricting blood flow. As a result, erectile tissue in the penis fills with blood, causing an erection.

c. The erection facilitates penetration into the vagina.

2. The scrotum is a pouch of skin below the pelvis which contains the testes.

a. The scrotum maintains the testes about 2^{o}C cooler than the abdominal cavity.

b. This is necessary for the proper production of sperm.

B. The internal reproductive organs consist of gonads that produce sperm and hormones, accessory glands that secrete products essential to sperm movement, and ducts to carry the sperm and glandular secretions.

1. The male gonads, or **testes,** consist of highly coiled tubes, called **seminiferous tubules**, where sperm are produced.

2. Special cells scattered throughout the seminiferous tubules produce testosterone.

3. From the seminiferous tubules of the testes, the sperm pass through the coiled tubules of the **epididymis** where they mature and are stored until ejaculation or reabsorption by the body.

C. **Ejaculation** propels sperm from the epididymis to the muscular vas deferens.

1. The **vas deferens** run from the scrotum around and behind the urinary bladder, where each is joined by a duct from the seminal vesicle.

2. Each opens into the urethra, the tube that carries both urine and semen.

3. The urethra runs through the penis and opens to the outside at the tip of the penis.

D. A variety of sex glands add secretions to **semen**.

1. The male ejaculate contains between 2-5 mL of fluid with 50–130 million sperm per mL or 100-650 M sperm in total - (that's a lot!).

2. A pair of **seminal vesicles** contributes about 60% of total semen volume.

a. Fluid from the seminal vesicles contains mucus, fructose, a coagulating enzyme, and prostaglandins.

(1) Fructose is an energy source for the sperm *in vitro* but they don't contact it *in vivo* so the purpose is unclear.

(2) Prostaglandins are chemicals secreted by cells that affect a localized area.

(a) They thin the mucus at the opening of the uterus so that sperm may enter.

(b) They also cause rhythmic contractions of the uterus which increase the movement of the sperm toward the egg.

(3) A coagulating enzyme causes the semen to thicken once inside the female, making it easer for the uterine contractions to move it.

(4) The alkalinity of the seminal vesicles helps neutralize the acidic environment of the vagina, protecting the sperm.

3. The **prostate gland** (prostata, G - to put in front of), secretes directly into the urethra.

a. The prostate fluid contains anticoagulant enzymes which thins the semen so

the sperm can start swimming.

4. The **bulbourethral glands** (or Cowper's glands) are a pair of small glands along the urethra below the prostate.
    a. Prior to ejaculation, they secrete clear mucus that neutralizes any acidic urine remaining in the urethra.
    b. The bulbourethral fluid carries some sperm released before ejaculation. This is partly why the withdrawal method of birth control is not recommended.
5. Sperm can live for up to 72 h in the female reproductive tract.Sperm are 25 μm and travel ~20 cm in female (8000x its length) at 17-67 μm/s. The human equivalent would be traveling 14.4 km at 6.5 km/h

II. The hormonal control of the male reproductive system is started in the hypothalamus.
A. The hypothalamus produces GnRH which stimulates the pituitary to release FSH and LH
    1. FSH stimulates cells in the testes to help produce sperm. These cells release a hormone (inhibin) which inhibits the production of FSH. This hormone also has this effect in females.
    2. LH stimulates the cells which produce testosterone.
B. Testosterone is responsible for the primary and secondary male sex characteristics.
    1. Primary sex characteristics are associated with the development of the vas deferens and other ducts, development of the external reproductive structures, and sperm production as well as sex drive (and some increase in general aggression).
    2. Secondary sex characteristics are features not directly related to the reproductive system, including deepening of the voice, distribution of facial and pubic hair, secretion of body oils, and muscle growth.

III. Female reproductive anatomy is a complex system for accepting an embryo and nourishing a growing fetus.
A. External reproductive structures include two sets of labia surrounding the clitoris and vaginal opening. Collectively, these are called the vulva.
    1. The **labia minora** are thin folds of skin that surround the vaginal opening.
    2. The **labia majora** surround and protect the labia minora and the clitoris.
    3. The **clitoris** functions in sexual arousal.
        a. During sexual arousal, the clitoris, vagina, and labia engorge with blood and enlarge.
B. Internal reproductive organs consist of a pair of gonads and a system of ducts and chambers.
    1. The **vagina** is a thin-walled chamber that forms the birth canal and is the repository for sperm during sexual intercourse after male ejaculation.
        a. The environment is very acidic to discourage the growth of microbes.
        b. During sexual arousal, **Bartholin's glands** secrete mucus into the vaginal opening, providing lubrication to facilitate intercourse.
    2. The **cervix** is a muscular ring which separates the vagina from the uterus.
        a. It holds the fetus in place until birth, when it dilates to allow the fetus to pass through.
    3. The **uterus** accepts the fertilized egg and holds the developing embryo.
        a. The inner layer, or **endometrium**, has many blood vessels which nourish the embryo.
            (1) It is shed during menstruation if pregnancy does not occur.
        b. The muscular outer layer; which provides support for the fetus and later for

childbirth, is called the **myometrium**. **Mammary glands** are not part of the human reproductive system but are important to mammalian reproduction.

(1) Within the glands, small sacs secrete milk, which drains into a series of ducts opening at the nipple.

(2) Milk supplies protein, sugar, fat, and antibodies to the baby.

(3) The low estrogen level in males prevents the development of the sensory apparatus and fat deposits, so that male breasts remain small, with nipples unconnected to the ducts.

4. The **ovaries** lie within the abdominal cavity.

a. Each ovary contains about 200,000 follicles.

(1) A follicle is a structure which consists of an egg cell surrounded by cells which nourish and protect the developing egg.

(2) Of all these follicles, only a few hundred will ever mature and release an egg. One matures during each menstrual cycle.

(3) Usually one follicle matures and releases its egg during each menstrual cycle in the process of **ovulation.**

(a) After ovulation, the remaining follicular tissue develops into the **corpus luteum.**

(4) Follicles produce the primary female sex hormone, estrogen.

5. At ovulation, the egg is released into the abdominal cavity near the opening of the **oviduct** (Fallopian tubes).

a. These tubes are the passageway through which the egg must travel from the ovaries to the uterus. Sperm, also, must swim through the oviducts to meet the egg. After being released, the egg survives for about 24 h in the oviduct so fertilization must occur during that period.

b. The end of the oviduct has an opening near the ovary which is edged by fringes called the **fimbria**. These are covered with cilia and serve to "sweep up" the egg when it is released during ovulation.

c. Cilia inside the oviduct sweep the egg toward the uterus.

IV. A complex interplay of hormones coordinates two different cycles - the menstrual (or uterine) cycle and the ovarian cycle.

A. The hypothalamus secretes GnRH which causes the pituitary to release FSH and LH

1. FSH stimulates a follicle to develop and begin producing estrogen. This occurs during **follicular phase** of the ovarian cycle.

a. Low [estrogen] early in the cycle inhibits the pituitary so FSH and LH remain low.

b. High [estrogen] later in the cycle stimulates both the hypothalamus and pituitary to secrete hormones.

(1) As a result, [LH] increases.

(2) LH induces the final maturation of the follicle and **ovulation** (the midpoint of the ovarian cycle).

c. Estrogen triggers the thickening of the endometrium.

B. The increase in LH stimulates the corpus luteum which then begins secreting progesterone and estrogen in what is known as the **luteal phase** of the ovarian cycle.

1. These two hormones together have a negative effect on the hypothalamus and pituitary, inhibiting the secretion of LH and FSH.

a. They also stimulate further growth of the endometrium, strengthen the uterus, inhibit further ovulation, and prevent uterine contractions.

2. As the hypothalamus and pituitary are inhibited, there is a resulting decline in [LH].

a. This causes the corpus luteum to deteriorate.
b. The resulting lower [estrogen] and [progesterone] allow the hypothalamus and pituitary to begin producing FSH and LH which starts the cycle again

C. If pregnancy does not occur, the decrease in [progesterone] triggers uterine contractions and the endometrium is shed, marking the beginning of flow phase.

D. Estrogen is also responsible for female secondary sex characteristics, including deposition of fat in the breasts and hips, increased water retention, and stimulation of breast development.

V. Fertilization, pregnancy, and birth.

A. Only about 200 sperm reach the oviducts and only a few reach the egg. Only one fertilizes it - usually.

B. The fertilized egg implants itself in the uterine wall; it is important that menstruation not occur now or the zygote would be lost.

C. The loss of the corpus luteum would terminate a pregnancy, if one occurred.
1. The estrogen and progesterone from the corpus luteum inhibit the release of GnRH.
2. The resulting lack of LH means the corpus luteum cannot be maintained.
3. As progesterone decreased, uterine contractions would begin and the lining would be shed.
4. The solution is to maintain estrogen and progesterone.
a. The developing zygote produces **hCG** (human chorionic gonadotropin), a hormone which maintains the corpus luteum for about 3 months.
b. Some hCG is excreted in the urine, where it is detected by pregnancy tests.

D. **First trimester**
1. During the first 2-4 weeks, the embryo gets nutrition directly from the endometrium.
a. The placenta allows diffusion of material between maternal and embryonic blood, providing nutrients, exchanging gases, and disposing of wastes for the embryo.
2. The placenta develops and will eventually provide the medium for exchange between the mother and embryo. Embryonic and maternal blood vessels are very close together in the placenta and materials can be exchanged between the two.
3. Most of the organs develop during this trimester and after the 8^{th} week all the major adult structures are present. It is during this time that the embryo is most sensitive to drugs and other chemicals which can cause birth defects.
4. After 8 weeks, the embryo is called a fetus and reaches about 5 cm in length by the end of the trimester.

E. **Second trimester**
1. The fetus grows to about 30 cm and becomes quite active.
2. Hormonal levels stabilize as hCG declines, the corpus luteum deteriorates, and the placenta takes over the secretion of progesterone and estrogen, which maintains the pregnancy.

F. **Third trimester**
1. The fetus grows to about 50 cm long and 3-4 kg in weight.
2. At this size, the fetus does not have much room in the uterus so movement decreases.
3. Maternal abdominal organs become compressed and displaced, leading to frequent urination, digestive blockages, and back strain.

G. The events that trigger **labor** are not fully understood.
1. High levels of estrogen at the end of pregnancy trigger a sensitivity to the hormone

oxytocin.

a. Produced by the fetus and the mother's pituitary, this hormone stimulates powerful contractions by the smooth muscles of the uterus.
b. It also stimulates release of prostaglandins from the placenta. The prostaglandins enhance the contractions.
c. The stress of these contractions increases the release of oxytocin and the prostaglandins in a positive feedback loop.
d. After birth, it contributes to the production of milk.

H. The birth process involves the dilation of the cervix, expulsion of the baby, and then expulsion of the placenta.

1. The drop in progesterone after birth release the pituitary from negative feedback and it begins releasing **prolactin**. This hormone stimulates the mammary glands to produce milk.
2. **Relaxin** increases cardiac output and blood flow to the kidneys as well as loosening ligaments of the pelvis to facilitate the passage of the baby.