The Reproductive Systems

• Sexual reproduction produces new individuals
  – germ cells called gametes (sperm & 2nd oocyte)
  – fertilization produces one cell with one set of chromosomes from each parent

• Gonads produce gametes & secrete sex hormones

• Reproductive systems
  – gonads, ducts, glands & supporting structures
  – Gynecology is study of female reproductive system
  – Urology is study of urinary system & male reproductive system
Chromosomes in Somatic Cells & Gametes

• Somatic cells (diploid cells)
  – 23 pairs of chromosomes for a total of 46
    • each pair is homologous since contain similar genes in same order
    • one member of each pair is from each parent
  – 22 autosomes & 1 pair of sex chromosomes
    • sex chromosomes are either X or Y
    • females have two X chromosomes
    • males have an X and a smaller Y chromosome

• Gametes (haploid cells)
  – single set of chromosomes for a total of 23
  – produced by special type of division: meiosis
Male Reproductive System

- Gonads, ducts, sex glands & supporting structures
- Semen contains sperm plus glandular secretions
Formation of Sperm

Spermatogenesis is formation of sperm cells from spermatogonia.
Supporting Cells of Sperm Formation

- Sertoli cells -- extend from basement membrane to lumen
  - form blood-testis barrier
  - support developing sperm cells
  - produce fluid & control release of sperm into lumen
Spermatogenesis

- Spermatogonium (stem cells) give rise to 2 daughter cells by mitosis
- One daughter cell kept in reserve -- other becomes primary spermatocyte
- Primary spermatocyte goes through meiosis I
  - DNA replication
  - tetrad formation
  - crossing over
Spermatogenesis

- Secondary spermatocytes are formed
  - 23 chromosomes of which each is 2 chromatids joined by centromere
  - goes through meiosis II
- 4 spermatids are formed
  - each is haploid & unique
  - all 4 remain in contact with cytoplasmic bridge
  - accounts for synchronized release of sperm that are 50% X chromosome & 50% Y chromosome
Hormonal Control of Spermatogenesis

• Puberty
  – hypothalamus increases its stimulation of anterior pituitary with releasing hormones
  – anterior pituitary increases secretion LH & FSH

• LH stimulates Leydig cells to secrete testosterone
  – an enzyme in prostate & seminal vesicles converts testosterone into dihydrotestosterone (DHT-more potent)

• FSH stimulates spermatogenesis
  – with testosterone, stimulates sertoli cells to secrete androgen-binding protein (keeps hormones levels high)
  – testosterone stimulates final steps spermatogenesis
Hormonal Effects of Testosterone

- Testosterone & DHT bind to receptors in cell nucleus & change genetic activity
- Prenatal effect is born a male
- At puberty, final development of 2nd sexual characteristics and adult reproductive system
  - sexual behavior & libido
  - male metabolism (bone & muscle mass heavier)
  - deepening of the voice
Semen

• Mixture of sperm & seminal fluid
  – glandular secretions and fluid of seminiferous tubules
  – slightly alkaline, milky appearance, sticky
  – contains nutrients, clotting proteins & antibiotic seminalplasmin

• Typical ejaculate is 2.5 to 5 ml in volume

• Normal sperm count is 50 to 150 million/ml
  – actions of many are needed for one to enter

• Coagulates within 5 minutes -- reliquefies in 15 due to enzymes produced by the prostate gland

• Semen analysis----bad news if show lack of forward motility, low count or abnormal shapes
Penis

- Passageway for semen & urine
- Body composed of three erectile tissue masses filled with blood sinuses
- Composed of bulb, crura, body & glans penis
Cross-Section of Penis

- **Corpora cavernosa**
  - upper paired, erectile tissue masses
  - begins as crura of the penis attached to the ischial & pubic rami and covered by ischiocavernosus muscle

- **Corpus spongiosum**
  - lower erectile tissue mass
  - surrounds urethra
  - begins as bulb of penis covered by bulbospongiosus muscle
  - ends as glans penis
Root of Penis & Muscles of Ejaculation

- Bulb of penis or base of corpus spongiosum enclosed by bulbospongiosus muscle
- Crura of penis or ends of corpora cavernosa enclosed by ischiocavernosus muscle
Erection & Ejaculation

• Erection
  – sexual stimulation dilates the arteries supplying the penis
  – blood enters the penis compressing the veins so that the blood is trapped.
  – parasympathetic reflex causes erection

• Ejaculation
  – muscle contractions close sphincter at base of bladder and move fluids through ductus deferens, seminal vesicles, & ejaculatory ducts
  – ischiocavernous & bulbospongiosus complete the job
Female Reproductive System

- Ovaries produce 2nd oocytes & hormones
- Uterine tubes transport fertilized ova
- Uterus where fetal development occurs
- Vagina & external genitalia constitute the vulva
- Mammary glands produce milk
Follicular Stages

- Stages of follicular development
  - primordial
  - primary
  - secondary
  - graafian
  - ovulation

- Corpus luteum is ovulation wound
  - fills in with hormone secreting cells
- Corpus albicans is white scar left after corpus luteum is not needed
Histology of a Graafian Follicle

- Zona pellucida -- clear area between oocyte & granulosa cells
- Corona radiata is granulosa cells attached to zona pellucida--still attached to oocyte at ovulation
- Antrum formed by granulosa cells secreting fluid
- By this time, the oocyte has reached the metaphase of meiosis II stage and stopped developing -- first polar body has been discarded
Life History of Oogonia

- Germ cells from yolk sac migrate to ovary & become oogonia
- As a fetus, oogonia divide to produce millions by mitosis but most degenerate (atresia)
- Some develop into primary oocytes & stop in prophase stage of meiosis I
  - 200,000 to 2 million present at birth
  - 40,000 remain at puberty but only 400 mature during a woman’s life
- Each month, hormones cause meiosis I to resume in several follicles so that meiosis II is reached by ovulation
- Penetration by the sperm causes the final stages of meiosis to occur
Review of Oogenesis

During fetal development meiosis I begins but stops in prophase.

After puberty, primary oocytes complete meiosis I, which produces a secondary oocyte and a first polar body that may or may not divide again.

The secondary oocyte begins meiosis II but stops in metaphase.

A secondary oocyte (and first polar body) is ovulated.

After fertilization, meiosis II resumes. The oocyte splits into an ovum and a second polar body.

The nuclei of the sperm cell and the ovum unite, forming a diploid (2n) zygote.
Histology of the Uterus

- **Endometrium**
  - simple columnar epithelium
  - stroma of connective tissue and endometrial glands
    - stratum functionalis
      - shed during menstruation
    - stratum basalis
      - replaces stratum functionalis each month

- **Myometrium**
  - 3 layers of smooth muscle

- **Perimetryrium**
  - visceral peritoneum
Blood Supply to the Uterus

- Uterine arteries branch as arcuate arteries and radial arteries that supply the myometrium
- Straight & spiral branches penetrate to the endometrium
  - spiral arteries supply the stratum functionalis
  - their constriction due to hormonal changes starts menstrual cycle
Vulva (pudendum)

- Mons pubis -- fatty pad over the pubic symphysis
- Labia majora & minora -- folds of skin encircling vestibule where find urethral and vaginal openings
- Clitoris -- small mass of erectile tissue
- Bulb of vestibule -- masses of erectile tissue just deep to the labia on either side of the vaginal orifice
Female Reproductive Cycle

• Controlled by monthly hormone cycle of anterior pituitary, hypothalamus & ovary
• Monthly cycle of changes in ovary and uterus
• Ovarian cycle
  – changes in ovary during & after maturation of oocyte
• Uterine cycle
  – preparation of uterus to receive fertilized ovum
  – if implantation does not occur, the stratum functionalis is shed during menstruation
Hormonal Regulation of Reproductive Cycle

- GnRH secreted by the hypothalamus controls the female reproductive cycle
  - stimulates anterior pituitary to secrete FSH & LH
  - FSH initiates growth of follicles that secrete estrogen
    - estrogen maintains reproductive organs
  - LH stimulates ovulation & promotes formation of the corpus luteum which secretes estrogens, progesterone, relaxin & inhibin
    - progesterone prepares uterus for implantation and the mammary glands for milk secretion
    - relaxin facilitates implantation in the relaxed uterus
    - inhibin inhibits the secretion of FSH
Overview of Hormonal Regulation

- **GnRH** stimulates release of FSH and LH from the **Anterior pituitary gland**.
- **FSH** stimulates the **Ovaries** and **LH** stimulates **Corpus luteum**.
- Initial secretion of estrogens by growing ovarian follicles and their further development.
- Estrogens promote development and maintenance of female reproductive structures, femininity, and breasts. They increase protein anabolism, lower blood cholesterol, and moderate levels inhibit release of GnRH, FSH, and LH.
- Progesterone works with estrogen to prepare endometrium for implantation, sets up breasts to secrete milk, inhibits release of GnRH and LH.
- Relaxin inhibits contractions of uterine smooth muscle, helps in labor by relaxing pubic symphysis and dilating the uterine cervix.
- Inhibin inhibits release of FSH and, to a lesser extent, LH.
Phases of Female Reproductive Cycle

- **Ovarian cycle**
  - Primordial follicles
  - Primary follicles
  - Secondary follicle
  - Mature (Graafian) follicle
  - Ovulation

- **Corpus luteum**
  - Corpus hemorhagicum
  - Progesterone and estrogens

- **Uterine (menstrual) cycle**
  - Stratum functionalis
  - Menstruation
  - Proliferative phase
  - Menstruation
  - Stratum basalis
  - Preovulatory phase

- **Days**
  - Menstrual phase
  - Preovulatory phase
  - Ovulation
  - Postovulatory phase
Hormonal Changes
Menstrual Phase

• Menstruation lasts for 5 days
• First day is considered beginning of 28 day cycle
• In ovary
  – 20 follicles that began to develop 6 days before are now beginning to secrete estrogen
  – fluid is filling the antrum from granulosa cells
• In uterus
  – declining levels of progesterone caused spiral arteries to constrict -- glandular tissue dies
  – stratum functionalis layer is sloughed off along with 50 to 150 ml of blood
Preovulatory Phase

• Lasts from day 6 to 13 (most variable timeline)
• In the ovary (follicular phase)
  – follicular secretion of estrogen & inhibin has slowed the secretion of FSH
  – dominant follicles survives to day 6
  – by day 14, graafian follicle has enlarged & bulges at surface
  – increasing estrogen levels trigger the secretion of LH
• In the uterus (proliferative phase)
  – increasing estrogen levels have repaired & thickened the stratum functionalis to 4-10 mm in thickness
Ovulation

- Rupture of follicle & release of 2nd oocyte on day 14
- Cause
  - increasing levels of estrogen stimulate release of GnRH which stimulates anterior pituitary to release more LH
- Corpus hemorrhagicum results
Signs of Ovulation

- Increase in basal body temperature
- Changes in cervical mucus
- Cervix softens
- Mittelschmerz—pain
Postovulatory Phase

• Most constant timeline = lasts 14 days

• In the ovary (luteal phase)
  – if fertilization did not occur, corpus albicans is formed
    • as hormone levels drop, secretion of GnRH, FSH & LH rise
  – if fertilization did occur, developing embryo secretes
    human chorionic gonadotropin (hCG) which maintains
    health of corpus luteum & its hormone secretions

• In the uterus (secretory phase)
  – hormones from corpus luteum promote thickening of
    endometrium to 12-18 mm
    • formation of more endometrial glands & vascularization
  – if no fertilization occurs, menstrual phase will begin
Negative Feedback on GnRH

- High levels of estrogens (without progesterone) stimulate release of GnRH, LH, and FSH.
- Moderate levels of estrogens inhibit secretion of GnRH, FSH, and LH.
- Inhibin inhibits secretion of FSH and LH.
- Low levels of progesterone and estrogens promote secretion of GnRH, FSH, and LH.

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- Ovary:
  - Growth of primary and secondary follicles.
  - Maturation of one dominant follicle.
  - Ovulation.
  - Formation of corpus luteum.
  - Formation of corpus albicans.

- Ovarian hormones:
  - Increasing secretion of estrogens and inhibin by granulosa cells.
  - Increased secretion of progesterone and estrogens by cells of corpus luteum.
  - Increased secretion of inhibin by cells of corpus luteum.
  - No secretion of progesterone and estrogens by corpus albicans.

- Uterus:
  - Repair and proliferation of endometrium.
  - Preparation of endometrium for arrival of fertilized ovum.
  - Menstruation.