Reproduction
Chapter 20

**Function**
- Not for homeostasis of the individual
  - person can survive indefinitely without a reproductive system
- Continuation of the species
  - continuation of genes beyond the lifespan of a single individual

**General Reproductive System Organization**
- **Primary Reproductive Organs (Gonads)**
  - Testes (male) and Ovaries (female)
  1. Produce gametes
     - Sperm and Ova
  2. Produce and secrete sex steroid hormones
     - testosterone, estrogen and progesterone
     - responsible for gamete development, development of reproductive tract and secondary sex characteristics

**Gametogenesis**
- **Gametogenesis**
  - production of gametes
  - Oogenesis (Ova production)
  - Spermatogenesis (Sperm production)
- produced through **meiosis**
  - pairs of homologous chromosomes split among daughter cells
  - 23 chromosomes each

**General Reproductive System Organization**
- **Secondary Reproductive Organs**
  - reproductive tract
    - tube connecting gametes to external environment
  - accessory sex glands
    - supportive secretions
- **External Genitalia**
  - visible portions of reproductive tract
  - sexual stimulation

**Fertilization**
- **Fertilization**
  - union of gametes
- Two gametes fuse together
  - combine genetic information of the parents
- Development from single cell to multicellular adult
  - unique combination of genes
Hypothalamic/Pituitary Regulation of Reproduction

- **Gonadotrophins - FSH and LH**
  - secreted by ant. pituitary
- **Influence both male and female reproductive development and function:**
  - stimulate spermatogenesis/oogenesis
  - stimulate gonadal hormone secretion
  - maintain structure of gonads
- **Release induced by GnRH from the hypothalamus**
  - low level secretion during childhood, increases markedly at onset of puberty

Males vs. Females

- **Gamete production**
  - Eggs released intermittently = 1 mature egg/month
  - Mature sperm are produced continuously
- **Sex steroid release**
  - Female hormones have cyclical release
  - Testosterone released continuously
- **Duration of reproductive life**
  - Reproductive capability begins at puberty for both M and F
  - Female reproduction ends during middle age (menopause)
  - Male reproductive potential continues throughout life

Testes

- **Primary reproductive organ**
  - Produce Sperm
  - Produce Testosterone
- **Housed in Scrotum**
  - external to peritoneal cavity
  - low temp. (35 °C) needed for sperm prod.

2. **Sertoli cells**
   - Large cells that line walls of seminiferous tubules
   - Surround and support developing sperm:
     - Provide nourishment
     - Deposit secretions (spermatogenesis)
     - Secrete seminiferous tubule fluid
     - Protect sperm from immune system

3. **Spermatogenic cells**
   - actively differentiate into mature sperm cells
   - 64 days to complete
   - normal male = 30 million/day
Spermatogenesis

- Sperm development and testosterone production under hormonal control
  - LH → Leydig cells → testosterone
  - FSH → Sertoli cells → spermatogenesis

Mature Spermatozoa

- head
  - chromosomes
- tail
  - swimming
- midpiece
  - mitochondria
- acrosome
  - enzyme filled vesicle
  - 'enzymatic drill'

Male Reproductive Tract

- Epididymis
  - storage of mature sperm
- Vas Deferens
  - conduct sperm out of scrotum to urethra
- Ejaculatory Duct
  - merger point of both vas deferens
  - receives glandular secretions
- Urethra
  - common channel for expulsion of semen and urine

Male Accessory Glands

- Produce Seminal Fluid
  - support sperm in female repro. tract
  - provide nutrients and lubricate tubes
  - semen = seminal fluid + sperm
- Seminal Vesicles
  - (60% of semen volume)
  - supply fructose (energy), prostaglandins
  - induce contractions in female repr. tract

Male Accessory Glands

- Prostate Gland
  - produces alkaline fluid
  - neutralizes vaginal acidity
- Bulbourethral Glands
  - Secrete lubricating fluid for sexual intercourse

Penis

- Male copulatory organ
- Consists of erectile tissue
  - spongy tissue with arterioles
  - Constricted when flaccid
  - Dilate for erection
- Contains urethra
- Glans penis (enlarged end)
  - emerges from prepuce (foreskin)
Ovaries

- **Eggs (Ova)**
- **Female Sex Hormones:**
  - *Estrogen* (estradiol 17β)
    - ova maturation and release
    - secondary sex characteristics
    - maintenance and maturation female reprod. tract
  - *Progesterone*
    - secondary sex characteristics
    - promote fertilization of ovum
    - prepare reproductive tract for pregnancy

Secondary Sex Organs

- **Female reproductive tract**
  - oviducts (Fallopian Tubes)
  - Uterus
    - Implantation/gestation
    - Vagina
    - copulation
    - Connected to uterus at the cervix
    - Sperm enters uterus via cervical canal

External Genitalia

- labia majora
- labia minora
- clitoris

Oogenesis

- germ cells (oogonia) arise early in embryonic development
  - 6-7 million by 5th month of gestation
  - production ceases, and most die off
- differentiate into **primary oocytes** near end of gestation
  - contains 46 replicated chromosomes
  - begin meiosis, but halt in initial stages

Ovarian Cycle

- lasts ~28 days
- 2 alternating phases:
  - **Follicular phase** (Day 1-14)
    - 1° follicle develops with FSH stimulation
      - 1° follicle - 1° oocyte w/ single granulosa layer
      - 2° follicle - granulosa layer divides into numerous layers, fluid filled vesicles form
      - mature (Graafian) follicle - vesicles merge to form fluid filled antrum
  - **Luteal phase** (Day 15-28)
    - corpus luteum forms
    - prepares uterine lining for pregnancy

At birth, ovaries contain ~2 million primary oocytes
- gradually lost (400,000 remain at puberty)
- primary oocytes surrounded by single layer of granulosa cells (ovarian follicle)
- One 1° oocyte matures and is released from its follicle each month
  - About 400 total in lifetime, rest degenerate
  - By menopause, few eggs remain
Ovarian Cycle

- **Ovulation** of mature egg
  - Day 14 of ovarian cycle
- **Luteal phase** (Day 14-28)
  - Presence of corpus luteum
  - Prepares reproductive tract for pregnancy

Ovarian Follicle

- Oocyte
- Zona pellucida = gel-like membrane around oocyte
- Granulosa Cells = surround and support oocyte
  - Cells secrete Follicular Fluid into antrum containing estrogen
- Thecal cells = specialized connective tissue cells
  - Secrete testosterone used by granulosa cells to make estrogen

Oogenesis

- Egg completes 1st meiotic division just before ovulation
- Releases 1st polar body to become a 2nd oocyte
- Begins 2nd meiotic division, but then stops
  - Not completed until fertilization

Corpus Luteum Formation

- After egg is released follicle becomes corpus luteum
  - Secretes estrogen and progesterone
  - Build-up of uterus
- If egg is fertilized corpus luteum remain
  - Maintains uterine buildup
- If not, corpus luteum degenerates
  - Onset of new follicular phase

Hormonal Regulation of Ovarian Cycle

- Under control of hypothalamus (GnRH)
  - Stimulates FSH and LH release from ant. pituitary
- 1st follicle begins to develop under stim. by FSH
- As follicle matures, estrogen (estradiol) secretion increases

Hormonal Regulation of Ovarian Cycle

- As estrogen increases, positive feedback on the ant. pit. (stim LH prod)
- LH surge
  - Rapid increase in LH release on Day 13
- Follicle ruptures and releases the egg
  - Ovulation
Hormonal Regulation of Ovarian Cycle

- Cells of ruptured follicle form the Corpus Luteum
  - secretes Estrogen and Progesterone
  - help prepare uterus for a fertilized egg
  - progesterone inhibits FSH and LH = no new follicles mature

- If egg is fertilized…
  - corpus luteum is maintained
  - halts development and release of a 2nd egg
- If egg is not fertilized…
  - corpus luteum degenerates within 2 weeks

Uterine (Menstrual) Cycle

- E and P induce cyclical buildup and breakdown of uterine lining
  - preparation for pregnancy
  - on average occurs every 28 days in women
- Uterus consists of 3 layers:
  - Perimetrium = outer layer of connective tissue
  - Myometrium = smooth muscle
  - Endometrium = lining with many blood vessels, glands

- Proliferative phase
  - estrogen induced
  - starts buildup of endometrium while follicle matures
  - corresponds with later part of Follicular Phase (Days 5-14)
  - lasts ~ 10 days

- Secretory phase
  - progesterone induced
  - Completes buildup
  - Increases # blood vessels and secretory glands
    - engorged with glycogen for embryonic support
  - Corresponds to Luteal Phase (Day 14-28)

- Menstrual phase
  - due to ↓ progesterone as corpus luteum degenerates
  - discharge of blood and endometrial debris
  - Fall in P, release uterine prostaglandin
    - vasoconstriction and contraction
  - corresponds with early Follicular Phase (Days 1-5)
Fertilization
• Occurs in oviduct
  – of millions of sperm, only a few hundred reach oviduct
• sperm head entry triggers change in zona pellucida
  – prevents other sperm from entering
• ovum completes 2nd meiotic division
  – ejects 2nd polar body.
• sperm and egg nuclei fuse → zygote

Early Development
• zygote begins mitotic cell divisions (cleavage) 30-36 hr after fertilization
• Forms blastocyst by Day 6 (hollow ball of cells)
  – inner layer = inner cell mass (embryo)
  – outer layer = chorion
  • consists of trophoblast cells

Implantation
• zygote enters uterus 3 days after fertilization
• blastocyst implants in endometrium on Day 6
• blastocyst begins cell differentiation
  – Embryo
  – Fetus (8+ weeks)

Implantation
• chorion of implanted embryo secretes Human Chorionic Gonadotropin (hCG)
• prevents degeneration of the corpus luteum through 3rd month of pregnancy
  – maintains E and P production, thus endometrium

Placenta
• develops from adjacent chorionic and endometrial tissue
• allows exchange between maternal and fetal blood
• performs functions urinary, digestive, respir. systems
• Hormonal production

Other Extraembryonic Membranes
• Amniotic sac
  – fluid filled cavity (amniotic fluid)
  – Protects embryo
• Chorion
  – outer membrane
Childbirth

- Hormonally driven
- Oxytocin
  - peptide hormone from hypothalamus, stored in posterior pituitary
  - induces strong uterine contractions → expulsion of fetus
  - affected by estrogen and progesterone secretion
    - estrogen stimulates oxytocin secretion and ↑ oxytocin receptors on myometrial cells
    - progesterone reduces sensitivity of uterus to estrogen, oxytocin and prostaglandins

At term, estrogen levels ↑
  - placenta converts fetal adrenal androgens into estrogen
  - labor begins when oxytocin reaches critical level
  - Stages of labor
    - Cervical dilation (10 cm)
      - head of fetus pushes on cervix
    - Fetal Expulsion
    - Placental Expulsion