The Reproductive System

Introduction

- General system functions
  - Production of gametes
  - Method for transfer of spermatozoa to ovum
  - Site for fertilization
  - Stable environment for protection and development of zygote

Reproductive System
- Primary sex organs
  - Testes and ovaries
    - Produce sex cells (gametes)
    - Secret sex hormones
      - Androgens (males)
      - Estrogens and progesterone (females)
- Accessory reproductive organs
  - Ducts
  - Glands
  - External genitalia

Male Reproductive System
- Testes
- Ducts
- Accessory glands
- Penis
- Hormonal function of the testis

Testes
- Reside in scrotum
- Paired, located outside of body
  - Descend into scrotum through inguinal canal
- Cryptorchidism
Testes

- Septa divide the testis into lobules
  - Contain seminiferous tubules
    - Site of sperm production (spermatogenesis)
      - Cells lining the tubules
        » Spermatogonial cells in various stages of development
        » Sustentocytes → support developing spermatocytes and produce androgen-binding protein (ABP)
      - Cells around the tubules
        » Interstitial/Leydig cells → produce testosterone
        » Myoid cells → contract & squeeze spermatozoa into tubule lumen

Ducts

- Direct sperm cells out of body
  1. Epididymis
  2. Ductus (vas) deferens
  3. Ejaculatory duct
  4. Urethra
Ducts

- Epididymis
  - Final aspects of sperm development
  - Stored until ejaculation
  - Duct contracts moving sperm into the ductus deferens

Ducts

• Ductus (vas) deferens
  - Passes through the inguinal canal into abdomen
  - Joins the duct of the seminal vesicle to form the ejaculatory duct
  - Propels sperm to the urethra
  - Vasectomy
    • Cutting and ligating the ductus deferens
    • Nearly 100% effective form of birth control

Ducts

• Ejaculatory duct
  - Right and left join in prostate gland
  - Join urethra
Accessory Glands

- **Semen**
  - Sperm + testicular fluid + accessory gland fluids
  - Fluid nourishes and activates sperm
  - Neutralizes acidity of urethra and vagina

- **Glands**
  - Seminal vesicles
  - Prostate gland
  - Bulbourethral glands

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Accessory Glands

- **Seminal vesicles**
  - Produce viscous alkaline seminal fluid
    - Fructose, coagulating enzyme
    - 60-70% of the volume of semen
  - Duct of seminal vesicle joins the ductus deferens to form the ejaculatory duct

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Accessory Glands

- **Prostate**
  - Encircles part of the urethra inferior to the bladder
  - Secretes milky fluid
    - Enzymes play a role in the activation of sperm
    - Enters urethra during ejaculation
  - Diseases
    - Prostatitis
    - Benign prostatic hyperplasia (BPH — “Enlarged prostate”)
    - Prostate cancer

Accessory Glands

- Bulbourethral glands
  - Inferior to the prostate
  - Secrete prior to ejaculation
    - Thick, clear mucus
      - Neutralizes traces of acidic urine in the urethra
      - Helps neutralize acidity of vagina
      - Lubricates the glans penis during intercourse

The Penis

- Structure
  - 3 regions
    - Root - internal
    - Shaft - external
    - Glans – most distal portion
  - Prepuce (foreskin)
    - Cuff of loose skin covering the glans
    - Circumcision
      - Surgical removal of the foreskin

The Penis

- Urethra
  - Erection
    - Erectile tissue fills with blood
      - Causes the penis to enlarge and become rigid
      - Parasympathetic reflex

The Penis

- Ejaculation
  - Propulsion of semen from the male duct system
  - Sympathetic spinal reflex
    - Ducts and accessory glands contract and empty their contents
    - Bladder sphincter muscle constricts
      - Prevents the expulsion of urine
    - About 3 - 5 ml of semen released
      - 300 million sperm cells
      - Few survive
      - Counts below 20 million/ml = fertility problems
The Penis

- Impotence
  - Erectile dysfunction (ED)
  - Physical abnormalities
  - Psychological causes
  - Affects 50% of American men over 40 to some degree

Hormonal Function of the Testes

- Testosterone
  - Produced by interstitial (Leydig) cells
  - Functions
    - Development of male reproductive system
    - Completion of sperm maturation
    - Secondary sexual characteristics
      - Body hair
      - Bone and muscle growth
      - Aggressive behavior

Female Reproductive System

- Ovaries
  - Produce female gametes (ova)
  - Secrete female sex hormones
    - Estrogen and progesterone
  - Accessory ducts include
    - Oviducts (uterine tubes, Fallopian tubes)
    - Uterus
      - Maintains zygote development
    - Vagina
      - Receives male gametes

Ovaries

- Each about twice as large as an almond
- Ovarian ligaments
Ovaries

- **Follicles**
  - About 1 million present at birth
  - About 400,000 present at puberty
  - Some develop into mature ova at sexual maturity
    - Maturation of a follicle occurs about every 28 days
      - Ovulation

Female Duct System

- **Uterine tubes**
- **Uterus**
- **Vagina**

Uterine (Fallopian) Tubes

- Extend from uterus to near ovary
  - End as infundibulum
- Post-ovulation
  - Cilia create currents, move ovum into uterine tube
  - Fertilization normally takes place within tube
    - Ectopic pregnancy
    - Pelvic inflammatory disease
Uterus

- Structure
  - Body
    - Main region
  - Fundus
    - Rounded superior region
  - Isthmus
    - Narrowed inferior region
- Layers
  - Serosa
  - Myometrium
  - Endometrium

Vagina

- Muscular tube from uterus (cervix) to outside the body
  - Birth canal
  - Organ of copulation
  - Pathway for menstrual flow
- Lined by mucous membrane
  - Acidic secretions retard bacterial growth
- Numerous immune cells
  - Rare cases: develop antibodies against sperm

Uterus (Figure 27.12a)

- Cervix
  - Narrow neck, or outlet
  - Projects into the vagina
  - Common site for cancer

Vagina (Figure 27.12b)
Hormonal Function of Ovaries

- Endocrine function
  - Estrogen and progesterone production
  - Development of reproductive organs
  - Secondary sexual characteristics
  - Affect protein anabolism
  - Affect fluid and electrolyte balance

Other Hormones

- FSH and LH
  - Produced by pituitary gland
- Human chorionic gonadotropin
  - Produced by placenta

External Genitalia

- Vulva
  - Skin folds surrounding vaginal orifice
  - Clitoris
    - Erectile tissue
    - Homologous to male penis
    - Sexual arousal

Accessory Organs

- Mammary glands
  - Present in both males and females
  - Modified sweat glands
    - Glandular alveoli capable of hormone-stimulated milk production
- Breast cancer
Gamete Formation

- Introduction
  - Chromosomes carry genetic information
    - In humans, cells contain 46 chromosomes
    - Gametes carry only 23 chromosomes – why?

Meiosis

- Special type of cell division in the reproductive tract
- Two cell divisions
  - Results in 4 daughter cells
    - Genetically unique
    - Spermatogenesis or oogenesis

Meiosis

- Non-disjunction
  - Chromosomes fail to separate properly
    - Trisomy
      - Trisomy 13 and 18 = usually fatal
      - Trisomy 21 = Down syndrome
    - Monosomy
      - Always fatal if involving somatic ce

Chromosomal Abnormalities

- Klinefelter’s syndrome
  - XXY males
  - Non-disjunction during meiosis I
Chromosomal Abnormalities

- Turner’s syndrome
  - All or part of one sex chromosome is missing
  - XO female

Spermatogenesis

- Begins within testes at puberty
- Spermatogonia – stem cells
  - Divide mitotically
  - Some of the daughter cells undergo a growth phase
    - Become primary spermatocytes
      - Undergo 2 divisions (meiosis)
        1. Produces 2 secondary spermatocytes (haploid)
        2. Produces 4 spermatids → mature into a spermatozoa

Spermatogenesis

- Spermatic cells give rise to sperm
  - Mitosis
    - Spermatogonia form primary spermatocytes
  - Meiosis
    - Primary spermatocytes become secondary spermatocytes and then spermatids
  - Spermiogenesis (maturation)
    - Spermatids become spermatozoa (sperm)
Spermatogenesis

- Spermatids lose excess cytoplasm and form a tail, becoming spermatozoa (sperm)
- Major regions
  1. Head
     - Genetic region
     - Nucleus
     - Acrosome with hydrolytic enzymes
  2. Midpiece
     - Metabolic region
     - Mitochondria!!!!!
  3. Tail
     - Locomotor region
     - Flagellum

Approximately 24 days

Oogenesis

- Production of female gametes
- Begins in fetus
  - Oogonia multiply by mitosis
  - Develop into primary oocytes within follicles
    - Eventually produce estrogen
    - Primary oocytes begin meiosis but stall in prophase I
    - About 1 million present at birth (300,000 – 400,000 at puberty)

Each month after puberty, a few primary oocytes are activated
  - One is selected each month to resume meiosis I
  - Result is two haploid cells
    - Secondary oocyte → majority of cytoplasm + chromosomes
    - First polar body → chromosomes
Oogenesis

- Secondary oocyte is ovulated
- Sperm penetration of second oocyte completes meiosis II
  - Produces
    - Ovum (functional gamete)
    - Second polar body

The Ovarian Cycle

- Oocyte prepared and released ≈ 28 days
- Three consecutive phases
  1. Follicular phase
     - Period of follicle growth (days 1–14)
  2. Ovulation
     - Midcycle
  3. Luteal phase
     - Period of corpus luteum activity (days 14–28)
The Ovarian Cycle

- Hormonal interactions
  - High estrogen levels induce surge of LH
  - Effects of LH surge
    - Triggers ovulation
    - Transforms ruptured follicle into corpus luteum (CL)
    - Luteal phase

- Luteal phase
  - Corpus luteum remains functional only if pregnancy occurs
  - Functions
    - Produces estrogen and progesterone
    - Inhibit pituitary release of LH and FSH
    - Maintain uterine lining

The Uterine (Menstrual) Cycle

- Definition
  - Cyclic changes in endometrium in response to ovarian hormones

- Three phases
  1. Days 1–5: Menstrual phase
  2. Days 6–14: Proliferative (preovulatory) phase
  3. Days 15–28: Secretory (postovulatory) phase – luteal phase

- Menstrual phase
  - No fertilization → corpus luteum degenerates → ovarian hormone levels drop sharply
  - Birth control pills
    - Mimic hormones produced by corpus luteum
    - Prevent ovulation

(d) The three phases of the uterine cycle:
- Menstrual: Shedding of the functional layer of the endometrium.
- Proliferative: Rebuilding of the functional layer of the endometrium.
- Secretory: Begins immediately after ovulation.
  Enrichment of the blood supply and glandular secretion of nutrients prepare the endometrium to receive an embryo.
The Uterine Cycle

- Menstrual phase (days 1-5)
  - Follicles growing within ovary during this time
  - Functional layer of endometrium sloughs
    - Menstrual flow occurs
    - Endometrial tissue, fluid and mucus pass through vagina

- Proliferative phase (days 6-14)
  - Estrogen from follicle stimulates growth of endometrium
  - Preparation for pregnancy
  - Ovulation usually occurs at the end of this cycle (day 14)

- Secretory phase
  - Corresponds with luteal phase of ovarian cycle
  - Progesterone and estrogen produced after ovulation
    - Further development of endometrium
  - In the absence of fertilization
    - CL degenerates
    - Estrogen and progesterone levels fall
    - Endometrium deteriorates
    - Another menstrual cycle begins
  - If fertilization occurs
    - Human chorionic gonadotropin (HCG) produced
      - Maintains CL
      - Home pregnancy tests

Menopause

- Cessation of reproductive cycles
  - By age 45-50 ovarian follicles cease to respond to FSH and LH
  - Follicles stop producing estrogen
    - No inhibition of pituitary
    - No LH surge
    - No ovulation, no corpus luteum, no progesterone

(c) Fluctuation of ovarian hormone levels: Fluctuating levels of ovarian hormones (estrogens and progesterone) cause the endometrial changes of the uterine cycle. The high estrogen levels are also responsible for the LH/FSH surge in (a).
Menopause

- Symptoms associated with high FSH and LH levels
  a) Vaginal dryness
  b) Irritability/depression
  c) Vasodilation of skin blood vessels → hot flashes & night sweats
  d) Thinning of skin, breast atrophy
- Clinical findings
  - Increased cholesterol
  - Loss of bone mass (osteoporosis)

Sexually Transmitted Diseases

- STDs
- Also called sexually transmitted infections (STIs) or venereal diseases (VDs)
- The single most important cause of reproductive disorders

Gonorrhea

- Bacterial infection of mucosa
  - Reproductive and urinary tracts
  - Painful urination in males
- Spread by contact with genital, anal and pharyngeal mucosa

Syphilis

- Bacterial infection
  - Transmitted sexually or contracted congenitally
  - Infected fetuses are stillborn or die shortly after birth
- Infection is asymptomatic for 2–3 weeks
  - Painless chancre appears at the site of infection
  - Disappears in a few weeks
- Untreated
  - May eventually infect nervous and vascular system
    - Severe signs, often fatal
- Treatment
  - Penicillin

Chlamydia

- Most common bacterial STD in the United States
  - Responsible for 25–50% of all diagnosed cases of pelvic inflammatory disease
- Symptoms
  - Urethritis
  - Penile and vaginal discharges
  - Abdominal, rectal, or testicular pain
  - Painful intercourse
  - Irregular menses
- Treatment
  - Tetracycline

Genital Herpes

- Caused by herpes simplex virus type 2
- Characterized by latent periods and flare-ups
  - Congenital herpes can cause malformations of a fetus
  - Virus hides in posterior root ganglia of nerves in genital area
- Treatment
  - Acyclovir and other antiviral drugs
Specific Female Disorders

- Endometriosis
  - Extra-uterine endometrial tissue
  - Responds to hormones
  - May be present throughout abdomen
    - Most commonly associated with uterus, tubes or ovaries
  - No drainage is possible = blood accumulates = pain

- Pelvic inflammatory disease
  - HPV
    - Men can carry, but it usually doesn’t cause a problem
  - Tumors
    - Common in cervix, uterus, and breast
    - May be malignant or benign

Specific Male Disorders

- Most common problems involve prostate
  - Prostatitis
  - Benign prostatic hyperplasia
  - Prostate cancer

Heredity

- Genes
  - Short sequences of DNA making up chromosomes
  - Specify order of amino acids which make proteins
  - Each cell contains two copies of a gene
- Alleles
  - Different forms of a gene
  - Homozygous and heterozygous
  - Dominant and recessive

- Inheritance
  - Individuals pass only one allele to offspring
    - Possible to predict appearance or trait

- Sex and sex-linked inheritance
  - Gender is genetically controlled
  - XY and XX
    - Sex linked inheritance
    - Women can carry an unexpressed allele which may be expressed in sons