Reproductive System (Chapter 28)
Lecture Materials
for
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Primary Sources for figures and content:

The Reproductive System
-only organ system not vital to survival
-primary sex organs = gonads: produce gametes
Gametes = sex cells: ovum and sperm
-sex cells are haploid (n): have half normal chromosome number (23 vs. 46)
All human tissues = somatic cells; diploid (2n), 46 chromosomes, 23 homologous pairs
-homologous chromosomes have same genes: one from ovum and one from sperm
1-1n/23 chrom. ovum + 1-1n/23 chrom. sperm = 1 2n/46 chrom. zygote (fertilized egg)
-zygote will divide by mitosis to produce all diploid somatic cells of body

Gametogenesis = process of gamete formation
-2n somatic cells produce 1n sex cells
-reducing chromosome number by half requires special cell division → meiosis

Cell Division: Mitosis and Meiosis (on handout)

Male Reproductive System
-consists of: male gonads = testes, and accessory reproductive organs = ducts, glands, external genitalia that aid sperm production/delivery

Scrotum
-sac of cutaneous membrane, fascia, muscle
-external to abdominopelvic cavity
-2 chambers, divided by raphae: each supports one testis
-maintains testes at optimal temp for sperm development (36.2°C/96.5°F)
-two muscles regulate temp:
- dartos muscle: smooth muscle in dermis, causes surface wrinkling to reduce heat loss
- cremaster muscle: skeletal muscle from internal obliques, adjusts proximity of testes to body
**Testes** (= male gonads)
- produce gametes (sperm) and hormones: androgens (testosterone) and inhibin

**Development**
- form in abdominal cavity: same tissue and position as ovaries
- descend prior to birth through inguinal canal

**Cryptorchidism** = failure of testes to descend, 3% full term 30% premature births, internal testis will be sterile

**Inguinal hernia** = protrusion of intestine through inguinal canal

**Structure**
- surrounded by two tunics:
  - tunica vaginalis: derived from peritoneum: parietal and visceral layers
  - tunica albuginea: fibrous capsule of testis
- partitions from tunica albuginea divide testis into lobules
- each lobule contains 1-4 coiled seminiferous tubules

**Vasectomy** = surgical sterilization: sever ductus deferens in spermatic cord

**Functional regions of testes**
A. Interstitial cells
- in CT around seminiferous tubules
- produce androgens (testosterone)
B. Seminiferous tubules
- surrounded by capsule and areolar CT
- outer edge lined with spermatogonia (sperm stem cell)
- spermatogonia divide and differentiate to produce spermatozoa for release into lumen
-also contain sustentacular cells: aid sperm differentiation, extend from basement membrane to lumen

Spermatogenesis = sperm formation

(on handout)

Structure of sperm/spermatozoon
1. head (genetic part):
   - flattened nucleus, compact DNA
   - covered by acrosome:
     lysosome-like cap containing hydrolytic enzymes for ovum penetration
2. midpiece (metabolic part)
   - contains mitochondria $\rightarrow$ ATP to power contractile filaments of flagella
3. tail (locomotor region)
   - flagellum: whip-like motion to propel cell

Role of Sustentacular cells in Spermatogenesis
1. Maintenance of blood-testis barrier:
   - cells linked by tight junctions, regulate environment inside tubule $\rightarrow$
     - high levels of androgens, estrogens, K$^+$, amino acids (testicular fluid)
   - excludes leukocytes

2. Support mitosis and meiosis:
   - stimulated by FSH and testosterone, promote cell divisions
3. Support during spermeogenesis:
   - hold spermatids and stimulate development
4. Secrete inhibin:
   - peptide hormone--inhibits FSH and GnRH (negative feedback for spermatogenesis)
5. Secrete Androgen Binding Protein:
   - binds androgens to retain them in tubule to stimulate spermiogenesis
6. Secrete Mullerian Inhibiting Factor:
   - prevent development of Mullerian ducts (uterus, uterine tubes) in fetus

Reproductive Tract
- spermatogenesis in seminiferous tubule takes 64-72 days
- immature sperm released into testicular fluid in lumen of tubule
- moved by fluid pressure and cilia to epididymis

A. Epididymis
- 6m coiled tubule around top and side of testis
- functions:
  1. monitor and adjust composition of testicular fluid (stereocilia absorb or secrete)
  2. recycle damaged spermatozoa
  3. protect, store, facilitate maturation of sperm:
     - transit takes $\sim$20d, sperm mature and gain ability to be motile
     - mature sperm stored few months
-during ejaculation, smooth muscle in wall propels sperm to ductus deferens

B. Ductus deferens

-passes through inguinal canal, anterior to pubis, loops over ureter, descends posterior to bladder
-ends in ampulla: connects to seminal vesicles and prostate
-during ejaculation, peristaltic contractions transmit sperm from storage in epididymis to ejaculatory duct to mix with glandular secretions which activate sperm (now motile)
-ejaculatory duct connects ampulla to urethra

C. Urethra
-shared by urinary and reproductive systems
-3 regions:
  1. prostatic urethra: connects to urinary bladder and ejaculatory duct, passes through prostate
  2. membranous urethra: passes through body wall (urogenital diaphragm)
  3. spongy/penile urethra: length of penis, opens at external urethral orifice

Accessory Glands
-produce fluid, nutrients, enzymes, buffers, that comprise bulk of semen

semen = sperm + gland secretions

A. Seminal vesicles
-on posterior bladder wall
-produce seminal fluid:
  1. fructose: nutrients to drive sperm motility
  2. prostaglandins: promote smooth muscle contraction to aid sperm mobility
  3. fibrinogen: converted to fibrin to form clot in vagina
  4. vesiculase: enzyme for fibrinogen conversion
  5. alkaline buffers: buffer acid pH of vagina
-during ejaculation sperm mixed with seminal fluid in ejaculatory duct become highly motile

B. Prostate gland
-encircles prostatic urethra
-secretes prostatic fluid into urethra:
  1. enzymes to digest cervical mucus
  2. fibrinolysin: breaks down semen clot to release sperm in vagina
  3. seminalplasm: antibiotic

C. Bulbourethral glands
-in urogenital diaphragm
-secrete alkaline mucus: neutralize urinary acids and lubricate glans
Semen
- 2-5ml/ejaculation
- 60% seminal fluid
- 30% prostatic fluid
- 10% testicular fluid + active spermatozoa
- 50-300 million sperm/ml
(less than 60 million total = sterile)

External Genitalia
A. Scrotum
B. Penis
-function: deliver sperm to female tract
-3 parts:
  1. root- attaches to body wall
  2. shaft- tubular, houses erectile tissue
  3. glans- distal end, covered by prepuce
preputial glands secrete smegma
Circumcision = remove prepuce: prevent UTIs

-shaft contains 3 columns of erectile tissue:
  1. 2 corpora cavernosa - anterior, stiffen shaft
  2. 1 corpus spongiosum - surrounds urethra, distal end forms glans, holds urethra open
erectile tissue = vascular channels surrounded by elastic CT and smooth muscle, fills with blood via parasympathetic stimulation

Male Sexual Function
1. Erection
-triggered by tactile or mental stimuli
-parasympathetic triggers release of NO
-NO dilates arterioles → blood fills channels
-expansion compresses drainage veins → blood pressure = stiff

-parasympathetic also triggers secretion from bulbourethral glands
-eventually spinal reflex triggered

B. Ejaculation
-spinal reflex → sympathetic stimulation
ducts and glands contract emptying contents to urethra
-skeletal muscles of penis contract, semen propelled out urethral orifice
C. Detumescence
-erection subsides: sympathetic constricts arterioles
-latent period: new ejaculation not possible (min-hrs)

Impotence = inability to achieve or maintain erection: due to alcohol, drugs, or hormonal, vascular, or nervous system problems

Hormones and Male Reproductive Function (on handout)

Age Related Changes
-male climacteric: ↓ testosterone = ↓ libido
-benign prostatic hypertrophy: prostate increases, can blocks urethra
-increased impotence
-sperm motility rate declines
Female Reproductive System
-consists of: female gonads = ovaries, and accessory reproductive organs = uterine tubes, uterus, vagina, that aid fertilization and embryo growth and delivery
Ovaries (= female gonads)
-produce: gametes (ova) and hormones estrogen, progesterone, inhibin
-lateral to uterus
-surrounded by two layers:
  1. germinal epithelium: simple cuboidal epithelium, from peritoneum

2. tunica albuginea: dense CT capsule
-cortex houses forming gametes in ovarian follicles:
  1. oocyte
  2. surrounding cells:
     - single layer = follicle cells
     - stratified = granulosa cells
-endocrine cells that produce female sex hormones
-medulla contains blood vessels and nerves

Oogenesis
(on handout)

The Ovarian Cycle
(on handout)

at birth: ~2 million primordial follicles
at puberty: ~200,000 remain
of those only ~500 will ovulate

Uterine tubes
-function: transmit oocyte to uterus
-site for fertilization
-muscular tube, lined with ciliated columnar epithelium and mucin secreting cells
-oocyte moved via peristalsis and cilia
-secretions to nourish oocyte (and sperm)
-3 regions:
  1. infundibulum - expanded end, has fimbriae with cilia that sweep ovarian surface to brush oocyte into uterine tube
  2. ampulla - muscular length, fertilization occurs here
  3. isthmus - connects to uterus
- transit ovary to uterus takes 3-4 days

*Ectopic pregnancy* = implantation of zygote in location other than uterus (0.6%), most spontaneously abort

Pelvic Inflammatory Disease = infection of uterine tubes (*N. gonorrhoeae, Chlamydia*), scaring can cause infertility

**Uterus**
- anterior to rectum, posterior and superior to bladder
- function: house and nourish fertilized ovum
- two regions:
  1. body - main portion, wall has 3 layers:
     a. perimetrium = visceral peritoneum
     b. myometrium: middle, thick muscular
     c. endometrium: inner, glandular mucosa, simple columnar epithelium over thick lamina propria, 2 zones:

- functional zone: thick, borders uterine cavity, glands, vessels and epithelium change with hormones through uterine cycle, shed in mensus
- basilar zone: thin, borders myometrium, remains constant, gives rise to new functional zone after mensus

  ![Diagram of Uterus](image)

2. cervix- inferior, tubular
  - connects to vagina through cervical canal at external os
  - mucosa has cervical glands: secrete thick mucus to block canal to prevent infection (mucus thins at mid ovarian cycle for sperm entry)

*Prolapse of the uterus* = damage to supporting ligaments results in uterus protruding through vaginal opening

![Diagram of Uterus and Pelvic Inflammatory Disease](image)
Uterine Cycle (Menstrual Cycle) 
(on handout)

*Endometriosis* = endometrial tissue growing outside uterus, painful mass that cycles, requires drugs or surgery

Menarche = first menstrual cycle

Menopause = last menstrual cycle

Amenorrhea = failure to initiate mensus, due to physical exertion and low body mass, (leptin permissive on gonadotropins)

**Vagina**
- functions to receive penis and deliver infants and menstrual flow
- elastic muscular tube, connects cervix to vestibule (external genitalia)
- 3 wall layers:
  1. adventitia
  2. muscularis
  3. mucosa: stratified squamous epithelium, folded into rugae when relaxed
- epithelium secretes glycogen, resident bacteria metabolize into lactic acid, low pH prevents pathogen colonization

**External genitalia** = vulva

1. mons pubis - anterior vulva, adipose over pubic symphysis
2. labia majora - lateral vulva (=male scrotum), surrounds labia minora
3. labia minora - encloses vestibule (=ventral penis)
4. vestibule - urethral orifice anterior, vaginal orifice posterior, flanked by greater vestibular glands (=bulbourethral glands) that produce secretions to lubricate vestibule
5. clitoris - anterior to vestibule, erectile tissue (=corpus cavernosa), covered by prepuce - formed by anterior labia

**Mammary Glands**
- lactation: milk to nourish newborn
- modified sweat glands over pectoralis muscles
- center = areola, pigmented skin around nipple
- divided into ~25 lobes around nipple, CT and adipose between lobes
- lobe contains lobules of alveoli- glandular structures that produce milk
- lobule empties to lactiferous duct, exits lobe to lactiferous sinus
- sinus stores milk during nursing
- pregnancy causes proliferation of alveolar tissue for milk production
**Effects of estrogen:**
1. stimulate bone and muscle growth
2. develop/maintain female secondary sex characteristics
3. stimulate sex drive in CNS
4. maintain accessory glands and organs for reproduction
5. initiates repair and growth of endometrium

**Female Sexual Function**
- triggered by tactile or mental stimuli
- parasympathetic triggers engorgement of erectile tissue: clitoris, vaginal mucosa, breast, and secretion by vestibular glands
- orgasm with smooth muscle contractions but mechanism poorly understood

**Age Related Changes**
- menopause: menstruation and ovulation cease due to lack of primordial follicles
- estrogen and progesterone levels decline
- GnRH, FSH, LH increase
- resulting hormone levels result in:
  - reduction of uterus and breast (glands)
  - osteopenia or osteoporosis
  - cardiovascular disorders