Structures of Urinary System

- Kidneys (2)
  - Retroperitoneal
  - Renal capsule
  - Adipose capsule
  - Renal fascia
  - Hilum
- Ureters (2)
- Urinary Bladder (1)
- Urethra (1)

1.2 million nephrons per kidney
- Functional unit of the kidney
  - Cortical nephrons
  - Juxtamedullary nephrons

- Parts of nephron
  - Renal corpuscle (glomerulus + Bowman capsule)
  - Renal tubules
    - Proximal tubule (pct)
    - Loop of Henle
    - Distal tubule (dct)

- Glomerular filtration membrane
  - Blood passes through the three layers and forms the filtrate
- **Juxtaglomerular apparatus**
  - Juxtaglomerular cells (renin)
  - Macula densa (sense changes in Na+)
  - Renin-angiotensin pathway: reg. BP
    - Decr. blood vol. or decr. Na+ → incr. renin → Angiotensin I → Angiotensin II → aldosterone (incr. reabsorption of Na+ and H₂O)

- **Urinary Bladder**
  - Detrusor muscle
  - Trigone
  - Micturition reflex

- **Urethra**
  - Internal and external sphincters
  - 3 to 4 cm in females
  - 18 to 20 cm in males

- **Renal Blood Flow**
  - Receive 1000 to 1200 mL of blood/min.
  - Glomerular filtration rate (GFR)
  - Autoregulation
    - Tubuloglomerular feedback

- **Structures of Urinary System**

- **Renal Blood Flow**
  - Neural regulation
  - Hormones
    - Renin-angiotensin system
    - Aldosterone
    - ADH (conserves water/incr. water reabsorption)
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Unit VIII

Renal Blood Flow

Nephron Function

- Filters plasma
- Reabsorbs and secretes
  - Tubular reabsorption and secretion
- Forms a filtrate of protein-free fluid
- Regulates filtrate to maintain fluid volume, electrolytes, and pH

Concentration and Dilution of Urine

- Glomerular filtration
  - Net filtration pressure
    - Glomerular capillary oncotic/hydrostatic pressure
    - Bowman capsule oncotic/hydrostatic pressure
  - Filtration rate
    - 180 L/day

- Countercurrent exchange system
  - Contributes to production of concentrated urine

- Aldosterone
- Antidiuretic hormone (ADH)
- Atrial natriuretic peptide (ANP)
  - produced by RA, when RA press. increases, inhibits secretion of renin
- Diuretics
  - enhance urine flow (by disrupting Na+ reabsorption and decr. ECF vol.)

Concentration and Dilution of Urine

- Urinary tract obstruction
  - interference with flow of urine at any site along urinary tract
  - Obstruction can be caused by anatomic or functional defect
  - Obstructive uropathy – changes in urinary system due to obstructions (anatomic)
Urinary Tract Infection (UTI)

- **UTI** - inflammation of urinary epithelium caused by bacteria
- **Acute cystitis**
- **Interstitial cystitis**
- **Acute and chronic pyelonephritis**

**Urinary Tract Infection (UTI)**

**Acute cystitis**
- Cystitis is an inflammation of the u.b.
  - *E. coli* most common cause
- Manifestations
  - Frequency, dysuria, urgency, and lower abdominal and/or suprapubic pain
- Treatment
  - Antimicrobial therapy, increased fluid intake, avoidance of bladder irritants, and urinary analgesics

**Urinary Tract Infection (UTI)**

**Interstitial cystitis**
- Nonbacterial infectious cystitis
- Manifestations
  - Most common in women 20 to 30 years old
  - Bladder fullness, frequency, small urine vol., chronic pelvic pain
  - Immunocompromised (undergoing chemo or radiation therapy)
- Treatment
  - No single treatment effective, symptom relief

**Urinary Tract Infection (UTI)**

**Pyelonephritis**
- Acute pyelonephritis
  - Acute infection of the renal pelvis & interstitium
    - Vesicoureteral reflux (urine reflux up ureter into kidney), *E. coli, Proteus, Pseudomonas*
- Chronic pyelonephritis
  - Persistent or recurring episodes of acute pyelonephritis that leads to scarring
  - Risk of chronic pyelonephritis increases in individuals w/ renal infections and some type of obstructive pathologic condition

**Urinary Tract Infection (UTI)**

**Chronic Pyelonephritis**

- Normal size - scarring on upper surface
- Shrunken size - scarring
**Glomerular Disorders**

- **Glomerulonephritis**
  - Inflammation of the glomeruli (typically after a strep infection)
  - Immunologic abnormalities (most common)
  - Drugs or toxins
  - Vascular disorders
  - Systemic diseases
  - Viral causes
  - Most common cause of end-stage renal failure

- **Mechanisms of injury**
  - Immune response - deposition of antigen-antibody complexes in glomerular capillaries
  - Formation of antibodies against the glomerular basement membrane → break down cells → incr. permeability

  [Kidneys are small and have granular external surface]

- **Acute poststreptococcal glomerulonephritis**

- **Rapidly progressing glomerulonephritis (RPGN)**
  - Antiglomerular basement membrane disease (Goodpasture syndrome) – rare

- **Chronic glomerulonephritis**

- **Uremia**
  - accumulation of N-wastes and metabolic toxins in plasma
  - Symptoms: confusion, GI complaints, fluid in lungs, infection
  - Describes clinical manifestations of CRF (chronic renal failure)

- **Chronic renal failure (CRF)**
  - Progressive, irreversible loss of renal function that affects nearly all organ systems
  - **Stages**
    - Chronic renal insufficiency (GFR 20-35% of normal)
    - Chronic renal failure (GFR 20-25% of normal)
    - End-stage renal failure (GFR <20% of normal)
• CRF due to:
  – Glomerulonephritis
  – Chronic infections (pyelonephritis or TB)
  – Congenital (polycystic disease)
  – Vascular (HT or nephrosclerosis)
  – Obstructions (renal calculi)
  – Diabetic neuropathy

• Alterations seen in following systems:
  – Musculoskeletal
  – Cardiovascular and pulmonary
  – Hematologic
  – Immune
  – Neurologic

Imbalances in following factors:
• Proteinuria and uremia
• Creatinine and urea clearance
• Fluid and electrolyte balance
  – Sodium and water balance
  – Phosphate and calcium balance
  – Potassium balance
  – Acid-base balance

– Gastrointestinal
  • Alteration in protein, carbohydrate, and lipid metabolism
– Endocrine and reproduction
– Integumentary

• Alterations seen in following systems:
  – Musculoskeletal
  – Cardiovascular and pulmonary
  – Hematologic
  – Immune
  – Neurologic

• 1. Which is an abnormal substance of urine?
   – A. Urea
   – B. glucose
   – C. NaCl
   – D. Creatinine

• 2. The presence of albumin in urine would indicate damage to:
   – A. Glomeruli
   – B. Collecting ducts
   – C. pyramids
   – D. None of the above

• 3. GFR is regulated by
   – A. ANS
   – B. ANF
   – C. Renin-angiotensin system
   – D. All of the above

Concept Check
4. An increase in permeability of the dct and cd is due to:
   - A. Decrease in ADH production
   - B. Increase in ADH
   - C. Decrease in blood plasma osmolality
   - D. Increase in water content in blood

5. UTIs occur:
   - A. Only in the kidneys
   - B. Anywhere but the kidneys
   - C. Anywhere in the urinary system

Matching:
   - ___ 6. acute cystitis    a. Infection of renal pelvis & interstitium
   - ___ 7. uremia           b. Inflam. that is most common cause of end-stage renal failure
   - ___ 8. glomerulonephritis c. Renal failure w/ elevated blood urea and creatinine
   - ___ 9. pyelonephritis   d. U.b. inflam. ranging from hyperemic mucosa to necrosis of u.b. wall

Development of the Reproductive System

• Dependent on sex hormones
  – Males—testosterone
  – Females—estrogen, FSH, and LH

Female Reproductive System

• External genitalia (vulva)
  – Mons pubis
  – Labia majora
  – Labia minora
  – Clitoris
  – Vestibule

Internal Genitalia

• Vagina
• Uterus
  – Cervix
• Fallopian tubes
• Ovaries
**Female Sex Hormones**

- **Estrogens**
  - Estradiol (E2): 95% produced by ovaries
  - remainder by adrenal gland & placenta (pregnancy)
  - Estrone
  - Estriol
- **Progesterone** – from corpus luteum
- **Androgens** – small amt. from ovaries & adrenal cortex

**Menstrual Cycle**

- **Menarche**
- **Menopause**
- **Phases**
  - Menstruation (menses)
  - Follicular/proliferative phase
  - Luteal/secretory phase
  - Ischemic/menstrual phase
Menstrual Cycle

- Ovarian cycle
- Uterine phases
- Vaginal response
- Body temperature change
  - BBT (basal body temp.) biphasic
  - Follicular phase = ~98°F
  - Luteal phase ~ 0.4 -1.0 °F elevation

Menstrual Cycle

- External genitalia
  - Testes
    - Produce gametes and sex hormones
  - Epididymis
    - Vas deferens
  - Scrotum
  - Penis
    - Glans and prepuce

Male Reproductive System

- Internal genitalia
  - Ducts
    - Vas deferens and ejaculatory duct
  - Accessory Glands
    - Seminal vesicles
    - Prostate gland
    - Bulbourethral glands

Male Reproductive System

- Spermatogenesis
  - Spermatogonia
  - Primary spermatocytes
  - Secondary spermatocytes
  - Spermatids
  - Sertoli cells
    (Sustentacular cells)
**Male Sex Hormones**

- **Androgens**
  - Primary androgen—testosterone
  - Produced mainly in (interstitial cells of) Leydig cells of testes
  - Testosterone
    - Sexual differentiation
    - Urogenital system dev.
    - Nervous and skeletal tissue dev.
    - Libido

**Disorders of the Female Reproductive System**

- **Primary dysmenorrhea** (painful menstruation)
  - Painful menstruation associated with prostaglandin release in ovulatory cycles

- **Secondary dysmenorrhea**
  - Painful menstruation related to pelvic pathology (endometriosis, PID, fibroids)

- **Pathophysiology**
  - Excess PGF from endometrium; GI upset, headaches, syncope
  - Treatment: Hormones, PG inhibitors, exercise, heat

**Hormonal and Menstrual Alterations**

- **Primary amenorrhea**
  - Absence of menstruation by age 14 (& no secondary sex characteristic dev. by age 16)
  - Pathophysiology:
    - Dysfunctional H-P-O axis; congenital or hypoplasia of uterus; genetic (Turner’s syndrome XO)

- **Secondary amenorrhea**
  - Absence of menstruation for three or more cycles or 6 months in women who have previously menstruated

**Hormonal and Menstrual Alterations**

- **Secondary amenorrhea**
  - Causes
    - Pregnancy (normal)
    - Dramatic weight loss
      - Malnutrition or excessive exercise
  - Anovulation
    - Hirsutism (increased testosterone)

**Hormonal and Menstrual Alterations**

- **Abnormal uterine bleeding**
  - Menstrual irregularity
  - Dysfunctional uterine bleeding
Infection and Inflammation

- **Pelvic inflammatory disease (PID)**
  - Acute inflammatory disease due to infection
  - May involve any organ of reproductive tract
    - Salpingitis (inflamm. of fallopian tubes)
    - Oophoritis (inflamm. of ovaries)
  - STDs migrate from vagina to the upper genital tract
  - Polymicrobial infection (due to gonorrhea or chlamydia)
  - Can lead to infertility, ectopic pregnancy, abscess, septic shock (death)

**Pelvic Inflammatory Disease (PID)**

*Salpingitis*

- Note: swollen fallopian tubes, adhesions on ovaries

**Leiomyomas (benign fibroid tumors)**

- dev. from SMC

Benign Growth and Proliferative Conditions

- **Endometriosis**
  - Presence of functioning endometrial tissue or implants outside the uterus (retrograde menses)
  - Responds to hormone fluctuations of the menstrual cycle
  - Occur mostly in abdominal & pelvic cavities

Female Reproductive Cancer

- **Cervical cancer** (2% of cancers in women)
  - Cervical dysplasia (CIN — cervical intraepithelial neoplasia — precancerous)
  - Invasive carcinoma of the cervix
- **Risk factors**
  - HPV and HIV
  - Multiple sexual partners
  - Poor nutrition and smoking
- **Vaccine (2006)**
  - Gardasil (Merck) against HPV 6,11,16,18
- **Pap smear** — screening test
Cervical Cancer
A: progressive degrees of CIN (cervical intraepithelial neoplasia)
B: Normal multiparous cervix
C: CIN Stage 1 (cancer only in cervix)

Female Reproductive Cancer
- Ovarian cancer (> 5% of all female cancer deaths)
- Cause — unknown; incr. risk with age, family history (breast or ovarian cancer)
- Pathophysiology:
  - Arise from epithelial cells (on outside of ovary, or stroma)
  - Associated with BRCA genes (breast cancer)
- Symptoms: abdominal pain & swelling (ascites)
- Metastasis: pelvis, colon, stomach, pleura

Disorders of the Testis
- Orchitis
  - Acute inflammation of the testis
  - Complication of a systemic disease or related to epididymitis
  - Mumps most common cause

Disorders of the Prostate Gland
- Benign prostatic hyperplasia (BPH)
  - Enlargement of the prostate gland
  - Symptoms associated with urethral compression
  - Relationship to aging
  - Evaluation
    - Digital rectal exams
    - Prostate-specific antigen (PSA) monitoring

Disorders of the Testis
Cancer of the testis
- Among the most curable of cancers (>95% cure)
- Common in men between ages 15 and 35
- Causes painless testicular enlargement
- Risk factors
  - History of Cryptorchidism (undescended testes)
  - Abnormal dev. of testes
  - Klinefelter (XXY)
  - History of testicular cancer

Disorders of the Prostate Gland
- Cancer of the prostate
  - Accounts for 29% of all cancers in males
  - Prostatic cancer is asymptomatic until adv. stages
  - Symptoms are similar to BPH
- Pathophysiology
  - 95% of neoplasms are adenocarcinomas
  - Related to steroid hormone use
  - T $\rightarrow$ DHT and estradiol (in animal studies: both $\rightarrow$ carcinogenic effect)
  - Action of IGF (insulin growth factor) potent mitogen (increase cell prolif. and decre. apoptosis)
  - Cancer cell lives and multiplies
Disorders of the Prostate Gland

- Cancer of the prostate
  - Dietary factors (high sat. fat, incr. calcium levels → decr. Vit. D which protects against prostate cancer, low fiber and complex CHO, incr. protein
  - Hormones (anabolic steroids)
  - Vasectomy (possibly due to elevated androgens, antisperm antibodies)
  - Chronic inflammation
  - Familial factors (5-10%)

Benign Breast Lesions

- Nonproliferative breast lesions
  - Fibrocystic changes (FCC)

- Proliferative breast lesions without atypia
  - Epithelial hyperplasia
  - Florid hyperplasia
  - Sclerosing adenosis
  - Complex sclerosing lesion
  - Papillomas

Breast Cancer

- Most common cancer in American women
- Leading cause of death from ages 40 to 44
- Second most common killer after lung cancer
- Black women more likely to die from it

Breast Cancer

- Reproductive factors (early 1st pregnancy lowers risk)
- Hormonal factors (ovarian androgen excess, HRT incr. risk)
- Environmental factors and lifestyle
  - Radiation
  - Diet (high intake fruits, veg., whole grains, low fat)
  - Chemicals (xenoestrogens – mimic estrogens, found in pesticides, plastics, detergents, drugs) (PCBs, DDT)
- Physical activity
- Familial factors and tumor-related genes

Breast Cancer

- Manifestations
  - Painless lump, dimpling of skin, edema

- Pathophysiology:
  - 70% arise from ductal (glandular) epithelium
  - Genetic alterations of DNA, chromosomes, suppression of apoptosis
  - 1/3 are hormone dependent (Progesterone or estrogen receptor positive)

- Treatment
  - Based on stage of cancer
  - Surgery, radiation, chemotherapy, hormone therapy, biologic therapy and bone marrow transplantation
### Disorders of the Male Breast

- **Gynecomastia**
  - Overdevelopment of the breast tissue in a male
  - Results from hormone alterations
    - Idiopathic and system disorders, drugs, or neoplasms

- **Male breast cancer**
  - Most commonly seen after age 60
  - Tumors resemble carcinomas of breast in women
  - Crusting and nipple discharge are common clinical manifestations

### Chlamydial Infections

- **Chlamydia (bacterial)**
  - Infections caused by *Chlamydia trachomatis*
  - Most common STI in the United States
  - Obligate, gram-negative, intracellular bacterium

### Sexually Transmitted Urogenital Infections

- **Syphilis**
  - *Treponema pallidum*
    - Corkscrew-shaped, anaerobic bacterium that cannot be cultured in vitro
    - Infects any body tissue
    - Syphilis becomes a systemic disease shortly after infection.
      - Maternal-fetal transmission

### Sexually Transmitted Viral Infections

- **Human papillomavirus (HPV)**
  - 120 different types of HPV
    - 30 serotypes are unique to stratified squamous epithelium
    - Divided into high-risk and low-risk serotypes
  - HPV is a nonenveloped, circular double-stranded DNA virus

### Sexually Transmitted Parasitic Infections

- **Trichomoniasis**
  - Caused by *T. vaginalis*
    - Anaerobic, unicellular, flagellated, parasitic protozoan
    - Adheres to and damages squamous epithelial cells
      - Urethra, vagina, and Skene and Bartholin glands
  - Accounts for 25% of infectious vaginitis cases
Sexually Transmitted Parasitic Infections

- Pediculosis pubis
  - Caused by the crab louse *Phthirus pubis*
  - Transmitted primarily by intimate sexual contact or contact with infected bed linens or clothing
  - A crab louse has a 25- to 30-day life cycle
    - Stages: egg or nit, three nymphal stages, and an adult stage

- Scabies
  - Caused by the adult female itch mite, *Sarcoptes scabiei*
  - Transmission of scabies requires prolonged close skin-to-skin contact
    - Typically occurs between family members or sexual partners

Concept CHECK

1. Progesterone
   - A. Stim. lactation
   - B. Incr. uterine tube motility
   - C. Thins the endometrium
   - D. Maintains the thickened endometrium

2. The ovaries produce
   - A. Ova, estrogens, oxytocin
   - B. Ova only
   - C. Ova and estrogens
   - D. Testosterone & semen

3. Cells that produce testosterone:
   - A. Interstitial cells
   - B. Testicular endocrine cells
   - C. Sustentacular cells
   - D. Spermatogonia

4. The function of testosterone:
   - A. Dev. Of male gonads
   - B. Bone and muscle growth
   - C. Influence sexual behavior
   - D. Growth of testes
   - E. All of the above

5. Acute PID
   - A. Mainly affects males
   - B. Is usually caused by viruses
   - C. Never causes peritonitis
   - D. May cause infertility or tubular pregnancy

6. Endometriosis
   - A. Has ectopic endometrium responding to changing hormone levels of the menstrual cycle
   - B. Occurs mainly in the pleural cavity
   - C. Causes infertility in most women
   - D. Does not occur after treatment

7. The infectious cause of orchitis is
   - A. Streptococci
   - B. Gonococci
   - C. Chlamydial organisms
   - D. Mumps virus