I. Introduction
   A. Consists of:
      -
      -
      -
      -
      -

   B. Location of kidneys
      Positioned retroperitoneal
      Between vertebrae T12 and L3
      -

   C. Functions of the kidneys
      Removal of metabolic wastes from the blood and excretion out of the body
      Regulation of:
      -
      -
      -
      -
      Volume, composition, and pH of blood

D. Surrounding structures
   1. Fat and connective tissue
      3 Layers:
         Innermost:
         Middle:
         Outermost:

   2. Adrenal glands

   3. Ureters
      Nephroptosis – floating kidneys
      - congenital loose kidney
      - in thin people
II. Kidney Anatomy
   A. Hilus (hilum) – concave on medial side
   B. Cortex
   C. Medulla
   D. Renal pyramids – triangular shaped structures, 6-18 per kidney
   E. Renal papilla
   F. Renal columns – extension of cortex between pyramids
   G. Renal pelvis
   H. Minor & major calyx (calyces)
      Minor calyx – cup-like structure that surrounds papilla of each pyramid
      Major calyx –

III. The Nephron
    Nephron =
    A. Renal corpuscle = glomerulus + Bowman’s capsule
       1. Bowman’s capsule
          Parietal epithelium –
          Capsular space –
          Visceral epithelium –
       2. Glomerular capillaries
          Filtration membrane:
          -
          -
          -

    Glomerular filtrate – filtrate of blood that passes through capillary walls into lumen of Bowman’s capsule
Glomerulonephritis – inflammation of renal cortex – affects filtration
- immune response
- clog up pores

3. Tubules
   a. Proximal convoluted tubules (pct)
      Function –
   b. Loop of Henle
      Descending limb – thick and thin segments
      Ascending limb – thick and thin segments
      Function -
   c. Distal convoluted tubule
      Function –

4. Collecting system
   - transport tubular fluid to pelvis
   a. Collecting ducts –
   b. Papillary ducts –

Urine pathway:
Collecting duct → papillary duct → ______________ → major calyx →
____________ → ureter → ______________ → urethra →

5. Juxtaglomerular apparatus (JGA) = macula densa + juxtaglomerular cells
   - secretes EPO
   - secretes renin

When BP is too low →
Renin – angiotensin system is activated and angiotensin is formed
Bio 104 Urinary System

IV. Blood Flow through the Kidney
Renal A. → Interlobar A. → ____________________ → Interlobular A. →

Afferent arteriole → ____________________ → Efferent arteriole →

Peritubular capillaries / Vasa recta → ____________________ → Arcuate V. →
_________________ → Renal V.

Blood Supply of Nephron:
The glomerulus receives blood from the afferent arteriole and
passes it to the efferent arteriole

The efferent arteriole gives rise to the peritubular system, which surrounds
the renal tubule

Vasa recta –

Distinctive Features
A. 2 Capillary beds:
   1. glomerulus –
   2. peritubular capillaries / vasa recta –

B. Efferent arteriole – “goes out” of glomerulus
   - has smaller diameter than afferent arteriole (which “goes in”)


V. Cortical and Juxtamedullary Nephrons
Cortical nephrons:
   -
   -
Juxtamedullary nephrons:
   -
   -
VI. Urine Formation

Nephrons remove wastes from blood and regulate water and electrolyte balances.

Urine is the final product of the processes of:

- Glomerular Filtration:

- Tubular Reabsorption:
  - substances move from renal tubules into blood of ____________

- Tubular Secretion:
  - substances move from blood of peritubular capillaries into ____________

A. Glomerular Filtration

- The first step in urine formation is filtration of substances out of the glomerular capillaries into the glomerular capsule.

- Glomerular filtrate passes through the fenestrae of the capillary endothelium.

1. Filtration pressure and Rate

Net filtration pressure (NFP) =

Glomerular Filtration Rate (GFR) is directly proportional to the NFP.
2. Control of Filtration Rate

   Primarily 3 mechanisms are responsible for keeping GFR constant

   - increased SNS impulses decrease GFR by causing afferent
     arterioles to constrict

   -

   -

   \[
   \text{GFR} = 125 \text{ ml / min} \rightarrow 180 \text{ liters / day}
   \]

Factors affecting GFR:

   a. shock, hemorrhage →

   b. heart failure → kidney failure →

   c. prostate enlargement → urinary tract obstruction →

   d. hypertension

B. Tubular Reabsorption

   Transports substances from the glomerular filtrate into the blood within the
   peritubular capillary

   \( \text{Na}^+ \) and \( \text{H}_2\text{O} \) reabsorption

   - Osmosis reabsorbs water due to:

   Reabsorption:

   1. 99% of filtrate is reabsorbed

   2. only certain substances are reabsorbed:

   3. Reabsorption occurs by active and passive process

C. Tubular Secretion

   Transports substances from the blood within the peritubular capillary into
   the renal tubule

   In DCT, potassium or hydrogen ions may be passively secreted in
   response to active reabsorption of sodium ions
Bio 104 Urinary System

Secretion:

- 

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<tr>
<th>Ions</th>
<th>Wastes</th>
<th>Others</th>
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VII. Regulation of Urine Concentration and Volume

The DCT and collecting duct are impermeable to water

If ADH is present, these segments become permeable and water is reabsorbed by osmosis into the hypertonic medullary interstitial fluid

A. Role of ADH

ADH = antidiuretic hormone
- 
- stored and released by posterior pituitary gland
- 

If solute concentration is too high:
Hypothalamus $\rightarrow$ posterior pituitary gland $\rightarrow$ _____________

$\rightarrow$ _____________

* More water reabsorbed and concentration of blood returns to normal

If solute concentration is too low:
Less ADH is secreted $\rightarrow$

Diabetes insipidus:
B. Countercurrent Multiplier
   Helps maintain the NaCl concentration gradient in the medullary interstitial fluid

   Fluid in ascending limb –

   Fluid in descending limb –

C. Urine Composition
   - 95% water
   - may contain trace amounts of amino acids and electrolytes
   - volume varies with fluid intake and environmental conditions

pH:
Specific Gravity:
Water Content:
Volume:
Color:
Odor:
Bacterial content:

   Urea – by product of amino acid catabolism

   Uric Acid – product of nucleic acid metabolism
Renal Clearance = the rate at which a chemical is removed from plasma
Test of renal clearance:
- Inulin clearance test

* Tests of renal clearance used to calculate GFR

VIII. Ureters, Urinary Bladder, Urethra
A. Ureters
- parallel to vertebral column
- join to urinary bladder

3 layers in the wall of the ureters:
- 
- 
- 

B. Urinary Bladder
Hollow, distensible, muscular organ located within the pelvic cavity
- posterior to the symphysis pubis
- inferior to the parietal peritoneum

Trigone –

Histology:
Mucosa –
Submucosa –
Muscularis – 3 layers of smooth muscle

Internal urethral sphincter:

C. Urethra
   Tube that conveys urine from the urinary bladder to the outside of the body

   External urethral sphincter

   -
   -

1. Comparison of female and male urethra

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<th>Female</th>
<th>Male</th>
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<tr>
<td>Size</td>
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<td>Walls</td>
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<td>External urethral sphincter</td>
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<td>Urinary &amp; reproductive Pathways</td>
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<td>Parts</td>
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2. Micturition -

Micturition reflex – coordinates urination

- urge to urinate when ~200 ml urine is in urinary bladder

Urinary bladder can hold ____________

PSN ➔

*plus voluntary control:

Life Span Changes:
Clinical Application
IX. Water, Electrolyte, and Acid-Base Balance (Chapter 21)

A. Average adult male has 40 liters of water

The total body water is divided into 2 areas

Intracellular fluid contains _____%  
Extracellular fluid contains _____%

B. Body Fluid Composition
Extracellular fluids have high concentrations of:

Intracellular fluids have high concentrations of:

C. Water balance is regulated through the production of urine

Water intake includes:

Water loss includes:

Regulating the release of ADH is important for regulation of water output

Dehydration causes ADH levels to
Excess Water intake causes ADH levels to
Bio 104 Urinary System

D. Electrolyte Balance

Source of electrolytes:

Loss of electrolytes:

1. Potassium and Sodium Balance

Potassium ions increase

Adrenal cortex is signaled

**Aldosterone** is secreted

Renal tubules increase reabsorption of Na\(^+\) and increase secretion of K\(^+\)

Sodium ions are conserved and potassium ions are excreted

2. Aldosterone

- Control of Aldosterone via renin-angiotensin pathway:

  Low blood [Na\(^+\)] = {decrease BP and GFR}

  Kidney renin increases

  Adrenal cortex

  Increase aldosterone secretion

  Na\(^+\) reabsorption at dct

  Hyposecretion –

  Hypersecretion –
E. Acids / Bases
   Strong acids – release more $\text{H}^+$
   Weak acids –

   Strong bases –
   Weak bases – release fewer $\text{OH}^-$

   Regulation of hydrogen ions:
   -
   -
   -
   -

F. Clinical application
   Dehydration

   Water intoxication

   Edema