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
IV. Blood Flow through the Kidney

Renal A. → Interlobar A. → ___________________ → Cortical radiate 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 form 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

GFR = 125 ml / min $\rightarrow$ 180 liters / day
Factors affecting GFR:
   a. shock, hemorrhage $\rightarrow$
   b. heart failure $\rightarrow$ kidney failure $\rightarrow$
   c. prostate enlargement $\rightarrow$ urinary tract obstruction $\rightarrow$
   d. hypertension

B. Tubular Reabsorption
   Transports substances from the glomerular filtrate into the blood within the peritubular capillary
   Na$^+$ and H$_2$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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<th>Ions</th>
<th>Wastes</th>
<th>Others</th>
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1. 

2. 

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

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<td>External urethral sphincter</td>
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<td>Urinary &amp; reproductive Pathways</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:
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 $\text{Na}^+$ and increase secretion of $\text{K}^+$

   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 $H^+$

Weak acids –

Strong bases –

Weak bases – release fewer $OH^-$

Regulation of hydrogen ions:

- 

- 

- 

F. Clinical application

Dehydration

Water intoxication

Edema