I. Chapter 26: Renal Function

a. Anatomy

i. Blood Supply:

1. Abdominal Aorta
2. Divides into 2 Renal Arteries (1 in each kidney)
3. Nephron afferent arteriole
4. Glomeruli
    a. The glomerulus is the point of blood filtration
5. Efferent Arteriole
6. Peritubular capillaries
7. Peritubular venules
8. Renal Vein
9. Inferior Vena Cava

ii. Kidneys: paired organs located in the posterior abdomen, either side of the vertebral column

iii. Right Kidney is slightly lower than the left kidney

iv. Functional unit is the nephron

1. Each nephron has 1 collection duct

v. Renal Perenchyma has 3 Anatomic Sections

1. Pelvis → urinary collecting structures and calyces
2. Medulla → the middle portion, renal pyramids
3. Cortex → outer portion, glomeruli and nephron tulubles

vi. Urine Pathway

1. Bowman's Capsule
    a. 1st part of urine formation
2. Proximal
3. Loop of Henle
    a. Descending → concentrating area
    b. Ascending → diluting, losing NaCl
        i. ADH in aquaporins
4. Distal Convoluted Tubule
5. Collecting Duct
6. Fuse together to form the Renal Calyx
7. Renal Pelvis
8. Ureter
9. Bladder
10. Urethra

vii. "Dirty" Blood comes through the afferent arteriole, then the glomerulus, then Bowman's capsule, into filtrate

b. Main Functions

i. Urine Formation

1. Normal Urine output = 1500 mL/day, which is about 1% of the overall filtrate
2. Mechanism of toxic waste product removal
3. 1000-1500 ml of blood/min passes through kidney (1-1.5 L)

4. Glomerular Filtration Rate (GFR)
    a. High hydrostatic pressure in glomerular capillaries filter substances in Bowman's capsule at 130mL/min
    b. Glomerular filtrate (premature urine) is plasma without proteins
        i. Cells & large plasma proteins cannot be filtered
        ii. >187000 ml of filtrate produced per day
    c. Important clinical assessment of renal function

ii. Fluid and electrolyte balance regulation
1. Kidneys filter blood and produce urine
2. Ureter → duct from kidney to urinary bladder
    a. Branches and envelops renal pyramids which form medulla. The outer layer of medulla is cortex
3. Urethra → tube for urine excretion
4. The ureter, renal artery, and renal vein enter the kidney from its concave side
5. Nephrons
    a. Glomeruli in cortex
    b. Proximal convoluted tubules
        i. Initial, twisted renal tubule segments in cortex
    c. Renal tubule descends into medulla to form the Loop of Henle
        i. Urine concentration unit
    d. Tubule then returns to the cortex as the Ascending Loop of Henle and becomes the Distal Convoluted Tubule
    e. Distal Tubules join collecting duct in cortex
    f. Collecting ducts descend through renal pyramids and empty into the renal pelvis
6. Glomerulus
    a. Site of blood filtration
    b. Blood enters via afferent arteriole and leaves efferent arterioles
        i. Think "e" in efferent for exit
    c. Efferent arterioles become peritubular capillaries surrounding tubule and serving as exchange sites
    d. Renal tubule starts with Bowman's capsule which encloses the glomerulus
    e. Glomerulus produces fluid without cells or large molecules (Filtered)
    f. High filtration rate due to high pressure and high permeability
    g. The pores of the glomerulus give it its permeability
    h. Pressure due to diameter
7. Pelvic divisions join and leave the kidney as a ureter
8. Renal blood vessel organization parallels nephron organization
9. Glomeruli drained by arterioles become peritubular capillaries
10. Vasa Recta → Network of peritubular capillaries parallel to Loops of Henle and the collecting duct
11. All Peritubular capillaries from the nephron join into venules that form the renal vein
12. Proximal Convoluted Tubule

a. Water and solute reabsorption site
b. Cells have microvilli to increase surface area
c. Actively transport Na, glucose and amino acids… water follows solute transport

13. Urine concentration is due to countercurrent multiplier mechanism in loops of Henle
    a. Tubule fluid flows in opposite directions in ascending and descending limbs
14. Loops increase interstitial fluid osmolarity in a graduated way
15. Loop of Henle Segments
    a. Thin descending limb → loses water to adjacent interstitial fluid with high Na and Cl concentration
    b. Thick Ascending limb → Actively transports Na (Cl follows) and raises interstitial fluid concentration
    c. Thin ascending limb → receives concentrated fluid and allows Na and Cl diffusion into interstitial fluid
16. Fluid reaching the distal collecting duct is less concentrated
    a. Solutes in medulla create a concentration gradient
17. Concentration gradient is preserved by Vasa Recta
18. Blood Flowing down descending limb loses water and gains solutes. Concentrated blood then flows up ascending limb, gains water and loses solutes so water is returned to blood
19. Regions of the nephron differ in water permeability
20. Aquaporins → membrane proteins abundant in highly water-permeable areas, such as proximal convoluted tubule and descending loops of Henle
21. Water reabsorption starts in the distal convoluted tubule
22. Fluid that leaves the tubule and flows into collecting duct has the same solute concentration as blood plasma but with a different composition
23. In the collecting duct, urea is a major solute in tubular fluid
24. Fluid flows down collecting duct and loses water to interstitial fluid due to the concentration gradient established in the Loops of Henle
25. Some Urea also diffuses and adds to osmotic force. Urea recycling contributes to urine concentration
26. **Takes out sodium Chloride to maintain sodium gradient, blood pressure**
27. **H2O moves out and solutes become more** concentrated

iii. Acid-Base Balance Regulation
    1. Bicarb ions
        a. Major buffers in blood
        b. Formed by carbon dioxide hydration followed by carbonic acid dissociation
        $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$
    2. Lungs control CO2 levels in blood
        a. Acid portion of reaction because more CO2 means more H ions
    3. Kidneys control base portion of reaction by removing H ions and adding