Biology 48 - Human Physiology
Lecture Summary Sheet - Norris

Renal Physiology

I. Definitions
  A. Interstitial Fluid
  B. Plasma
  C. Urine (waste)

II. General Overview

III. Physiology
  A. Body Fluids

  B. Composition

  C. Regulation of Water Balance
    1. Intake
    2. Loss

    3. Regulatory Mechanisms
      a. Intake (via Thirst)

      b. Loss (via Renal Regulation)

IV. Regional Physiology of the Nephron
  A. Renal Corpuscle
    1. Glomerular Filtration

      a. Renal Clearance (percentage of plasma content that is removed from plasma)

$$\text{renal clearance (ml/min)} = \frac{\text{urine concentration (mg/ml) x urine flow (ml/min)}}{\text{plasma concentration (mg/ml)}}$$

      b. Glomerular Filtration Rate (GFR)

      c. Renal Blood Flow

  B. Proximal Convoluted Tubule (PCT)

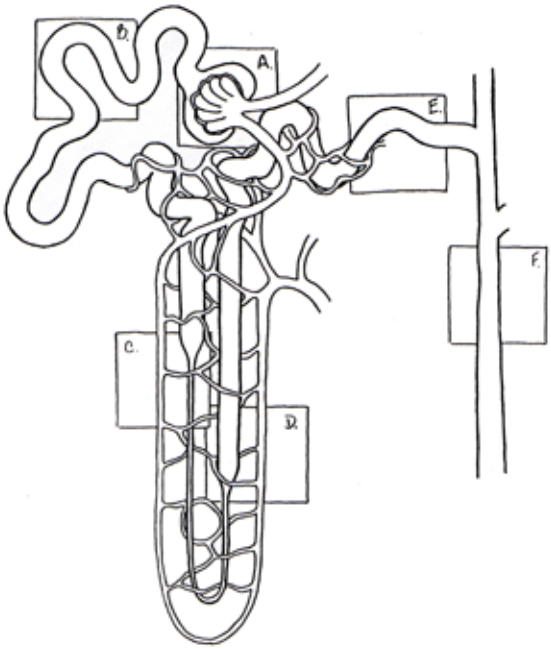
    1. Active Reabsorption

      a. Transport Maximum
      b. Renal Threshold

    2. Passive Reabsorption

    3. Secretion

C. Loop of Henle - Descending Limb



D. Loop of Henle - Ascending Limb
1. Thin Segment
2. Thick Segment

3. Counter-Current Multiplier
a. Loop of Henle

b. Vasa Recta

E. Distal Convoluted Tubule (DCT)

F. Collecting Duct

V. Acid-Base Balance
A. Buffers
B. Respiratory

C. Renal Conservation of HCO_3^-

D. Renal Secretion of H^+

VI. Renal Regulation
A. Intrinsic (autoregulation)

B. Extrinsic (see flow chart)
1. Autonomic Innervation

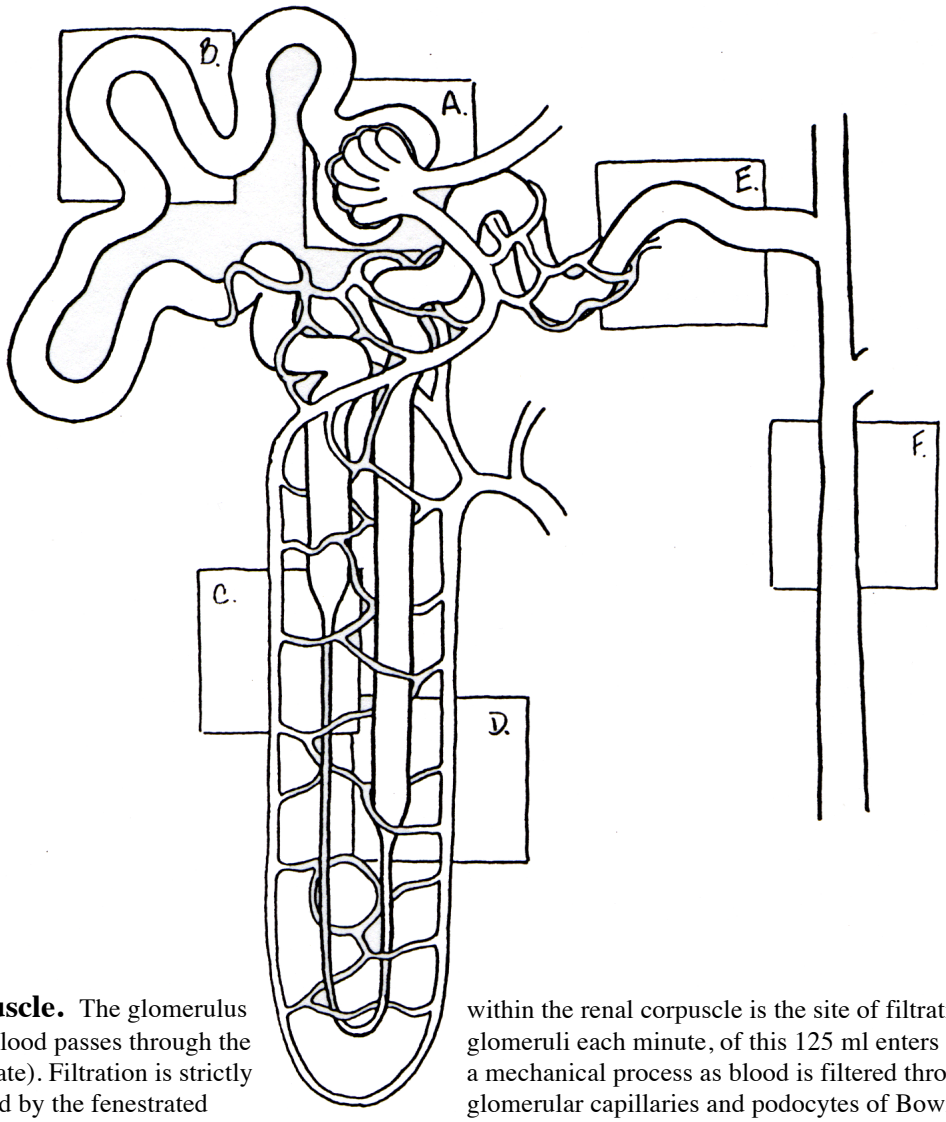
2. Antidiuretic Hormone (ADH, aka vasopressin)
a. Hypothalamic Osmoreceptors
b. Posterior Pituitary

3. Aldosterone (renin-angiotensin-aldosterone system)
a. Juxtaglomerular Apparatus
- Juxtaglomerular Cells (afferent arteriole)
- Macula Densa Cells (DCT)

4. Atrial Natriuretic Factor

VII. Additional Key Terms / Topics

acidosis	alkalosis	colloid osmotic pressure	excretion	fenestrated
filtration	micturition	natriuresis	oncotic pressure	osmolarity
peritubular fluid		podocytes	primitive urine	reabsorption
secretion	transport maximum (Tm)		vasa recta	



A. Renal Corpuscle. The glomerulus within the renal corpuscle is the site of filtration. About 1000 ml of blood passes through the glomeruli each minute, of this 125 ml enters Bowman's capsule (called filtrate). Filtration is strictly a mechanical process as blood is filtered through minute pores formed by the fenestrated glomerular capillaries and podocytes of Bowman's capsule. The rate of filtration is influenced by hydrostatic and osmotic pressure differentials between the glomerular capillaries and Bowman's capsule. Hydrostatic pressure is regulated in part by changes in the diameter of the afferent and efferent arterioles.

B. Proximal Convoluted Tubule (PCT). Filtrate entering the PCT has about the same osmolarity as plasma but does not contain any large proteins. As much as 80% of the filtrate will be reabsorbed within the PCT. Nearly all nutrients, such as glucose & amino acids are actively reabsorbed. Sodium (Na^+) is also actively reabsorbed while chloride (Cl^-) and water follow passively. Hydrogen ions (H^+) are actively secreted and bicarbonate ($HCO3^-$) is reabsorbed.

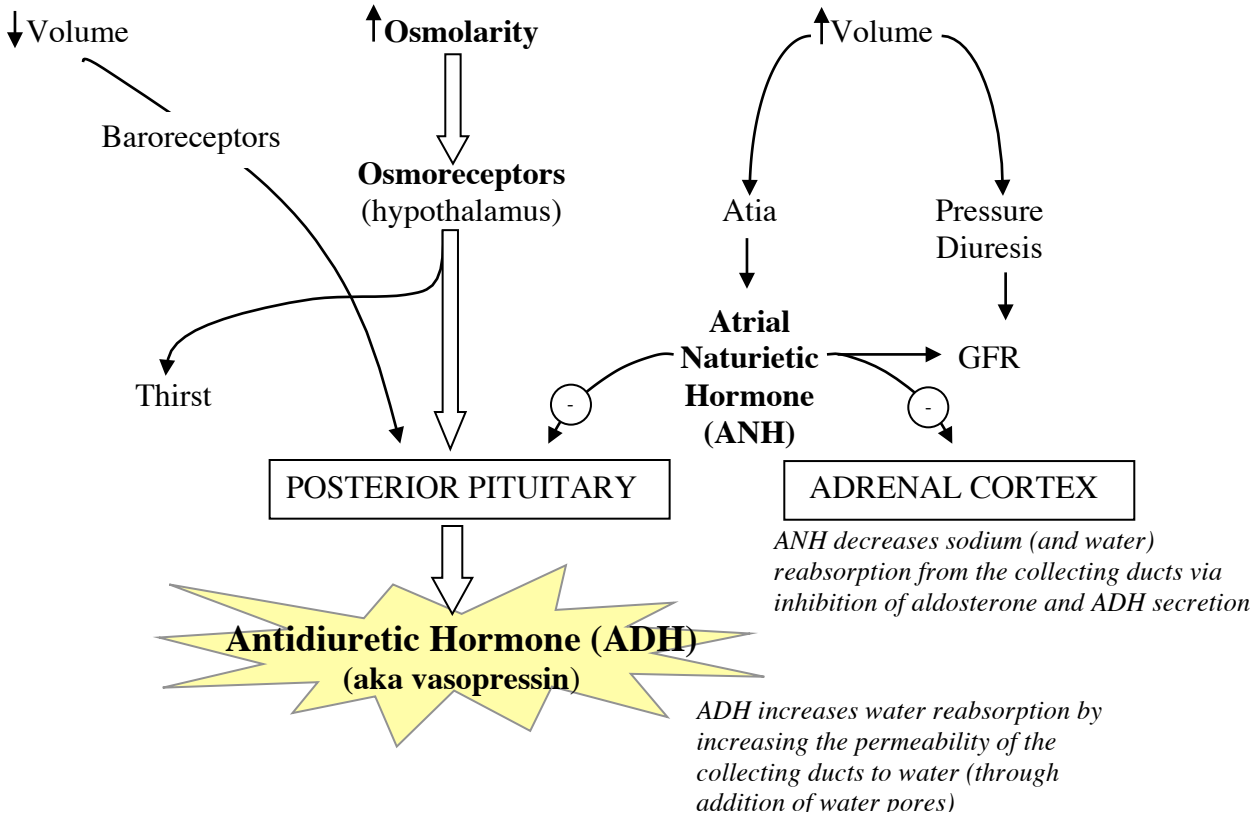
C. Descending Loop of Henle. The descending limb is impermeable to salt but is freely permeable to water which diffuses out as the tubule descends into an increasingly hypertonic interstitial fluid of the medulla. Consequently the filtrate becomes concentrated within the descending limb.

D. Ascend Loop of Henle. The ascending limb is impermeable to water but salts (Na^+ & Cl^-) are actively reabsorbed contributing to the hypertonicity of the interstitial fluid. The filtrate becomes more dilute as salt is removed but waste molecules remain concentrated within the filtrate.

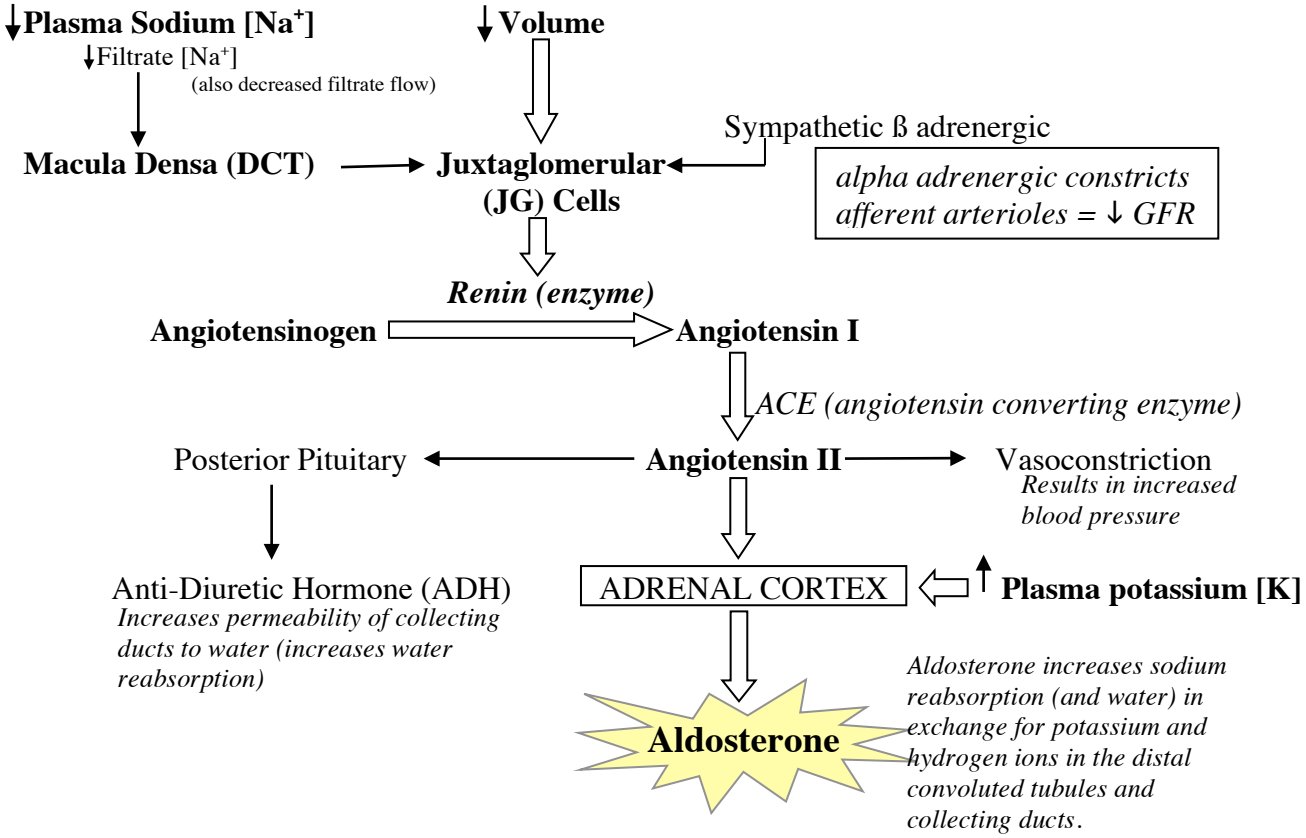
E. Distal Convoluted Tubule (DCT). The DCT is essentially impermeable to water except when aldosterone is present. Under the influence of aldosterone Na^+ is reabsorbed and K^+ is secreted (water follows Na^+ passively).

F. Collecting Duct. In the absence of ADH the collecting duct is impermeable to water. In the presence of ADH the collecting duct becomes permeable to water and water is reabsorbed by osmosis as the tubule descends into the increasingly hypertonic interstitial fluid of the medulla.

ANTIDIURETIC HORMONE (ADH) and ATRIAL NATURIETIC HORMONE
(stimulatory pathway for ADH, stimulatory pathway for ANH)



RENIN-ANGIOTENSIN-ALDOSTERONE SYSTEM (stimulatory pathway for aldosterone)



Study Questions – Renal Physiology:

1. Define "interstitial fluid," "plasma," and "urine".
2. Describe the fluid inputs and outputs associated with the kidneys.
3. Describe the distribution and composition of fluids in the body and the associations between each "compartment".
4. Describe the different routes of water intake and water loss.
5. Describe the regulatory mechanisms regulating water intake.
6. Describe the anatomical association between the renal blood vessels and the renal tubules (nephron).
7. Name and describe the three nephron processes of urine production.
8. Describe the role of the renal corpuscle.
9. What is glomerular filtration? What filters? How is this determined? How much filters? How is the rate of filtration described?
10. How is glomerular filtration controlled?
11. Describe the role of the proximal convoluted tubule (PCT). How much filtrate enters and leaves the PCT?
12. Describe the mechanism associated with sodium, glucose, and water reabsorption in the PCT.
13. Define "renal threshold." What characterizes molecules that exhibit a renal threshold?
14. Describe the two general functions of the loop of Henle. How much filtrate enters and leaves the loop of Henle?
15. Describe the function of the descending limb of the loop of Henle.
16. Describe the function of the ascending limb of the loop of Henle.
17. What single factor distinguishes the distal convoluted tubule (DCT) and collecting ducts from all other regions of the nephron?
18. Describe the regulatory mechanisms that control the DCT and collecting duct.
19. Describe the three general mechanisms for regulating blood pH.
20. Describe the mechanism and significance of intrinsic control over glomerular filtration.
21. Describe the role of the autonomic nervous system in regulating urine production.
22. Describe the source of antidiuretic hormone (ADH).
23. Describe the stimuli that trigger ADH secretion (or inhibit secretion).
24. Describe the target cells and effect of ADH.
25. Describe the source of aldosterone.
26. Describe the stimuli that trigger aldosterone secretion (or inhibit secretion).
27. Describe the structure and function of the juxtaglomerular apparatus.
28. Describe all of the steps in renin-angiotensin-aldosterone pathway.
29. Describe the target cells and effect of aldosterone.
30. Describe the source, stimuli, and effect of atrial natriuretic hormone.