No questions will be written with the intention of “tricking” you. All questions I write will be reviewed by other faculty including Drs. Jeffries and Pisarri before ever ending up on your final exam. Please do argue if you think a question is either unclear or unfair.... getting credit will generally entail convincing me that the perspective from which you answered the question made your answer at least as good as my choice.

**Body Fluids**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Description</th>
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<tbody>
<tr>
<td>Know the normal concentrations of the major ions in the body.</td>
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<tr>
<td>Calculate a missing value using the net filtration equation when given values for the other parameters. Requires simple algebra plus knowing the equation.</td>
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<tr>
<td>Calculate fluid shifts across cell membranes in response to the addition of solute-containing water to the ECF compartment. Potential solutes include glucose (D5W), NaCl, mannitol, urea, CaCl2. Requires calculating final volumes and osmolarity, and knowing where the added solute ends up in order to get a final answer.</td>
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<tr>
<td>Calculate the direction of fluid flux if osmotic forces are opposed by hydrostatic forces at t=0. Requires knowing that $\pi = 19.3$ mmHg/mOsm difference and summing the forces across membrane(s).</td>
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<tr>
<td>Estimate all body compartment volumes if given any one of them. Requires simple algebra plus knowing that a lean young male has ~60% body water and female has ~55% body water in addition to the typical volume percentages for each body water compartment.</td>
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<tr>
<td>Calculate clearances, including free water clearance, and/or excretion rates from the values provided, and be prepared to also answer questions related to reabsorption, secretion, fractional excretion, or the meaning attached to clearance rates.</td>
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**Creatinine clearance:** On your exam, I would assume it equals GFR unless you are specifically asked to contrast it with inulin. As you know, the clinical values should still be approximately equal due to the potentially canceling errors when calculating creatinine clearance (tubular secretion + overestimation of plasma creatinine). In the real world, some question authors are oblivious to the errors, others only attempt to correct for tubular secretion, and some recognize that there are offsetting errors. I can assure you that we will be very careful when phrasing questions related to creatinine clearance.

**PAH clearance:** On your exam, I would assume it equals RPF unless you are specifically asked to calculate the estimated actual RPF and/or RBF. As you know, $C_{PAH}$ gives a value for *effective* RPF, a value ~10% less than estimated actual RPF due to the fact that some blood entering the kidneys circulates through fat, connective tissue, etc., instead of the nephrons. Again, we will attempt to be very precise. However, the outside world has question authors spanning the gamut of competence and [insert insulting word of choice for people who you find irritating here], and this is a potentially fruitful area for those in the upper right quadrant.

Recognize the main causes of extracellular and intracellular edema, and diseases or circumstances that could cause edema.
Sodium Balance

Know normal plasma ranges for Na⁺, and have a general sense of the requirements and recommendations.

Where does the body sense extracellular volume?

Understand the driving forces for glomerulotubular balance and the general nature of the tubuloglomerular feedback mechanism.

Understand/interpret these figures:

The information below is unfortunately important... That value of 67% for proximal tubular sodium reabsorption is NOT written in stone as shown below in these figures. If hormones are clamped (i.e., held) at a given level, that value of ~67% is maintained during increases or decreases in ECV. The problem is that these hormone levels are not maintained constant during increases or decrease in ECV. Ang II, for example, increases GFR due to selective efferent arteriolar constriction. By itself, this action would increase GFR: 67% reabsorption would lead to both an increased volume reabsorbed and an increased volume delivered to the distal nephron... i.e., 33% of a bigger number is also a bigger number. However, Ang II also directly stimulates proximal tubular sodium reabsorption, and it is possible that this stimulation can be enough that distal delivery is actually decreased.

The value for proximal tubular sodium reabsorption will always be 67%, FENa ~ 1%, etc., unless I specifically ask for the effects of hormones... these values shown below are ~ “normal” for ~ “normal” hormone levels. I combined portions of two slides and added some comments to help get these points across at the nephron level. The next page shows the effects of these changes at the “whole organ” level.

Values are increased... the increased delivery to the TAL and DCT manifests as easy “pinckin’s” for the cells

NEVERTHELESS... excretion is increased ~ 6 fold
alterations in hormone levels slide the acute “intrinsic” pressure natriuresis relationship to the left or right so that Na intake (and by necessity output) can vary markedly with blood pressure maintained at a relatively constant level

Contrast the effects of a sudden increase in water intake with a step increase or decrease in Na⁺ intake.

Know the permeability and general transport characteristics with respect to both water and urea along the length of the nephron.

Describe the role of urea in the water concentrating mechanism. How is the urea itself concentrated?

Know the tubular fluid characteristic at each major nephron structure relative to both the original filtrate and transepithelial osmotic pressures, and if/how the tubular fluid changes during its passage through that nephron segment.

Know where ADH comes from and the general receptor-effector mechanism for water transport in the principal cells of the collecting duct.

Understand the interrelationships between plasma ADH and osmolality or blood pressure as shown in the slide figures.
Potassium

Know the normal range and generalizations regarding recommended intake and food sources.

How do changes in $[K^+]_{ECF}$ influence excitable tissues? What happens to the T wave in and EKG as $[K^+]_{ECF}$ changes?

Identify the major hormones stimulating cellular $K^+$ uptake during internal regulation of ECF $K^+$ levels.

Describe the interrelationship between ECF $H^+$ and plasma $K^+$.

Where is potassium reabsorbed in nephron?

<table>
<thead>
<tr>
<th>If potassium deficiency...</th>
<th>If normal or excess potassium...</th>
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What are the major influences on $K^+$ reabsorption?

Contrast the nephron that is dumping $K^+$ with a nephron that is conserving it.

Identify stimuli for aldosterone release.

How does aldosterone exerts its effects in the principal cells of the collecting duct?

How can aldosterone provide the fine tuning for both $Na^+$ and $K^+$ excretion?

What happens to tubular $K^+$ secretion as the luminal flow rate increases? How can ADH maintain constant excretion of $K^+$?

[Note that the answer to this question is given in the slides without the underlying mechanism as is customary unless one is studying advanced renal physiology... but, for the curious, ADH does this by increasing $Na^+$ reabsorption through the same $Na^+$ channels influenced by aldo].
# Acid-Base Balance, Renal Emphasis

- Know the normal values for plasma pH, [HCO3⁻] and PCO₂.

- Describe the role of the kidneys in excreting the daily load of acid, and contrast their role with that of the lungs.

- Discuss the body buffer systems with respect to their buffering capacity and the rate at which they respond.

- Compare and contrast the transport mechanisms for reabsorption of bicarbonate by the proximal tubule and collecting duct.

- Describe the means by which NH₄ gets into the lumen of the collecting duct of titration of secreted acid.

- Describe the roles of glutamine and phosphate ion in the kidney with respect to acid-base balance.

- How do alpha-intercalated cells differ from beta-intercalated cells?

- Describe the calculation of net acid excretion.

- Use the Henderson-Hasselbach equation to explain the roles of the kidneys and lungs in acid-base regulation and compensation, and to identify simple acid-base disorders.

- Calculate the pH, [HCO3⁻] or PCO₂ from the Henderson-Hasselbach equation when given values for two of the parameters. Recognize that this equation holds true in a test tube as well as the body, so it’s easily possible to create non-physiological circumstances.

- Calculate the anion gap.