Last Name, First Initial

November 26, 2013

Be sure to read all instructions and questions carefully.
Be brief in your answers.
Write clearly.
Backs of pages will not be graded.

Honor Pledge

All students are required, when requested, to attach the following statement to any material turned in for a grade in any course at Georgia Institute of Technology:

On my honor, I pledge that I have neither given nor received inappropriate aid in the preparation of this assignment.

_____

Signature

_____

Name (Printed clearly)

Equations:

$$Volume = \frac{amount}{concentration}$$

$$J = K_f\left[\left(P_{glomerulus} - P_{Bowman's capsule}\right) - \pi_{glomerulus}\right]$$

$$Filtration\ of\ X = [X]_{plasma} * GFR$$

$$Clearance\ of\ X = \frac{excretion\ rate\ of\ X\ (mg/min)}{[X]_{plasma}(mg/mL plasma)}$$

BMED 3100 Systems Physiology Test 4
Circle the best answer (2 pts ea)

1. When **extracellular osmolarity** increases, intracellular volume

INCREASES , DECREASES, or STAYS THE SAME.

2. When **extracellular volume** increases, intracellular volume

INCREASES , DECREASES, or STAYS THE SAME.

3. When **afferent arteriole resistance** increases, the glomerular filtration rate

INCREASES , DECREASES, or STAYS THE SAME.

4. When **oncotic (colloid osmotic) pressure** in the glomerulus increases, the glomerular filtration rate

INCREASES , DECREASES, or STAYS THE SAME.

5. When **vasopressin levels** increase, the osmolarity of the urine

INCREASES , DECREASES, or STAYS THE SAME.

6. When **aldosterone levels** increase, the osmolarity of the blood

INCREASES , DECREASES, or STAYS THE SAME.

7. When **ACE** is inhibited, angiotensinII (ANGII) concentration

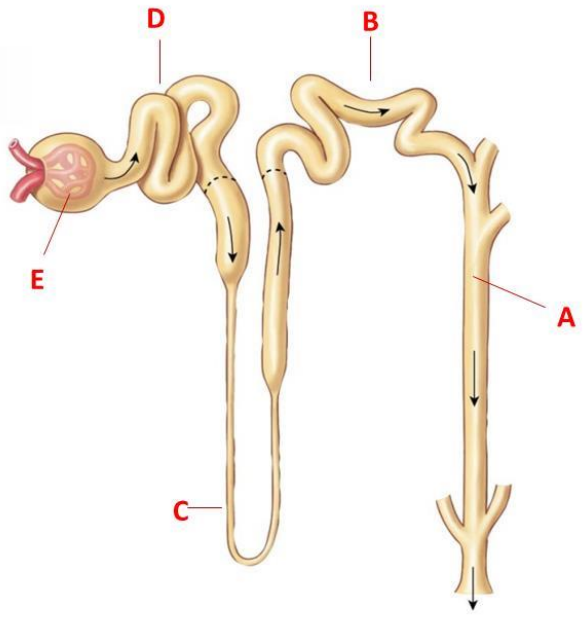
INCREASES , DECREASES, or STAYS THE SAME.

8. When **body fluid pH** decreases, CO_2 levels primary disturbance is excess H^+ metabolic acidosis, which increases CO_2 (equation 9), compensation is hyperventilation, which decreases P_{CO2} back to normal or below

INCREASE , DECREASE, or STAY THE SAME.

9. Label the following by writing the letter with arrows next to the correct anatomical feature (1 pt ea).

A. Collecting duct
B. Distal nephron
C. Loop of Henle
D. Proximal tubule
E. Renal corpuscle



10. For the measurements given answer the following (show your work) (12 pts)
    a) What is the value for the glomerular filtration rate?
    b) Assuming that Substance A is freely filtered, what is the filtered load of A?
    c) What is the clearance of Substance A?
    d) Is substance A reabsorbed or secreted? Explain your answer.

$\dot{V}$ (urine flow rate	1 ml/min
P_{inulin} (plasma concentration of inulin)	100 mg/ml
U_{inulin} (urine concentration of inulin)	12 g/ml
P_A (plasma concentration of Substance A)	10 mg/ml
U_A (urine concentration of Substance A)	2 g/ml/

a) GFR = clearance for inulin

$$GFR = Clearance\ of\ inulin = \frac{12\ g/ml * 1\ mL/min}{100(mg/mLplasma)} = \mathbf{120\ mL/min}$$

b) Filtered load is the rate of filtration of a particular substance, which, if freely filtered is:

$$Filtered\ load\ of\ A = \frac{10mg}{mL} * 120\frac{mL}{min} = \mathbf{1200\ mg/min}$$

c) The clearance of Substance A is

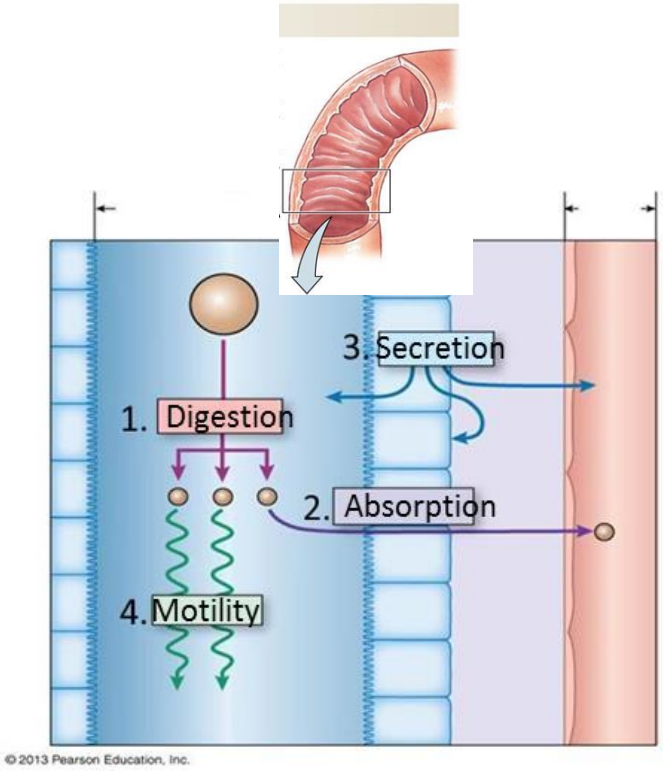
$$Clearance\ of\ A = \frac{2\frac{g}{mL} * 1\ mL/min}{10\ (mg/mLplasma)} = \mathbf{200\ mL/min}$$

d) **Substance A is secreted** because the clearance is greater than the clearance of inulin, which is neither reabsorbed nor secreted. Even if some were reabsorbed, more is secreted, so the net condition is secretion.

11. Explain why lactose intolerance sometimes leads to diarrhea (6 pts).

Lactose intolerance means that the enzyme lactase is lacking, so lactose cannot be broken down into glucose and galactase. Undigested lactose is not absorbed and remains in the lumen of the intestine, increasing the osmolarity of the chime. This causes water to move into the intestine (and/or not be reabsorbed), leading to diarrhea.

12. The following diagrams pertain to the **small intestine**.
a) Label the picture with the correct digestive process in the box and give an example of the function (8 pts).
For example, if it was the stomach, and you were labeling Secretion, you could write ***Secretion: HCl***



process	example
1. Digestion: polypeptides	
2. Absorption: glucose	
3. Secretion: Bicarbonate	
4. Motility: peristaltic movement	

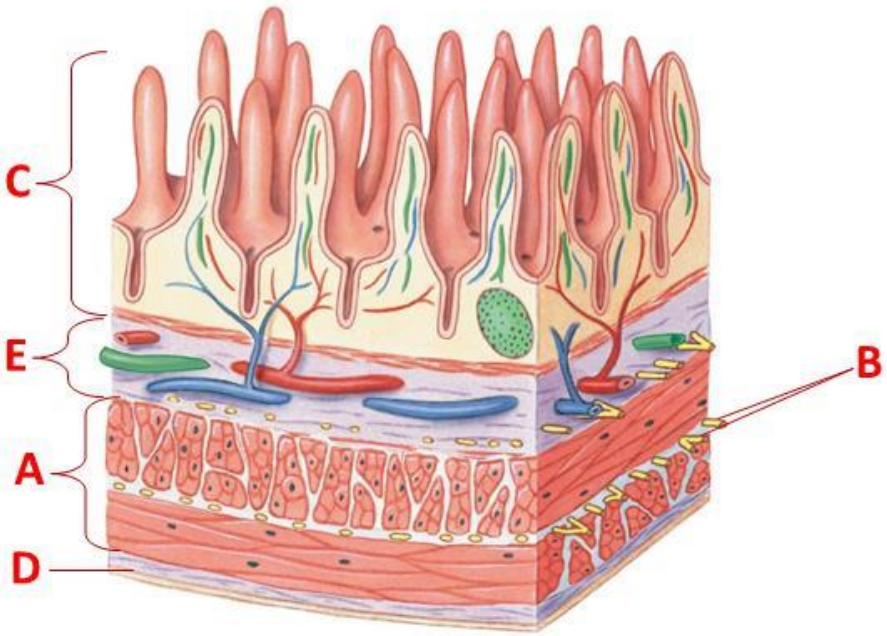
Acceptable answers:

Small Intestine

M: mixing and propulsion primarily by segmentation
S: enzymes; HCO_3^- and enzymes (pancreas); bile (liver); mucus (goblet cells); hormones: CCK, secretin, GIP, and other hormones
D: carbohydrates, fats, polypeptides, nucleic acids
A: peptides by active transport; amino acids, glucose, and fructose by secondary active transport; fats by simple diffusion; water by osmosis; ions, minerals, and vitamins by active transport

b) Label the cross section of the small intestine by putting the correct letter next to the correct structure, connecting with a line as necessary. (5 pts)

A. Muscularis externa
B. Myenteric plexus
C. Mucosa
D. Serosa
E. Submucosa



13. If a person drinks a high salt beverage (0.5 L, 500 mOsM) that is 100% absorbed into the blood, what is the change in intracellular volume and osmolarity at equilibrium (assuming that there is no excretion and ignoring any renal or other compensation mechanisms; initial body fluid osmolarity = 300 mOsM; initial ECF volume = 14 L; initial ICF volume = 28 L). (10 pts).

Initial conditions:

Compartment	Volume (L)	Osmolarity (mOsM)	Total osmoles (mosmoles)
ECF	14	300	4200
ICF	28	300	8400

Upon drinking beverage (0.5L, 500 mOsM), prior to total body equilibrium.

Compartment	Volume (L)	Osmolarity (mOsM)	Total osmoles (mosmoles)
ECF	14.5	306.9	4450
ICF	28	300	8400

At final total body fluid equilibrium: take total osmoles and divide by total volume to get equilibrium osmolarity (302.4mOsM). To get final volume: take osmoles in that compartment (which does not change, since they are nonpenetrating) divided by the osmolarity at equilibrium.

Compartment	Volume (L)	Osmolarity (mOsM)	Total osmoles (mosmoles)
ECF	14.7	302.4	4450
ICF	27.8	302.4	8400

14. Why does dehydration occur during untreated Type 1 Diabetes? Use a **concept map** to convey your answer

10 pts: renal response: 6 (renal threshold, 2; excess solute leading to increased water loss, 2; unsuccessful compensation attempt from decreased volume/pressure). ECF conditions: 2 (hyperglycemia – too much glucose in the blood-lead to increased ECF osmolarity); concept map organization and readability: 2.

Osmotic diuresis: The loss of water in the urine due to unreabsorbed solutes.

Because hyperglycemia lead to increased ECF osmolarity and renal osmotic diuresis, which can end up in competition and failure of one or both compensation mechanisms. Increased ECF osmolarity leads to increased vasopressin (ADH) secretion and increased thirst. These responses attempt to conserve water (ADH) and add water (thirst) to reduce the osmolarity back to normal. Overcompensation may contribute to diabetes associated hypertension. Renal compensation, however, can make the situation worse, since osmotic diuresis also increases (or maximizes) solute reabsorption, increasing ECF osmolarity even further. The renal threshold for glucose is exceeded (i.e. saturation of glucose reabsorption transporters) with hyperglycemic conditions, leaving more in the nephron and increasing tubular osmolarity. This will draw more water into the nephron tubule (osmotic diuresis) and polyuria, which leads to further loss of blood volume and blood pressure.

BMED 3100 Systems Physiology Test 4

15. Uncle Bob has high blood pressure and his primary doctor has recommended he take a diuretic, but you suggest he ask his doctor about ACE inhibitors. Relate how you explain the difference in mechanism to him. (10 pts)

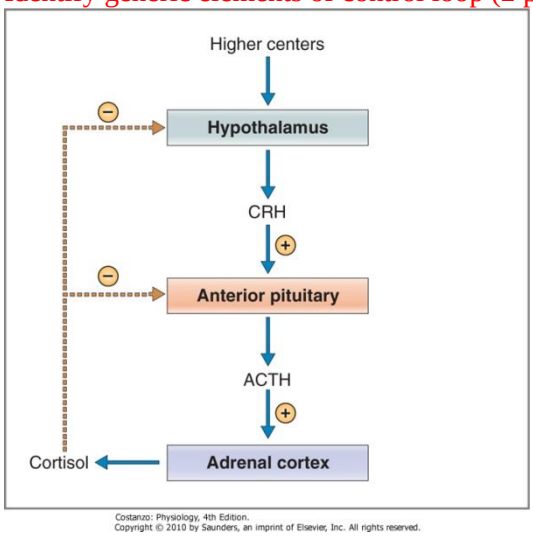
There are different ways to reduce blood pressure. A diuretic causes increased urine output, reducing the blood volume and therefore blood pressure. A diuretic is like vasopressin and works by causing water channels (aquaporins) to be inserted in a part of the kidney that normally does not allow water movement. Angiotensin converting enzyme (ACE) converts angiotensin I to angiotensin II, which causes vasoconstriction, vasopressin release, and aldosterone release. Aldosterone causes more sodium to go from the kidney to the blood, and water follows, so to reduce the amount of angiotension II and aldosterone will reduce the blood volume and therefore blood pressure.

Extra explanation; not necessary for points. More specifically:

- *Vasopressin regulates urine osmolarity and indirectly, blood (and extracellular fluid) volume*
  - *Posterior pituitary hormone (also called antidiuretic hormone (ADH) (A DIURETIC COUNTERS THIS)*
  - *Vasopressin present – cells permeable to water – urine has ⇑ osmolarity, causes concentrated urine*
  - *Vasopressin absent – cells in collecting duct impermeable to water - ⇓ osmolarity, causes dilute urine*
  - *Aquaporins – aquaporin-2 – water channel controlled by vasopressin:*
    - *Vasopressin binds to receptor on basolateral side of collecting duct cell, activates a G-protein/cAMP second messenger system. Phosphorylation of intracellular proteins cause AQP2 water pores to insert on the apical membrane*
  - *Regulated by ECF osmolarity (osmoreceptors) and blood pressure*
    - *Osmoreceptors in hypothalamus*
      - ***Osmolarity > 280 mOsM: osmoreceptors fire, vasopressin release, increased renal water reabsorption, thirst***
      - ***Osmolarity < 280 mOsM: osmoreceptors don't fire, vasopressin isn't released***
    - *Decreases in blood pressure and blood volume less powerful stimuli for vasopressin release*
      - ***Blood volume decreases, atrial stretch receptors, vasopressin release, water conserved***
      - ***Blood pressure decreases, carotid, aortic baroreceptors, vasopressin release, water conserved***
- *Renin-angiotensin-aldosterone system (RAAS)*
  - *Juxtaglomerular cells (JG cells) in afferent arterioles secrete renin; sensitive to pressure; sympathetic stimulation*
  - *Renin converts angiotensinogen into angiotensin I*
  - *In the blood, angiotensin converting enzyme (ACE) converts ANGI into ANGII*
  - *ANGII causes synthesis and release of aldosterone*
  - *Aldosterone then cause the tubule to reabsorb Na^+*
  - *Angiotensin II infuences blood pressure*
    - *ANGII activation in the brain increases vasopressin secretion – fluid retention conserves blood volume*
    - *ANGII stimulates thirst*
    - *ANGII potent vasoconstrictor*
    - *Activation of ANGII receptors increases sympathetic output*
    - *ACE inhibitors – class of drugs to lower blood pressure*
  - *Aldosterone: regulates reabsorption of Na^+ in the distal tubule and collecting duct*
    - *More aldosterone, more Na^+ reabsorption*
    - *Synthesized in adrenal cortex*
    - *Target is principal cell (P cell)*
    - *Enters P cell by diffusion, receptor is cytoplasmic, activation opens apical Na^+ transporter*
    - *In distal tube (Na^+ and water separately regulated); In proximal tube (Na^+ and water regulated together)*
    - *Aldosterone secretion controlled by:*
      - *Increased K^+ stimulates aldosterone release*
      - *Increased osmolarity – inhibits aldosterone release*
      - *Angiotensin II*

16. Mrs. Whitaker has been diagnosed with Addison's disease following lab work that showed excess ACTH, decreased cortisol, and decreased aldosterone, all characteristic of Addison's disease. As a treatment, Mrs. Whitaker is given a glucocorticoid, which mimics the effect of endogenous cortisol. Using a control loop of the HPA (hypothalamus-pituitary-adrenal) axis, explain the physiologic reasoning behind this treatment course. Be sure to include all the elements of a control diagram (sensor, pathways, integrating center, etc) as well as the anatomical elements and hormones involved. (10 pts)

Identify generic elements of control loop (2 pts). HPA axis (3 pts), feedback (3 pts), explanation (2 pts)



17. In a normal individual, what are the metabolic actions that result from an increase in insulin? (8 pts)

Must have at least 2:

1. insulin increases glucose transport into most cells (insulin-sensitive cells)

2. insulin enhances cellular utilization and storage of glucose.

    Activates enzymes for **glycolysis** & glycogen synthesis (**glycogenesis**)

    Inhibits enzymes for glucose synthesis (**gluconeogenesis**) fat breakdown (**lipolysis**)

3. insulin enhances utilization of amino acids

4. insulin promotes fat synthesis