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Last Name, First Initial

September 10, 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.

_____KEY_____
Signature

_____
Name (Printed clearly)

BMED 3100 Systems Physiology Test 1

1. Define the following: (2 pts each)

Homeostasis

A state of equilibrium (or dynamic steady state) in which the internal environment of the body remains in the normal range. OR Regulation of the body's internal environment in response to an external and/or internal change.

Osmotic equilibrium

When the fluid concentrations of solutes are the same on both sides of a membrane. OR Equal osmolarities on the two sides of a cell membrane.

Second messenger (as it pertains to cell signaling)

A molecule inside cells that acts to transmit signals from a receptor to a target. Also called a intracellular cascade of signal transduction from the receptor to a target.

Synergism (as it pertains to endocrinology and cell signaling)

Combined action of two hormones (or proteins or ligands or signals) is greater than the summed action of each hormone by itself.

Ligand (as it pertains to cell-cell communication and cell signaling)

A molecule that binds to a membrane (or cellular) receptor that initiates a response; the first messenger.

Depolarization (as it pertains to membrane potential)

A change in membrane potential when cations enter the cell, making the cell less negative / more positive.

Specificity (as it pertains to membrane transport and / or cell signaling)

The ability of an enzyme or receptor to bind to a particular molecule or a group of closely related molecules in a unique fashion

Dissociation constant (as it pertains to molecular interactions)

The ratio of the protein and ligand (reactants) concentrations to the complex (product) concentration; represents the tendency for a particular molecular interaction; high Kd=low affinity.

2. Circle the best answer (2 pt each)

If a protein in the blood is acting as a steroid hormone carrier and the hormone concentration is reduced, the dissociation constant will INCREASE or DECREASE or STAY THE SAME.

Lipids can dissolve in the cell membrane because the partition coefficient is relatively HIGH or LOW.

Small solutes have a HIGHER or LOWER diffusivity than large solutes (all other conditions constant).

The inside of a cell membrane is POSITIVE or NEGATIVE with respect to the outside.

The ISF contain MORE or LESS proteins than the ICF.

3. (3 pts) What is the primary function of blood? By what mechanism does blood carry out that function?

Function (what): to carry oxygen and nutrients to the cells.
Mechanism (how): blood carries oxygen in hemoglobin in RBC and delivers oxygen and nutrients to the cells via capillary exchange down concentration gradients and through specific membrane carriers

4. (3 pts) How does the structure of exchange epithelium facilitate the ability to carry out its primary function?

Structure: exchange epithelium is made of simple squamous epithelial cells
Function: this arrangement allows diffusion and transport across a relatively (relative to cuboidal/columnar cells) short distance.

5. A normal cell (300 mOsM) is placed in the following solutions. Predict whether the cell SHRINKS, SWELLS, stays the SAME. (3 pts each)

20 mmol/cm^3 NaCl =40000mOsM _____**SHRINKS**_____

300 mM urea = 300 mOsM _____**SAME**_____

1% KCl = 268 mOsM _____**SWELLS**_____

150 mOsM $CaCl_2$ _____**SWELLS**_____

6. Which solution has the higher osmotic pressure: a solution of 2mM KCl or a solution of 1mM $MgCl_2$? How did you come to this conclusion (show your work – what are the actual osmotic pressures? What is your assumption(s)?) (4 pts – correct answer 1, correct osmotic pressure 2, equation & assumptions 1)

Assume σ=1, RT are constant. Units (RT) = L·atm/mol·K * K = L·atm/mol, π units = atm

KCl: π = 2 * 2 mM * RT= 4 mOsM RT; $MgCl_2$ π = 3 * 1 mM * RT = 1 mOsM RT
therefore the KCl solution has the higher osmotic pressure

7. If these two solutions were in two equal volume compartments of a chamber separate by a membrane permeable to only chloride, what is the Nernst potential for chloride, treating the KCl side as the cell and the $MgCl_2$ side as the extracellular space? (4 pts – equation 1, correct answer 3)

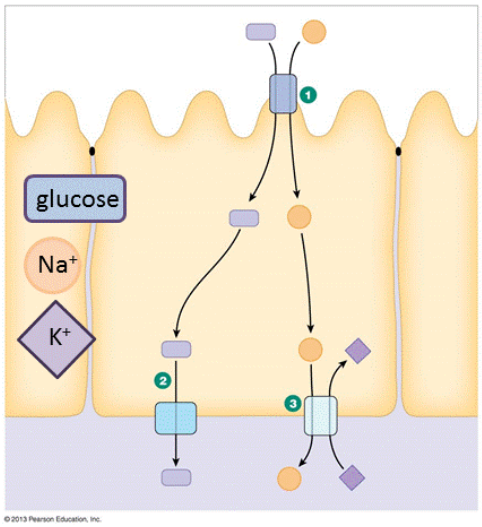
$[Cl^-]_{out}$ = 2mM; $[Cl^-]_{in}$ = 2mM $E_{Cl} = -61log_{10}\frac{[2\ mM]}{[2\ mM]} = 0\ mV$

8. If that membrane were a cell membrane with a resting membrane potential of -50 mV, in which direction will the ions move *if the membrane is suddenly open to Cl* (is implied)? Why? (4 pts)

Chloride ions will move out of the cell (2 pts) because the resting potential is more negative than the equilibrium potential for Cl^-, therefore the negative ions will move out of the cell to bring the inside of the membrane more positive – closer to the Nernst potential. (2 pts).

9. (3 pts) What type of tissue is shown below?___**Transporting (1 pt) epithelial tissue (2 pts)**_

10. (6 pts) Fill in the boxes to the right of the figure.



Type of transporter

1. Na-glucose symporter / co-transporter
2. GLUT transporter
3. Na-K ATPase pump

Name / type of membrane side

1. Apical side or lumen /luminal side
2. Basolateral side
3. Basolateral side

The general type of transporter is acceptable.
1) (secondary active) co-transporter or symporter
2) (facilitated transport) carrier transporter
3) (active transport) membrane pump; this is not a counter-transporter / antiporter, which is a secondary transporter type

11. (9 pts) In the figure, what are the relative concentrations of Na^+, K^+, and glucose in the lumen, the cell, and the extracellular fluid (high / low)?

	Sodium	Potassium	Glucose
Lumen	**high**	**low**	**low**
ICF	**low**	**high**	**high**
ECF	**high**	**low**	**low**

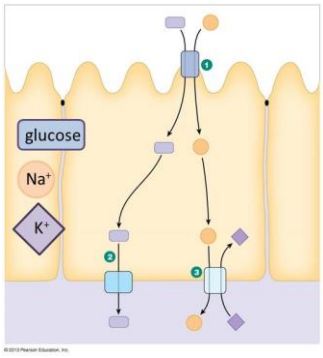
12. (4 pts) For the same figure, the $[glucose]_{intracellular}$ suddenly doubles from 40 mOsM to 80 mOsM. If $[glucose]_{extracellular}$ was originally at 20 mOsM, will the flux of glucose out of the cell stay the same, increase, or decrease? If it changes, by what factor will it change? Assume no saturation. Show your work, including any equations used.

Flux increases. (1 pt)

$\boldsymbol{J = PA(C_A - C_B)}$ **(1 pt – some /all of flux equation to demonstrate how change is calculated)**

($C_A - C_B$) goes from 20 mOsM to 60 mOsM, therefore Flux (J) increases by 3 times. (2 pts)

13. (4 pts) Assuming all transport rates are unchanged (i.e. holding steady / do not consider transport / pretend all transport is essentially stopped while you answer this question) and luminal sodium concentration increases. What will happen to the intracellular fluid volume and why?



ICF volume will decrease (1 pt) because the ECF has become hypertonic (1 pt for explaining the change in osmolarity in the ECF) and water leaves the cell to try and reach osmotic equilibrium (2 pts – explanation for the water movement).

14. (6 pts) If cellular metabolism severely decreases (assume drastic drop in oxygen), what will happen to each of the transporters in the figure and why?

1: Decrease – Reducing the activity of the Na^+/K^+ pump will decrease the extrusion of Na^+ from the cell and will allow intracellular [Na^+] to increase. Therefore, the Na^+ gradient will be smaller and there will be less glucose co-transport.

2: Decrease – Reducing the glucose transport from the lumen will reduce the concentration gradient of glucose from the cell to the ECF on the basolateral side.

3: Decrease ATP production would be reduced and not available for the activity of the Na^+/K^+ pump (requires hydrolysis of ATP). Therefore, the activity of the Na^+/K^+ pump is reduced.

15. (12 pts) Choose a hormone (from the list): _**answer varies**____

What type of hormone is it? **answer varies** (2 pts)_

Construct a simple concept map for the reflex loop that controls this hormone level in the body. Include the stimulus, afferent and efferent pathways, integrating center(s), effector, and feedback (with generic and specific labels).

Will vary, but general elements must be present: Afferent pathway is stimulus to cell, integrating center is endocrine cell or gland, efferent pathway is blood carrying the hormone, effector is the target gland or organ. Most feedback will be negative to the sensor/integrating center

5 pts for correct reflex loop
5 pts for correct physiology