READ THIS PAGE BEFORE YOU BEGIN THE EXAM.

1. Write your name on every page, in both packets of stapled-together pages.
   (5 points off for EACH unnamed page.)

2. Do NOT write on the BACK of any page unless you get a TA’s permission FIRST.

3. About writing answers:
   • All questions can be answered briefly.
   • For full credit, discuss mechanisms.
   • In problems asking for an answer and a reason, more credit is given for a correct reason.

4. Use a pen or pencil to write your answers, but do NOT use RED INK and DO NOT USE WHITE-OUT of any kind. However, if you use pencil, you cannot request a regrade.

5. All answers should be on pages in this packet. (Anything written on pages in the packet of multiple-choice questions will not be graded.)

6. Before you leave the testing room, turn in both packets of stapled-together pages.

POTENTIALLY USEFUL EQUATIONS:

\[ \pi = \sigma RT(C_\text{a}-C_i) \]
\[ F = A \eta \frac{\Delta V}{\Delta X} \]
\[ C_s = \frac{[S]_U}{[S]_P} \cdot V_U \]
\[ R = \frac{8 \eta l}{\pi r^4} \]
\[ J = k[(P_\text{cap}+\pi_{\text{int}})-(P_{\text{int}}+\pi_{\text{cap}})] \]
\[ V_m = \frac{G_{Na}}{\sum G} F_{Na} + \frac{G_K}{\sum G} F_K + \frac{G_{Cl}}{\sum G} F_{Cl} \]
\[ I_Y = G_{Y}(V_m-E_Y) \]
\[ I_{\text{total}} = \sum \{G_j[V_m-E_j]\} \]
\[ J = -PS(C_{out}-C_{in}) \]
\[ E = mc^2 \]
\[ \frac{1}{R_{\text{Total}}} = \sum \frac{1}{R_i} \]
\[ E_x = \frac{RT \ln[X^+]_{\text{out}}}{ZF} \frac{[X^+]_{\text{in}}}{\text{concentration}} = \frac{\text{quantity}}{\text{volume}} \]
\[ I_X = G_X (V_m-E_X) \]
\[ V = \frac{Q}{A} \]
\[ P = QR \]
\[ R_{\text{Total}} = \sum R_i \]
\[ I_X = G_X (V_m-E_X) \]
\[ A = \pi r^2 \]
\[ V = IR \]

WAIVER: By signing this waiver I give permission that this exam can be left for me to pick up in the hall outside the elevators on the third floor of Pacific Hall. I realize that this procedure may expose my grade to public scrutiny and my exam to theft. If I do not sign this waiver, I understand I will be able to get my graded exam back only as described on the course Web site.

____________________________________________________
Signature

Date
Multiple choice answers:

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Scores and grade:

Final: MT1 ___________
Final: MT2 ___________
Final: New ___________
Final: Total ___________
Midterm 1 ___________
Midterm 2 ___________
Grand Total ___________
Course Grade ___________
1. (20 points total) Edema is swelling of the body—often the arms or legs—caused by increased levels of interstitial fluid. Edema is a condition, not a disease state: it can have many different causes.

For each of the causes of edema listed below, briefly explain the major physiological mechanism that causes it.

A. (5 points) Eating too much salt.

B. (5 points) Sunburn (which damages the capillary wall cells, allowing leakage of large molecules).

C. (5 points) Failure of the valves in the veins of the legs.

D. (5 points) Right heart failure.
2. (20 points total) Hyperosmotic laxatives cause diarrhea by drawing water from the bloodstream into the colon, which is then expelled from the body through the anus. The loss of water from the bloodstream increases the osmolarity of the plasma.

A. (8 points) Describe what happens to the volume and osmolarity of the other two body fluid compartments as a result of this hyperosmotic diarrhea, before there is any compensation by kidney mechanisms.

B. (4 points) Is the release of ADH triggered by hyperosmotic diarrhea? Briefly explain.

C. (4 points) Would ADH help to reverse the changes in the body fluid volumes caused by hyperosmotic diarrhea? Explain your answer.

D. (4 points) Describe one other important mechanism triggered by the changes in the fluid compartments that would help to compensate for the effects of this laxative.
3. (10 points total) An increase in venous return to the right atrium (caused by increased blood volume, by increased blood pressure, or by both) causes the release of a hormone called Atrial Natriuretic Peptide (ANP) from cells in the right atrium. This hormone is part of a homeostatic system that involves both the cardiovascular system and the kidneys.

A. (5 points) ANP has a direct effect on the muscles of the veins and arterioles. Predict whether ANP would cause vasodilation or vasoconstriction, and explain your prediction.

B. (5 points) ANP also has an effect on the kidneys, acting primarily through aldosterone. Predict whether ANP would increase or decrease the amount of aldosterone in the blood, and explain your prediction.
4. (18 points total) People with a disease called Fanconi’s Syndrome (FS) have malfunctions in the reabsorption of molecules in the proximal tubule of their nephrons. In the most extreme form, the proximal tubule cannot reabsorb glucose, amino acids, or Na\(^+\). The major symptoms of FS are polyuria (the production of huge amounts of urine) and polydipsia (extreme thirst).

A. (5 points) Explain the polyurea: how do the kidneys of a person with FS produce an abnormally high quantity of urine?

B. (5 points) Explain the polydipsia: why (i.e., by what mechanism) is a person constantly thirsty?

C. (4 points) Would the glomerular flow rate (GFR) in an FS patient be higher, lower, or the same as the GFR of a normal person? Briefly explain why.

D. (4 points) How would the clearance of amino acids in an FS patient compare to a normal patient? State whether it would be higher, lower, or the same as the amino acid clearance in a normal person, and briefly explain why.

Multiple Choice Exam Questions

For the following three groups of statements (I-1 to I-15, II to II-15, and III-1 to III-8), circle every letter on page 2 of FINAL EXAM ANSWERS that makes a true statement. Note that any number of statements may be true—including none of them—so that if you do not circle a letter you are indicating that you believe that the statement is false. (You lose one point for every incorrect answer circled and for every correct answer not circled.)
I. Midterm 1 material:

I-1. Which of the following is a mechanistic explanation?
   A. The shivering mechanism in your body becomes activated because the body needs to maintain a homeostatic body temperature.
   B. Neurons are able to send long-distance signals throughout the body by using regenerative electrical potentials along axons.
   C. Resting potentials are established by the sodium, chloride, and potassium leak channels present in the lipid bilayer membrane of cells.
   D. Glial cells are present in the brain because neurons need support systems to function properly.

I-2. Negative feedback loops:
   A. always contain an odd number of negative signs.
   B. require a perturbation to activate them.
   C. resist changes to a controlled variable.
   D. drive a value to its lowest extreme.

I-3. The Na\(^+/\)K\(^+-\)ATPase:
   A. compensates for the uptake of Na\(^+\) and the loss of K\(^+\) in neurons.
   B. directly causes the resting potential.
   C. has an equilibrium potential that is determined by its electrochemical gradient.
   D. depends mainly on the high conductance of potassium channels.

I-4. In a typical neuron in the CNS:
   A. the resting potential is predominantly determined by potassium ion concentration because of the high resistance of K\(^+\) leak channels.
   B. ions move down their concentration gradients, which is maintained by the Na\(^+/\)K\(^+-\)ATPase.
   C. during an action potential, voltage-gated Na\(^+\) and K\(^+\) channels open independently of one another.
   D. during the rising phase of an action potential, the membrane potential approaches the equilibrium potential of Na\(^+\) because Na\(^+\) moves out of the cell via voltage-gated channels.

I-5. Voltage-gated Na\(^+\) channels:
   A. are time sensitive.
   B. are voltage sensitive.
   C. are responsible for the rapid hyperpolarization that occurs in an action potential.
   D. have two gates that control their conductance.

I-6. The following are mechanisms of transmitter inactivation at a synapse in the CNS:
   A. re-uptake and subsequent recycling of neurotransmitter by glial cells.
   B. enzymatic breakdown of the neurotransmitter.
   C. diffusion of neurotransmitter out of the synaptic cleft.
   D. release of competitive inhibitors to neurotransmitter receptors by presynaptic cells.

I-7. The binding of a neurotransmitter to a receptor at a synapse:
   A. opens post-synaptic voltage-gated ion channels that alter the V\(_m\).
   B. may induce an EPSP or IPSP depending only upon the reversal potential of the synaptic channels in the postsynaptic cell.
   C. will always induce an EPSP if the neurotransmitter is ACh.
   D. is blocked at the NMJ by curare.

I-8. At a metabotropic synapse:
   A. neurotransmitter binds to ion channel.
B. second messengers activate a cascade of enzymes.
C. transmission is slower than at an ionotropic synapse.
D. a large potassium conductance is activated in response to transmitter binding.

I-9. Sensory receptor neurons:
A. each has a trigger zone that contains a high density of voltage-gated Na⁺ and K⁺ channels.
B. produce receptor potentials that conduct without decreasing amplitude to the presynaptic terminal.
C. each has a transduction site that turns sensory stimuli into a change in Vm.
D. have their cell bodies located outside the central nervous system.

I-10. The stretch reflex:
A. is a monosynaptic reflex arc.
B. is activated by synapses of motor neurons onto skeletal stretch receptors.
C. functions through the relaxation of antagonistic muscles and excitation of synergistic muscles.
D. is useful for making quick adjustments to unforeseen forces on joints.

I-11. In the central nervous system there are:
A. Schwann cells.
B. ganglia.
C. oligodendrocytes.
D. nerves.

I-12. The pain pathway includes:
A. the thalamus.
B. the medial lemniscus.
C. the dorsal column.
D. the anterolateral tract.

I-13. The neural control of voluntary movement includes fibers:
A. that originate in the motor cortex.
B. from the right brain that cross over to the left side of the body at the pyramids.
C. of the dorsalateral tracts that activate motor neurons to limb muscles.
D. of the anterolateral tracts that activate trunk muscles.

I-14. The sympathetic nervous system:
A. has preganglionic neurons in the vagus nerve that synapse onto cells in the adrenal medulla.
B. uses only epinephrine and norepinephrine as postganglionic neurotransmitters.
C. forms a series of ganglia located near their target organs.
D. innervates skeletal muscle to increase muscle contraction in flight-or-flight responses.

I-15. If nuclei in the limbic system were removed, possible symptoms include:
A. sham rage.
B. lack of appetite.
C. lack of balance and coordination.
D. hypersexuality.
II. Midterm 2 material:

II-1. Steroid hormones:
   A. travel unaccompanied through the bloodstream and bind to surface receptors of target cells.
   B. can diffuse through cellular membranes.
   C. cause the production of new proteins.
   D. are derived from cholesterol.

II-2. Thyroid hormones:
   A. bind to G-protein coupled receptors and initiate 2nd messenger pathways to open ion channels.
   B. are released from the anterior pituitary gland upon stimulation from thyrotropin releasing factor.
   C. affect the transcription of genes while bound to their receptor molecule.
   D. like steroid hormones, have a prolonged effect on their target cells, longer than peptide hormones.

II-3. The posterior pituitary:
   A. utilizes a portal system to release hormones into the blood.
   B. controls the release of hormones from the anterior pituitary.
   C. releases hormones synthesized by hypothalamic cell bodies.
   D. releases ADH and oxytocin.

II-4. During excitation-contraction of skeletal muscles:
   A. extracellular Ca\(^{++}\) influx leads to muscle contraction.
   B. RyR in the sarcoplasmic reticulum open due to DHP receptor activation.
   C. Ca\(^{++}\) binds to tropomyosin.
   D. ATP binds to myosin heads, leading to the power stroke.

II-5. Which of the following are parameters that differ in different skeletal muscle types?
   A. amount of glycogen stores in mitochondria.
   B. amplitude of the depolarizing stimulus at the NMJ.
   C. myosin ATPase activity.
   D. amount of sarcoplasmic reticulum.

II-6. Which of the following describes smooth muscle function?
   A. Ca\(^{++}\) binds to and activates the myosin light chain kinase (MLCK) thereby increasing myosin ATPase activity, leading to contraction.
   B. Voltage-gated DHP receptors, through a conformational change, open RyR channels thus allowing for calcium release into the sarcoplasm.
   C. Unitary smooth muscles are electrically coupled via gap junctions allowing for contraction signals to spread throughout the entire muscle.
   D. Smooth muscle myosin heads are arranged anti-parallel to each other with no Z disks, which allows for contraction up to 50% of their rest length.

II-7. Which of the following contribute to smooth muscle relaxation:
   A. IP\(_3\) channels on the sarcoplasmic reticulum.
   B. Myosin phosphatase.
   C. Ca\(^{++}\)-Na\(^{+}\) antiport.
   D. Ca\(^{++}\) ATPase.
II-8. Characteristics of multi-unit smooth muscle cells include:
A. each cell functions independently of all other cells.
B. contraction can be neurogenic or myogenic.
C. it is found in the eyes, arterial walls, and the intestine.
D. each cell is surrounded by varicosities from autonomic postganglionic neurons that make synapses onto it.

II-9. Which of the following accurately describes cardiovascular functions?
A. Deoxygenated blood enters into the right atrium from the vena cava.
B. As blood passes through the lungs, the newly oxygenated blood flows through the pulmonary artery into the left atrium.
C. The bicuspid valve connects the left atrium and left ventricle.
D. Systemic edema results from the failure (inadequate pumping of blood) of the left side of the heart.

II-10. Heart pacemaker fibers contain:
A. If channels.
B. T-type voltage-gated calcium channels.
C. L-type voltage-gated calcium channels.
D. voltage-gated potassium channels.

II-11. In the conduction of action potentials through heart muscle:
A. gap junctions carry the excitation from muscle cell to muscle cell.
B. the apex of the ventricle is depolarized for a longer time than the area near the atrium.
C. repolarization begins in the apex and moves toward the atrium.
D. the conduction through the AV node is slower than anywhere else in the heart conducting system.

II-12. The ECG of a healthy heart:
A. represents the sum of many action potentials in cardiac cells, and can reach up to 100mV during the QRS complex in ventricular depolarization.
B. indicates the heart rate by the time between the onset of the P wave to the end of the T wave.
C. records the repolarization of the atria as the T wave.
D. the QRS complex will be larger if the polarity of the lead 1 electrodes is reversed.

II-13. Parasympathetic stimulation to the heart:
A. weakens the contraction strength of the ventricles.
B. opens K+ channels, which hyperpolarizes the membrane potential of SA node cells.
C. acts, in part, through nerve fibers that synapse directly onto ventricular contractile fibers.
D. acts through a branch of the vagus nerve.

II-14. Which of the following accurately portray heart rate modulation?
A. Starling’s Law of the Heart describes a more vigorous contraction of the ventricles when more blood returns to the heart.
B. If the heart rate decreases greatly, the contractile fibers can produce action potentials on their own, a capability called ventricular escape.
C. The autonomic nervous system is responsible solely for chronotropic effects on heart rate.
D. Parasympathetic fibers synapse on the SA node, causing a slowing of the heart rate.

II-15. In a typical cardiac cycle:
A. most of the blood pumped by the heart enters the ventricles during atrial systole.
B. heart valves open and close based on pressure differences between the chambers that they separate.
C. the “lub” and “dub” heart sounds are created by the opening and closing of heart valves.
D. the ventricles normally pump out all of the blood in each contraction.
III. New Material:

III-1. The resistance to blood flow is increased by:
   A. increasing the concentration of protein in the blood.
   B. adding additional blood vessels in parallel.
   C. decreasing the cross-sectional area of the vessel.
   D. increasing the length of the vessel.

III-2. Which of the following may be used to measure body fluid in corresponding compartments?
   A. Insulin, to measure intracellular fluid levels.
   B. Glucose, to measure intestinal tract fluid levels.
   C. D₂O, to measure intracellular fluid levels.
   D. Evans blue that binds to RBCs, to measure plasma fluid levels.

III-3. Along the entire nephron:
   A. inulin is filtered, but neither secreted nor reabsorbed.
   B. NaCl is both filtered and partially reabsorbed.
   C. glucose is both filtered and completely reabsorbed.
   D. para-amino hippuric acid (PAH) is both filtered and completely secreted.

III-4. Which of the following accurately portrays nephron structure and function?
   A. The proximal tubule is responsible for the bulk of reabsorption in the nephron.
   B. The loop of Henle begins at the Bowman's capsule and ends at the proximal tubule.
   C. The distal tubule selectively secretes urea and Na⁺.
   D. The collecting duct increases urine volume when ADH is present in the plasma.

III-5. Inulin is used to measure glomular filtration rate because:
   A. it is quickly metabolized, preventing inulin build-up that would skew the measurements.
   B. it is secreted all along the nephron.
   C. all the inulin that enters the nephron is excreted.
   D. it is freely filtered.

III-6. Places where a circulatory portal system is found:
   A. anterior pituitary.
   B. kidneys.
   C. posterior pituitary.
   D. liver.

III-7. ADH:
   A. is released in response to increased osmoreceptor activity in the hypothalamus.
   B. activates the release of aldosterone.
   C. release can be blocked by alcohol consumption.
   D. is released from the adrenal medulla.

III-8. Aldosterone:
   A. causes new channels to be added in response to transcriptional changes in chromosomes of distal tubule cells.
   B. binds to membrane-bound proteins and activates a 2nd messenger pathway.
   C. increases the permeability of water in the collecting ducts.
   D. ultimately causes an increase in blood pressure by increasing water reabsorption in the collecting ducts.