DEPARTMENT OF PHYSIOLOGY AND BIOPHYSICS
SCHOOL OF MEDICINE AND THE GRADUATE SCHOOL

HUMAN PHYSIOLOGY

FIRST EXAMINATION

MONDAY, FEBRUARY 14, 1994

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Instructions for Use of Optical Scan Answer Sheet

1. **DO NOT** bend fold or tear answer sheet in any way.

2. Use **ONLY** a **#2 pencil**. **DO NOT** use a pen.

3. **DO NOT** make any marks along the edge with the black lines. The computer will not be able to grade your sheet if you do so.

4. Print your name (**last name first**) in the boxes provided on the sheet.

5. **Darken** the blanks which correspond to each letter in your name and initial.

6. In the box marked "Student I.D. Number" write your **5-digit identifying number** given to you by the Registrar's Office at the beginning of the year. **Darken** the corresponding number box below. Please fill out **both** sides of the answer sheet.

7. For each question, **darken** the letter blank which corresponds to the correct answer. **DO NOT** write in more than one answer -- **the computer will reject your answer sheet and it will be marked wrong (i.e. no credit). Erase** thoroughly any mismarked blanks.

8. **NO EXTRA TIME WILL BE ALLOWED TO TRANSCRIBE ANSWERS ONTO THE ANSWER SHEET.**

9. **IF YOU DO NOT FOLLOW THE ABOVE INSTRUCTIONS, IT WILL NOT BE POSSIBLE TO GRADE YOUR EXAM.**

HUMAN PHYSIOLOGY

Answer Key
First Exam
February 14, 1994

1. D
2. B
3. B
4. E
5. B
6. C
7. B
8. E
9. E
10. C
11. A
12. B
13. B
14. D
15. B
16. E
17. E
18. B
19. E
20. A
21. omitted
22. A
23. C
24. B
25. D
26. C
27. C
28. D
29. D
30. E
31. A
32. B
33. B
34. B
35. B
36. C
37. B
38. E
39. B
40. C
41. C
42. C
43. A
44. D
45. C
46. E
47. B
48. B
49. C
50. A
51. C

1. Which of the following substances is the **anion** that contributes most to the total osmolarity of the extracellular fluid?

   A. sodium
   B. phosphate
   C. potassium
   D. chloride
   E. albumin

2. The intracellular fluid space:

   A. has a higher osmotic pressure than the interstitial fluid.
   B. can be measured with inulin + $^{3}H_{2}0$.
   C. contains approximately 20% of the total body water.
   D. would decrease in volume during a fall in plasma oncotic pressure.
   E. would increase in volume during a hemorrhage.

3. A 40 year old professor was injected with 80,000 counts per min (cpm) of chromium^{51}-labeled red blood cells. After equilibration the activity (concentration) of chromium^{51} in a blood sample was 50 cpm/ml. If her hematocrit was 40, her total blood volume was approximately:

   A. 2 liters
   B. 4 liters
   C. 6 liters
   D. 16 liters
   E. 40 liters

4. A 100 kg athlete drinks 2 liters of physiological salt solution (300 mOsm/L). After equilibration (and assuming no losses) which of the following will occur?

   A. The osmolarity of the intracellular fluid compartment will be 320 mOsm/L.
   B. The volume of the intracellular fluid compartment will be 42 liters.
   C. The 2 liters of solution will distribute evenly between the intracellular and extracellular fluid compartments.
   D. Two-thirds of the 2 liters of solution will be intracellular and one-third will be extracellular.
   E. The volume of the extracellular fluid compartment will be 22 liters.

5. Transferring red blood cells from an isotonic fluid to which of the following solutions will cause the cells to shrink in volume?

   A. 150 mM NaCl
   B. 300 mM NaCl
   C. 150 mM Urea
   D. 150 mM Sucrose
   E. 300 mM Sucrose

6. Which is the **FALSE** statement about the peak of the axonal action potential?

A. The membrane potential approaches the Na equilibrium potential.
B. The membrane potential overshoots 0 mV.
C. Most, if not all, Na channels are in the closed state.
D. $G_{Na} >>> G_K$
E. The amplitude of the action potential peak is reduced by treatment with TTX.

7. An artificial membrane is composed solely of phospholipids. Which of the following functional properties would you expect this membrane to exhibit?

A. Low electrical resistance
B. High capacitance
C. Impermeability to water
D. Impermeability to glycerol
E. High glucose permeability

8. Passive diffusion across a cell membrane differs from facilitated diffusion in that:

A. Facilitated diffusion is not dependent on a concentration gradient.
B. Facilitated diffusion requires energy from the hydrolysis of ATP.
C. Facilitated diffusion cannot be competitively inhibited.
D. Facilitated diffusion allows the passage of only small, lipid soluble molecules.
E. Facilitated diffusion exhibits a transport maximum.

9. Clathrin:

A. Is a typical antiport-transporter found in most cells.
B. Is a cytoskeletal protein involved in movement of synaptic vesicles to the membrane.
C. Is an intra-vesicle protein involved in the stabilization and concentration of transmitter within the vesicle.
D. Is a common membrane protein involved in secondary transport.
E. Is a protein which forms a cage-like structure around coated vesicles.

10. Ion channels:

A. allow the passage of ions at a slower rate than protein transports
B. discriminate between ions based on size of the ion alone
C. have multiple membrane spanning groups
D. have a hydrophobic inner core surrounded by a hydrophilic outer core
E. can not be modified by phosphorylation on the cytoplasmic surface

11. A medical student was shown to have a lower than normal plasma potassium concentration. Which of the following would you observe?

A. Cellular resting potentials would be hyperpolarized from their normal values.
B. Cellular resting potentials would be depolarized from their normal values.
C. A dramatically lowered threshold for the muscle action potential.
D. A decrease in the muscle action potential amplitude.
E. Increased muscle activity.

12. The chloride channel in the membrane of skeletal muscle fibers :

A. contributes to the rising phase of the action potential
B. aids in the repolarization of the muscle fiber
C. replaces the voltage-gated K^+ channel
D. is regulated by intracellular calcium levels
E. prolongs the duration of the action potential

For questions 13 and 14 use the artifical cell system diagrammed below:

OUT	IN
200 mM KCl 10 mM $MgCl_2$ 20 mM NaCl	20 mM KCl 10 mM $MgCl_2$ 200 mM NaCl

13. Assuming the resting potential of this cell is a Nernst equilibrium for K^+ which of the following values would be expected if you were to record a resting potential from this cell:

A. -60 mV
B. + 60 mV
C. 0 mV
D. - 120 mV
E. cannot determine the resting potential without a value for G_{Cl}

14. When stimulated, the membrane potential of this cell changes to 0 mV. Which of the following conductances could account for this new membrane potential?

A. $G_{Na} >>> G_{Mg}$
B. $G_K = G_{Cl}$
C. membrane solely permeable to Na^+
D. membrane solely permeable to Cl^-
E. $G_{Na} >>> G_K$

15. An increased duration of the axonal action potential can be caused by:

A. activation of the electrogenic Na^+/K^+ pump
B. blockade of inactivation of the voltage-gated Na channel
C. blockade of inactivation of the voltage-gated K channel
D. increased activation of the voltage-gated Ca channel
E. increased activation of the voltage-gated Cl channel

16. Which of the following factors is **NOT** required to determine the current generated by an ion as it moves through a channel:

A. the equilibrium potential for that ion
B. the membrane potential
C. the conductance of the channel
D. Ohm's law for the cell membrane
E. the capacitance of the membrane

17. The autonomic nervous system:

A. innervates skeletal muscle as well as smooth muscle
B. provides direct, tight control over the end organ
C. has mostly large, myelinated axons
D. has few, if any, reflex control mechanisms
E. has integrative capability

18. The following data were obtained from a whole-cell patch clamp study of a neuronal membrane:

i. The current voltage relationship was linear over all ranges of voltages studied.
ii. The current was found to be 0 at about -10 mV.

From this data, which of the following is most likely? Assume that the concentration gradients are typical of a normal cell.

A. The channel is a K^+ inward rectifier.
B. The channel involved is not voltage-dependent.
C. The channel involved is the K^+ leak channel which produces the resting potential.
D. The channel is a voltage-gated Ca channel.
E. It is impossible to derive any information about this channel from the data provided.

19. Which of the following is associated with the Node of Ranvier?

A. layers of myelin
B. a high density of voltage-gated K channels
C. oligodendrocyte end feet
D. a low capacitance compared to adjacent areas of the axon
E. a high density of voltage-gated Na channels

20. Which of the following is **NOT** associated with activation of the voltage-gated K channel?

A. the upsweep of the action potential
B. the relative refractory period
C. the undershoot of the action potential
D. the action potential duration
E. the repolarization of the action potential

21. Myelinated axons conduct an action potential faster than non-myelinated axons because:

A. their axonal diameter is larger
B. the space constant is shorter
C. the time constant is faster
D. the relative refractory period is shorter
E. the number of Na/K pump molecules is greater

22. Select the **FALSE** statement about myelin basic protein.

A. It is an axonal membrane protein that promotes binding of myelin to the axon.
B. It can be used to induce an immune-mediated encephalopathy in experimental animals.
C. It is necessary for the compaction of the myelin layers during axonal wrapping.
D. It is a membrane protein found in oligodendrocytes.
E. Genetic deletion is associated with motor dysfunction.

23. The calcium channel found in a pre-synaptic nerve terminal:

A. is a primary ligand-gated channel
B. is identical to calcium channels found in the rest of the neuron
C. produces an inward calcium current
D. is closed on depolarization
E. is not voltage-dependent

24. End plate potentials:

A. are produced by the opening and closing of voltage dependent Ca channels
B. are terminated by removal of acetylcholine from the synaptic junction
C. can be recorded at any site on the muscle fiber membrane
D. overshoot to +40 mV
E. can cause inhibition of the muscle fiber

25. The slow phase of calcium release during excitation-contraction coupling in skeletal muscle is most likely due to:

A. inactivation of the calcium release site
B. inactivation of the SR Ca ATPase
C. direct release of calcium from the t-tubule
D. calcium-mediated release of calcium from the SR
E. a change in sensitivity of the dihydropyridine receptor

26. Relaxation of skeletal muscle after a contraction is controlled by:

A. the hydrolysis of ATP by myosin ATPase
B. dephosphorylation of the myosin ATPase
C. the uptake of calcium by the SR Ca ATPase
D. the binding of calcium to troponin
E. the binding of calcium to cytostolic proteins

27. The binding of ATP to the myosin head during the cross-bridge cycle:

A. continues during rigor mortis
B. is dependent on exposure of the actin active site
C. promotes detachment of the cross-bridge
D. is not required for cross-bridge formation at any stage
E. is required for the binding of Ca^{++} to troponin

28. Greater amounts of tension can be measured from a skeletal muscle during tetany compared to during a twitch. This is because:

A. the SR releases 10 times more calcium per stimulus during high frequency stimulation compared to a single stimulation.
B. Type II motor units are recruited during tetany.
C. the length-tension relationship changes.
D. any series elastic elements are maximally stretched during the first few stimuli of tetany.
E. the number of cross-bridges formed per cycle increases during tetanus.

29. If you increase the length of a resting skeletal muscle to twice its normal body length and then stimulate to produce a maximal isometric contraction, you will find that:

A. the velocity of contraction will be markedly slowed at the new resting length
B. the maximal amount of tension developed by the muscle will be twice as great at the new length
C. the rate of ATP hydrolysis will be faster at the new length
D. tension development in the muscle at the new length will be greatly reduced
E. the number of cross-bridges formed will be unchanged at the new length

30. Which of the following is considered to be the major factor in the 'moment to moment' regulation of skeletal muscle tension?

A. the length-tension relationship
B. an increase in the number of muscle fibers
C. the action of steroid hormones
D. the force-velocity relationship
E. the recruitment of motor units

31. Select the **FALSE** statement about contraction in unitary smooth muscle.

A. Calcium entry across the plasma membrane is negligible.
B. Phosphorylation of myosin is necessary for interaction of myosin with actin.
C. Actin is anchored by dense bodies.
D. Tension development depends on crossbridge formation between actin and myosin.
E. Calcium binds to calmodulin.

32. Select the **FALSE** statement about gap junctions.

A. They are found in cardiac muscle and unitary smooth muscle.
B. They reduce synchronous activation of the coupled cells.
C. They serve to electrically couple adjacent cells.
D. They can be regulated by second messenger-activated kinases.
E. They allow passage of certain small molecular weight molecules.

33. Recruitment of Type 1 motor units:

A. produces a large increase in tension with the addition of each motor unit to the pool
B. generally occurs before Type II motor unit recruitment
C. involves activation of large diameter α motorneurons
D. produces a rapidly fatiguing response
E. involves primarily 'white' muscle fibers

34. Plasma calcium levels were found to be 5mM instead of a normal value of 1.5mM. Which of the following is a consequence of this change in extracellular calcium

A. The resting potential is depolarized.
B. The amount of current needed to initiate an axonal action potential is higher than normal.
C. The membrane potential at which the open probability of the voltage-gated Na channels is 1.0, shifts to more hyperpolarized values
D. Activation of the voltage-gated Na channel occurs at the same membrane potential.
E. Seizures

35. Characteristics of the sympathetic nervous system include:

A. a cranial-sacral outflow from the CNS
B. a short pre-ganglionic fiber
C. release of acetylcholine at all post-ganglionic junctions
D. release of norepinephrine at all pre-ganglionic junctions
E. decreased activation during stress

36. Which of the following relationships describes the effect of the impermeant anions inside the cell on the diffusable ions?

A. The Nernst equation
B. The Goldman-Hodgkin-Katz equation
C. The Donnan equilibrium
D. Ohm's Law for the membrane
E. Fick's Law

37. The rapid upstroke (phase 0) portion of the ventricular action potential is caused by the influx of which ion?

A. calcium
B. sodium
C. magnesium
D. potassium
E. chloride

38. The normal sequence of excitation in the heart is:

A. atria, left bundle branch, bundle of His, AV node, ventricular cells
B. SA node, atria, right bundle branch, bundle of His, ventricular cells
C. SA node, atria, left bundle branch, AV node, ventricular cells
D. SA node, atria, AV node, ventricular cells, left bundle branch
E. SA node, atria, AV node, bundle of His, ventricular cells

39. In the ventricular cell:

A. the slow inward current during the action potential is carried primarily by sodium.
B. repolarization is caused by an outward potassium current.
C. an outward chloride current produces the fast upstroke of the action potential.
D. an inward sodium current is responsible for the plateau phase.
E. during the resting phase (phase 4), the membrane is primarily permeable to calcium.

40. Action potentials in the SA node:

A. will not occur spontaneously in the absence of an external stimulus.
B. have longer plateaus that those of ventricular cells.
C. occur with greater frequency in the presence of sympathetic stimulation.
D. arise from a more negative resting potential than do those of Purkinje cells.
E. occur due primarily to sodium influx during the rapid upstroke (phase 0).

41. Factors which affect conduction velocity in different regions of the heart include all of the following **EXCEPT**:

A. complexity of gap junctions.
B. cell size.
C. duration of the action potential plateau.
D. density of myofibrils.
E. resting membrane potential.

42. The portion of the electrocardiogram which occurs during the delay between initial atrial and ventricular excitation is the:

A. Q-T interval
B. S-P interval
C. P-R interval
D. T-P interval
E. Q-S interval

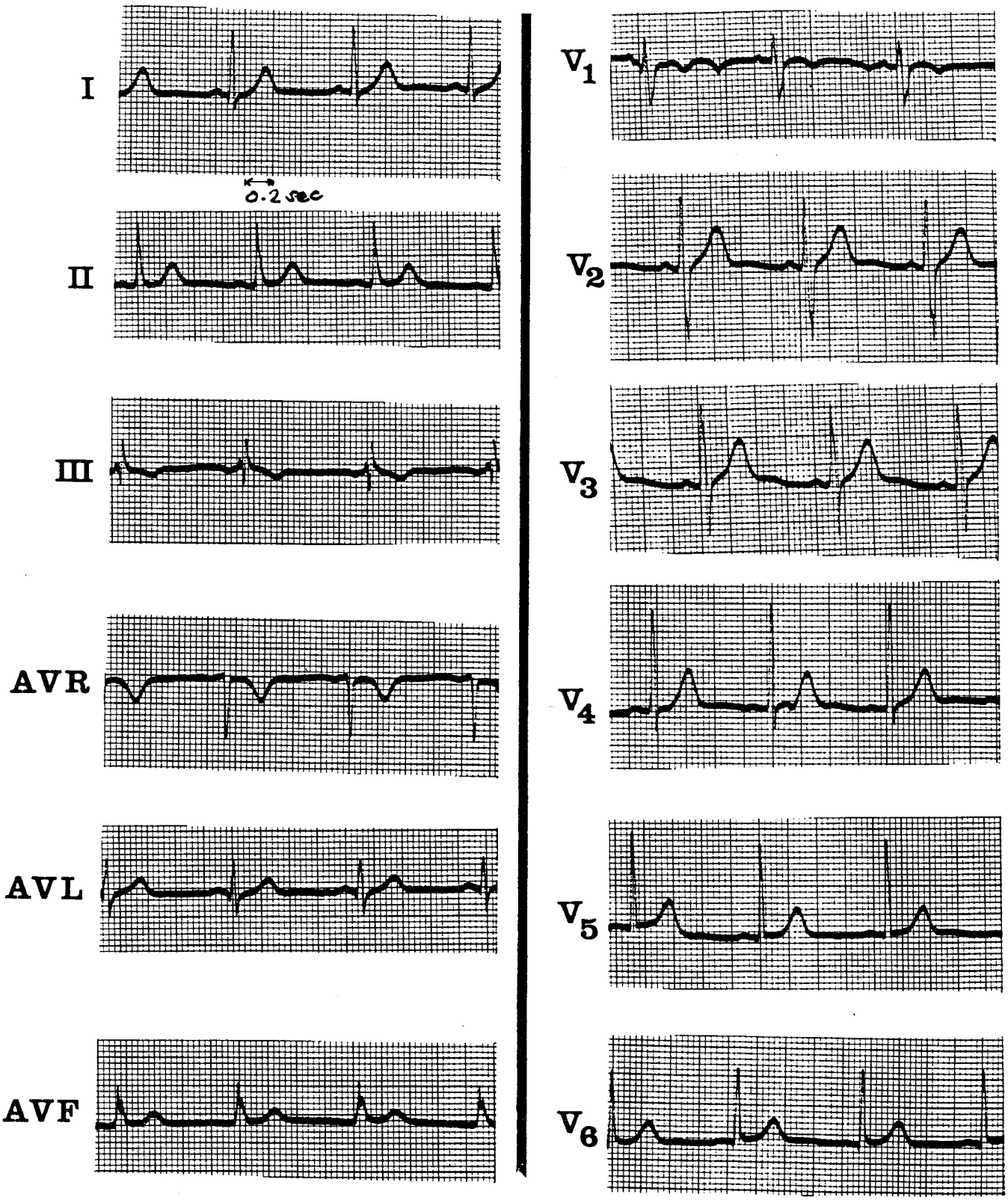
43. If an electrocardiogram from your patient showed three P-waves for each QRS complex, you would suspect that he/she had:

A. A-V node block
B. S-A node block
C. sinus tachyarrhythmia
D. ventricular fibrillation
E. atrial fibrillation

44. Requirements for maintaining a normal stable sinus rhythm in the heart include all of the following **EXCEPT**:

A. maintenance of a single dominant pacemaker.
B. fast ventricular conduction velocity.
C. slow conduction in the AV node.
D. ventricular action potentials with durations shorter than about 90 msec.
E. occurrence of spontaneous action potentials within the SA node.

For questions 45 - 47 the following electrocardiogram is recorded from a 29 year old patient, who came to the doctor's office complaining of general tummy/chest aches.



45. The patient's heart rate is about:

A. 30/minute
B. 50/minute
C. 70/minute
D. 100/ minute
E. 150/minute

46. The patient's rhythm is:

A. sinus bradycardia.
B. heart block.
C. ventricular tachycardia.
D. ventricular fibrillation.
E. normal sinus rhythm.

47. This patient has:

A. extreme right axis deviation due to myocardial infarction.
B. axis in the normal range.
C. extreme left axis deviation due to myocardial infarction.
D. right axis deviation due to heart displacement.
E. extreme left axis deviation due to severe hypertrophy.

48. Sympathetic stimulation produces:

A. prolonged AV conduction times.
B. increased heart rate.
C. increased QRS duration.
D. decreased contractility.
E. prolonged P-R intervals.

49. Conditions leading to ventricular fibrillation occur when:

A. the duration of the action potential plateau increases.
B. action potential upstroke velocity increases.
C. the resting potential of ventricular cells becomes less negative.
D. extracellular potassium is decreased slightly.
E. conduction velocity increases.

50. Vagal stimulation of the heart results in release of:

A. acetylcholine
B. norepinephrine
C. bradykinin
D. histamine
E. epinephrine

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The following question is intended to ascertain whether you learned certain material in the clinical conference. It will **NOT** count toward your score.

51. Select the **FALSE** statement about Multiple Sclerosis (MS).

A. MS is associated with an increase in antibody (IgG).
B. Symptoms of MS are exacerbated by heat.
C. There is a greater prevalence for MS in the tropics than in the colder regions of the world.
D. Myelin basic protein is found in the CSF of MS patients.
E. MS has an autoimmune component.