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

HUMAN PHYSIOLOGY

FIRST EXAMINATION

MONDAY, FEBRUARY 12, 1996

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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. DO NOT WRITE IN YOUR SOCIAL SECURITY NUMBER! Darken** the corresponding number box.

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.**

1. Which of the following is the most abundant substance in the plasma?

   A. protein
   B. chloride
   C. bicarbonate
   D. sodium
   E. potassium

For questions 2 and 3 use the information below:

An individual in good health is injected with 275,000 counts per minute (cpm) of radiolabeled albumin and 22 grams of inulin. After equilibration, the plasma activity (concentration) of radiolabeled albumin was calculated to be 50 cpm/ml and the hematocrit was 45%.

2. The total blood volume in this individual is approximately:

   A. 2 Liters
   B. 4 Liters
   C. 6 Liters
   D. 8 Liters
   E. 10 Liters

3. In the individual above, which of the following values would be the best estimate of the plasma concentration of inulin after equilibration?

   A. 0.01 g/L
   B. 22 g/L
   C. 1 g/ml
   D. 22 mg %
   E. 100 mg %

4. An 50 Kg student drinks 1 liter of a 150 mM NaCl solution. After equilibration (and assuming no losses) which of the following will occur?

   A. The liter will distribute evenly between the intracellular and extracellular fluid compartments.
   B. Two-thirds of the liter will be intracellular and one-third will be extracellular.
   C. The volume of the intracellular fluid compartment will increase by 1 liter.
   D. The amount of sodium in the extracellular compartment will increase by 150 millimoles.
   E. Water will leave the intracellular compartment.

5. Which of the following will cause fluid to move from interstitial fluid space into the vascular (plasma) compartment?

A. severe protein-calorie malnutrition
B. an increase in capillary hydrostatic pressure
C. an increase in tissue hydrostatic pressure
D. an increase in capillary permeability causing a leak of plasma proteins into the interstitial fluid compartment
E. eating a salty meal

6. Which of the following would increase intracellular fluid volume?

A. infusion of 500 ml of 150 mM NaCl solution
B. infusion of 500 ml of a 150 mM KCl solution
C. infusion of 500 ml of a 300 mM urea solution
D. an increase in arterial blood pressure
E. profuse sweating (assume sweat is hypotonic compared to plasma)

7. The amphipathic nature of the membrane lipids

A. promotes the entry of molecules with a low oil/water solubility.
B. inhibits the formation of a bilayer.
C. enables the lateral movement of proteins in the membrane.
D. hinders micelle formation.
E. creates a hydrophobic barrier to hydrophilic molecules.

8. Which of the following is clearly **NOT** associated with a V_{max} for the flux of a molecule?

A. facilitated diffusion
B. a symport
C. a sodium channel
D. the diffusion of glycerol
E. the sodium-potassium pump

9. Aminata (in the PBL case) was given an ORT (oral rehydration therapy) which contained glucose and sodium chloride. This combination was important because

A. glucose counter-transport on the brush border membrane requires the binding of sodium to the transporter.
B. a sodium gradient is essential for co-transport of glucose into the epithelial cells of the gut.
C. glucose is exchanged for sodium or potassium across the brush border.
D. glucose entry is a primary active transport mechanism which requires ATP and a sodium gradient.
E. the sodium channel is regulated by glucose binding.

10. Molecule "x" moves into the cell by simple diffusion. Which of the following factor(s) would decrease the flux of "x" into the cell?

A. an increase in the intracellular concentration of "x"
B. an increase in temperature
C. a decrease in the thickness of the membrane
D. an increase in the extracellular concentration of "x
E. an increase in the partition coefficient of "x"

11. Select the **FALSE** statement about ion channels.

A. Flux of an ion through a channel is a non-linear function of ion concentration.
B. Channels can be selective for one or more ions.
C. Channels are transmembrane spanning proteins.
D. A channel can be described as a "water or fluid-filled" pore.
E. Flux of an ion through a channel is slower than the flux via a transporter (carrier).

For questions 12 - 15 refer to the diagram below depicting an artifical situation.

OUTSIDE	INSIDE
5 mM Na^+	140 mM Na^+
140 mM K^+	5 mM K^+
10 mM Ca^{++}	2 mM Ca^{++}
155 mM Cl^-	147 mM Cl^-

12. The resting membrane potential (Vm) from the cell pictured above is <u>equal</u> to E_{K^+}. Select the **FALSE** statement about Vm for this cell.

A. The value of Vm is -98 mV.
B. The membrane is permeable to K^+ only.
C. Net flux of K^+ is zero.
D. A Nernst electrochemical equilibrium exists.
E. Na^+ does not affect the resting membrane potential.

13. Assume that the membrane potential changes to a new value. Voltage clamp experiments show that the conductances for K^+ and Cl^- become equal when this change occurs. What is the new Vm for this condition?

A. -87
B. +21
C. +43
D. 0
E. -1

14. The name of the equation you used to calculate the new potential in question #13 is

A. the Nernst equation.
B. Ohms law for the membrane.
C. the Goldman Hodgkin Katz equation.
D. the conductance equation.
E. Fick's law.

15. The membrane potential became more negative from the value determined in #13. Which of the following conditions could be responsible for this change?

A. The conductance for Cl^- increased.
B. The conductance for K^+ increased.
C. The conductance for Cl^- decreased.
D. The conductance for Na^+ decreased.
E. The conductance to Ca^{++} and K^+ increased simultaneously.

16. Which of the following is produced by exposure of a typical **nerve axon** to a high extracellular level of calcium?

A. The resting membrane potential depolarizes.
B. Activation of the voltage-gated sodium channel is shifted to a more depolarized value.
C. Inactivation of the voltage-gated sodium channel is inhibited.
D. Activation of the voltage-gated potassium channel is not affected.
E. The amplitude of the action potential increases.

17. In the electrical circuit analog, the driving force for movement of an ion across a membrane is

A. dQ/dt where Q = the charge of the ion and t = time.
B. the Nernst equilibrium potential for that ion.
C. the difference between the membrane potential and the equilibrium potential for the ion.
D. the inverse of resistance.
E. $R_m C_m$.

18. The unidirectional movement of an action potential from the axon hillock to the nerve terminal is due to

A. the unidirectional flow of current in the local circuit.
B. increased axial resistance at the axon hillock.
C. increased diameter at the nerve terminals.
D. the refractory periods of the action potential.
E. the presence of myelin.

19. A current-voltage relationship was obtained for an unknown channel found in a normal cell. After careful analysis you have decided that this is an L-type voltage-gated calcium channel. If this is true then,

A. the current will be zero at a membrane potential of 0 mV.
B. the activation voltage for the channel will be only slightly depolarized from the resting potential.
C. dihydropyridine will not block this channel.
D. the current-voltage relationship is linear.
E. alteration of the extracellular calcium concentration alters the reversal potential of the current as predicted by the Nernst equation.

20. Which of the following is a **TRUE** statement about a myelinated nerve?

A. The entire axon is ensheathed by myelin, although the amount of myelin at the Node of Ranvier is less than in the internodal region.
B. Voltage-gated sodium channels are found at high density underneath the myelin.
C. Myelination is carried out by astrocytes during development of the CNS.
D. The nodal regions contain an equal density of voltage-gated sodium and potassium channels.
E. The node serves as a "recharging zone" for the local circuit current.

21. The effect of myelin on conduction velocity is to

A. increase the internal resistance and, thus, decrease the space constant.
B. decrease the membrane capacitance and, thus, decrease the time constant.
C. increase the membrane capacitance and, thus, decrease the space constant.
D. decrease the membrane resistance and, thus, decrease the time constant.
E. decrease the diameter and, thus, decrease the space constant.

22. The voltage-gated potassium channel in a typical nerve axon membrane

A. is blocked by tetrodotoxin.
B. inactivates on about the same time scale as the voltage-gated sodium channel.
C. demonstrates slower activation kinetics than the voltage-gated sodium channel.
D. has a significantly different threshold of activation.
E. allows potassium to enter the cell down its concentration gradient

23. Calcium entry into a nerve terminal is prevented by removal of calcium from the external medium. The result is

A. increased transmitter release.
B. movement of vesicles to the docking sites at the active zone.
C. inhibition of nerve terminal depolarization by the axonal action potential.
D. complete failure of neuromuscular transmission.
E. increased intracellular sodium concentration due to a decrease in the Ca^{++}/Na^{+} exchange pump.

24. Inhibition of the chloride conductance in a typical skeletal muscle fiber membrane

A. delays the repolarization phase of the skeletal muscle action potential.
B. promotes "electrically silent" muscle contraction.
C. decreases the amplitude of the end plate potential.
D. blocks calcium-mediated release of calcium from the SR.
E. has no effect on the action potential amplitude.

25. In skeletal muscle, ATP is used to

A. activate the actin active site.
B. dissociate the myosin crossbridge from actin.
C. pump calcium out of the SR via calcium-ATPases.
D. increase the binding of troponin to tropomyosin.
E. regulate the fast phase of calcium release from the terminal cisternae.

26. Which of the following characteristics is **NOT** typical of an end plate potential (EPP)?

A. a depolarization that reaches a maximum value approximately 0 mV
B. the interaction of a ligand with a receptor
C. spread of the EPP in an "all or none" fashion down the muscle fiber membrane
D. the opening of one channel
E. passive repolarization

27. Select the **FALSE** statement about calcium-activated calcium release.

A. It is a major component of the slow release phase for calcium during excitation-contraction coupling.
B. It occurs via a direct action of calcium on the DHP voltage sensor in the T-tubule membrane.
C. It allows second messenger-mediated regulation of tension development in skeletal muscle.
D. It is found in all types of muscle.
E. The release process is altered by ryanodine.

28. In myotonic dystrophy such as periodic paralysis, skeletal muscle is unable to fully relax after contraction. Which of the following could produce this effect?

A. decreased accumulation of potassium in the T-tubules during depolarization of the tubule
B. increased membrane conductance of chloride
C. decreased inactivation of the voltage-gated sodium channels located on the membrane
D. decreased inactivation of the voltage-gated calcium channels located on the membrane
E. increased membrane conductance of potassium

29. In McCardle's syndrome, the genetic deletion of phosphorylase A

A. affects only oxidative (red) muscle.
B. results in hyperexcitability of the membrane.
C. promotes creatine phosphate formation.
D. produces contracture without the accompanying electrical signals.
E. increases lactic acid production in white muscle.

30. During isometric contraction of a skeletal muscle, the tension developed during a twitch is

A. greater than that developed during a tetanus.
B. the same as the maximum force generated by that muscle.
C. first used to stretch the series elastic element.
D. first used to shorten the overall muscle length.
E. independent of calcium released from the SR.

31. Select the **FALSE** statement about Type 1 motor units.

A. Type 1 motor units are recruited before Type 2 motor units when the demand for muscle tension increases.
B. Type 1 motor units are composed of small diameter α-motoneurons and very large diameter muscle fibers.
C. Type 1 motor units can sustain contraction for fairly long durations with minimal fatigue
D. Type 1 motor units contain mostly red or oxidative muscle fibers.
E. The myosin ATPase in muscles from Type 1 motor units is slower than that found in Type 2 motor units.

32. The length-tension relationship for skeletal muscle

A. represents the rate of crossbridge cycling.
B. is linear over all muscle lengths.
C. is generated by prestretching the muscle and then initiating an isotonic contraction
D. represents the effect of crossbridge formation on muscle tension
E. is a major mechanism for increasing tension in skeletal muscle.

33. Gap junctions

A. are found only in cardiac muscle.
B. are voltage-gated calcium channels located at the intercalated disk.
C. allow a membrane depolarization to spread from one muscle fiber to another.
D. are selectively permeable to sodium.
E. are characteristic of multi-unit smooth muscle compared to unitary smooth muscle.

34. Which of the following proteins is **NOT** typically found in smooth muscle?

A. troponin
B. actin
C. calmodulin
D. myosin light chain kinase
E. myosin

35. The primary characteristic of sustained (tonic) contraction in smooth muscle is

A. the low utilization of ATP.
B. the dependence on fast release of calcium from the SR.
C. an actin-activated contractile system.
D. the presence of an electrical syncytium.
E. the presence of dense bodies instead of a Z line to anchor the actin filaments.

36. Crossbridge cycling in smooth muscle

A. does not involve the interaction of actin and myosin.
B. is initiated by phosphorylation of myosin.
C. is exactly like skeletal and cardiac muscle.
D. is initiated by the binding of calcium to the myosin light chain kinase.
E. is not dependent on ATP.

37. Select from the following those characteristics which **BEST** describe the autonomic nervous system.

A. involuntary, with long unmyelinated preganglionic and postganglionic fibers
B. involuntary, with multiple branching of preganglionic noradrenergic fibers
C. modulatory, with multiple ganglionic neurotransmitters and receptors
D. sympathetic nerve activation of vascular smooth muscle always results in vasoconstriction
E. activated only in emergency situations, mediates fight-and-flight response

38. Complete the **TRUE** statement. The adrenal medulla

A. is the only place in the body where epinephrine is synthesized.
B. is innervated by postganglionic cholinergic fibers.
C. is a specialized parasympathetic ganglion.
D. secretes catecholamines which elevate blood pressure.
E. is a part of the enteric system.

39. Select the **FALSE** statement.

A. Sympathetic and parasympathetic nerves both innervate vascular smooth muscle but have opposing actions.
B. Sympathetic and parasympathetic neurotransmitters are both inactivated by uptake into the presynaptic neuron.
C. In both motor end plates and autonomic ganglia acetylcholine activates nicotinic receptors.
D. Pupillary dilation can either be mediated by sympathetic activation or parasympathetic inhibition.
E. Blockade of autonomic ganglionic transmission lowers blood pressure.

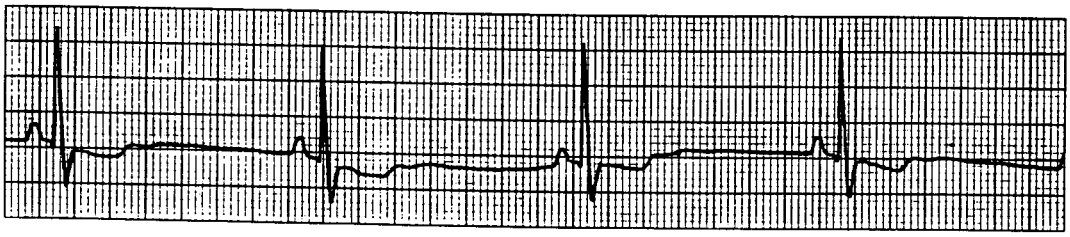
40. Normal repolarization proceeds from

A. epicardium to endocardium.
B. right to left ventricle.
C. ventricles to atria.
D. Purkinje fibers to ventricular apex.
E. AV node to SA node.

41. In the human heart, the normal sequence of activation is

A. atrium, AV node, bundle of His, bundle branches, interventricular septum, ventricular apex, ventricular free walls, ventricular outflow tract.
B. atrium, AV node, bundle of His, bundle branches, interventricular septum, Purkinje fibers, ventricular free walls, ventricular outflow tract, ventricular apex.
C. atrium, AV node, bundle branches, interventricular septum, Purkinje fibers, bundle of His, ventricular free walls, ventricular outflow tract, ventricular apex.
D. atrium, AV node, bundle branches, interventricular septum, Purkinje fibers, ventricular apex, ventricular free walls, ventricular outflow tract, bundle of His.
E. atrium, AV node, bundle of His, bundle branches, interventricular septum, Purkinje fibers, ventricular free walls, ventricular apex, ventricular outflow tract.

42. The following electrocardiogram was recorded from a patient who arrived in the emergency room after feeling faint. What is this person's approximate ventricular rate?



A. 40 bpm
B. 60 bpm
C. 80 bpm
D. 100 bpm
E. 120 bpm

43. The electrocardiogram in the tracing above

A. is normal.
B. shows ventricular tachycardia.
C. shows advanced AV block.
D. shows atrial fibrillation.
E. shows sinus bradycardia.

44. Select the **FALSE** statement about cardiac muscle.

A. It is striated.
B. It is composed of small cells approximately 50 μm long.
C. It contains numerous gap junctions.
D. It has many desmosomes.
E. It uses chemical transmission for intercellular communication.

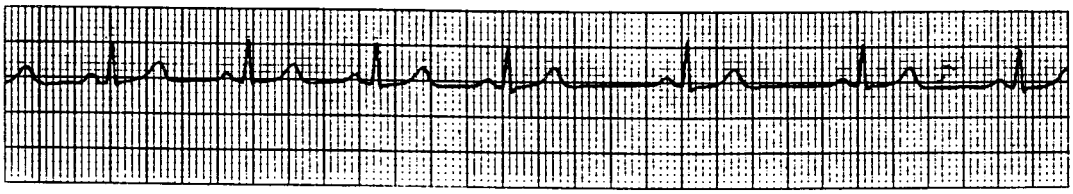
45. During ischemia of cardiac ventricular tissue

A. action potential duration usually becomes longer.
B. sodium permeability usually increases.
C. conduction velocity usually increases.
D. potassium permeability usually increases.
E. resting potential becomes more negative.

46. A positive voltage is usually recorded in the electrocardiogram

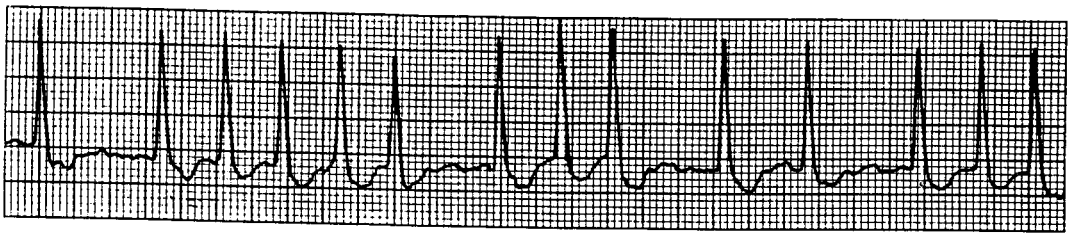
A. during the ventricular action potential plateau.
B. during ventricular repolarization.
C. during the period of ventricular diastole.
D. during SA nodal depolarization.
E. during conduction through the bundle of His.

47. Select the **FALSE** statement about the following electrocardiogram.



A. The rate suggests a tachycardia.
B. The rhythm is supraventricular.
C. The PR interval is normal.
D. The QT interval is normal.
E. There may be a respiration related arrhythmia.

48. The following electrocardiogram shows



A. ventricular bradycardia.
B. a regular rhythm.
C. variation within normal limits.
D. atrial fibrillation.
E. an abnormally short QRS duration.

49. Conduction velocity in the ventricle does **NOT** depend on which of the following?

A. cell size
B. density of myofibrils
C. calcium influx
D. density of intercalated disks
E. sodium influx

50. Contraction in ventricular tissue

A. is controlled by sodium influx.
B. is independent of extracellular calcium.
C. is regulated by changes in potassium conductance.
D. is controlled by the "funny" current.
E. involves calcium-induced calcium release.

51. Which of the following **CANNOT** be determined from the electrocardiogram?

A. the presence of myocardial infarction
B. the presence of ventricular hypertrophy
C. the strength of ventricular contraction
D. the need for a pacemaker
E. the anatomical orientation of the heart

52. Select the **FALSE** statement about the SA node.

A. Early diastolic depolarization involves the "funny" current.
B. The upstroke velocity of the action potential depends on extracellular calcium.
C. Pacemaker activity ceases upon removal of the heart.
D. Potassium ions carry the major outward current.
E. Active sodium channels are sparse.

53. Which one of the following currents does **NOT** play a major role in the <u>normal</u> ventricular action potential?

A. $I_{(K,ATP)}$
B. I_{Ca}
C. I_{Na}
D. I_{K}
E. $I_{Na/Ca}$

54. Arrhythmias may occur during myocardial infarction. Which of the following changes is **LEAST** likely to occur in the ischemic region?

A. conduction blocks
B. shortened action potential duration
C. decreased extracellular calcium
D. depolarized sarcolemma
E. decreased upstroke velocity

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REVISED
HUMAN PHYSIOLOGY
EXAM #1 ANSWERS
FEBRUARY 12, 1996

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