Final Exam – Key (incomplete)

Fill in your scantron form as follows:

- Write and bubble in your name in the upper left (last name first).
- Sign your form in the upper right. By so doing you verify that you are abiding by Creighton’s policy on academic honesty.

Multiple choice: As always, choose the best answer for each multiple-choice question. Answer on your scantron form. Each question is worth 3 points.

1. In class this semester we have talked a lot about the sodium levels, glucose levels, H\(^+\) levels, etc., in the “internal environment.” By this, we mean
   a. the extracellular fluid.
   b. the intracellular fluid.
   c. the urine.
   d. the lumen of the gut.
   e. More than one of the above.

2. Consider two solutions of uncharged particles. Each contains different amount of the solutes X, Y, and Z. If the barrier between the solutions is permeable only to X, which of the following will be true?
   a. X will diffuse across the barrier until the concentration of X on both sides is equal.
   b. X will diffuse across the barrier until the concentration of X on each side equals the concentration of Y and Z on that side.
   c. X will diffuse across the barrier until the concentration of X on each side equals the concentration of Y and Z on the other side.
   d. X will diffuse across the barrier until the total osmolarity on both sides is equal.
   e. X will not diffuse across the barrier.

3. When applied to movement across membranes, the term “active transport” refers specifically to the fact that
   a. channel proteins are involved.
   b. carrier proteins are involved.
   c. cotransport is involved.
   d. there is a cost in energy for the transport.
   e. the movement is driven by osmotic differences.

4. Which of the following gives the correct sequence of events for channel activity during an action potential in an axon?
   a. K\(^+\) channels open, K\(^+\) channels close & Na\(^+\) channels open, Na\(^+\) channels close.
   b. K\(^+\) channels close, K\(^+\) channels open & Na\(^+\) channels close, Na\(^+\) channels open.
   c. Na\(^+\) channels open, Na\(^+\) channels close & K\(^+\) channels open, K\(^+\) channels close.
   d. Na\(^+\) channels close, Na\(^+\) channels open & K\(^+\) channels close, K\(^+\) channels open.
   e. Axons don’t show action potentials.
5. Action potentials propagate faster along myelinated axons than unmyelinated ones because
   a. the insulation provided by the myelin means that depolarizations spread further along the axon.
   b. the myelin is a better electrical conductor than the axon itself.
   c. less time is wasted producing extra action potentials in the myelinated region.
   d. action potentials have a greater amplitude at the nodes of Ranvier.
   e. action potentials last longer at the nodes of Ranvier.

6. If a postsynaptic neuron is said to be showing spatial summation, then you would know for certain that
   a. there are two or more excitatory presynaptic neurons.
   b. there are two or more inhibitory presynaptic neurons.
   c. there are two or more presynaptic neurons of unknown type.
   d. there could be as few as one presynaptic neuron.
   e. None of the above is true.

7. Which of the following best describes sensory adaptation?
   a. Amplification of a weak stimulus by a G-protein system
   b. Two sets of sensors most sensitive to different intensities of a stimulus.
   c. The withdrawal reflex in response to extreme stimuli.
   d. The transduction of sensory information as action potential frequencies.
   e. A change in the response of a sensor to a constant level of stimulation.

8. The semicircular canals provide information on
   a. linear movements.
   b. rotational movements.
   c. air pressure changes.
   d. osmotic concentration.
   e. blood temperature.

9. How does the mammalian ear distinguish different frequencies of sound?
   a. The frequency of action potentials in the afferent neurons is proportional to the rate at which the stereocilia of the hair cells are being moved back and forth.
   b. The frequency of action potentials in the afferent neurons is proportional to the magnitude of movement of the stereocilia.
   c. Hair cells with different lengths of stereocilia respond to different frequencies.
   d. The vestibular and basilar membranes in different regions of the cochlea vibrate most strongly in response to different frequencies of sound.
   e. The mammalian ear cannot distinguish different frequencies.
10. The molecule in rod photoreceptors that changes conformation when struck by a photon is
   a. cyclic GMP.
   b. opsin.
   c. phosphodiesterase.
   d. retinal.
   e. transducin.

11. An autocrine agent is a chemical messenger that
   a. activates receptors on the cell that released it.
   b. diffuses to nearby cells and potentially activates receptors on those.
   c. travels through the bloodstream and potentially activates receptors on cells throughout the body.
   d. is associated with the immune system.
   e. is associated with the reproductive system.

12. Which of the following shows the correct sequence in the chain of hormones associated with the stress response?
   a. Adrenocorticotropic hormone → cortisol → corticotropin releasing hormone
   b. Corticotropin releasing hormone → adrenocorticotropic hormone → cortisol
   c. Cortisol → corticotropin releasing hormone → adrenocorticotropic hormone
   d. Adrenocorticotropic hormone → corticotropin releasing hormone → cortisol
   e. Corticotropin releasing hormone → cortisol → adrenocorticotropic hormone

13. Given what you know about thyroid hormones, which of the following is the most likely mechanism by which they help increase Na\(^+/\)K\(^-\)-ATPase activity?
   a. The hormones bind to and activate Na\(^+/\)K\(^-\)-ATPases already present in the cell membrane.
   b. The hormones activate G-protein complexes that directly activate Na\(^+/\)K\(^-\)-ATPases already present in the cell membrane.
   c. The hormones activate G-protein complexes that activate secondary messengers that activate Na\(^+/\)K\(^-\)-ATPases already present in the cell membrane.
   d. The hormones activate G-protein complexes that activate secondary messengers that promote the insertion of stored Na\(^+/\)K\(^-\)-ATPase into the cell membrane.
   e. The hormones cause the increased production of mRNA for Na\(^+/\)K\(^-\)-ATPase, which leads to the production and insertion of additional ATPase.

14. Levels of growth hormone peak during
   a. childhood.
   b. puberty.
   c. early adulthood.
   d. middle age.
   e. old age.
15. Which of the following molecules produces the force that muscles exhibit when they contract?
   a. Actin
   b. Myosin
   c. Tropomyosin
   d. Troponin
   e. DNA

16. A sarcomere produces the maximum amount of force when it is
   a. as short as it can get.
   b. as long as it can get.
   c. at an intermediate length.
   d. Any other possible answers?
   e. Nope, that’s it.

17. A substance that poisoned the Ca$^{2+}$ reuptake transporters in the SR might be expected to produce which of the following results the first time the muscle was stimulated?
   a. The muscle could not contract at all.
   b. Contraction would be delayed.
   c. Contraction would be weaker than normal.
   d. Contraction would last longer than normal.
   e. The muscle would show multiple twitch contractions.

18. Electrical signals are spread through the muscle of the heart via
   a. neurons that connect to each cell.
   b. gap junctions between myocardial cells.
   c. neurotransmitters.
   d. the nodes of Ranvier.
   e. prostaglandins.

19. During the heartbeat cycle, the atrioventricular valves close when
   a. atrial pressure exceeds ventricular pressure due to atrial filling.
   b. atrial pressure exceeds ventricular pressure due to atrial contraction.
   c. ventricular pressure exceeds atrial pressure due to ventricular filling.
   d. ventricular pressure exceeds atrial pressure due to ventricular contraction.
   e. Open 24 hours – we never close!
20. If you become overheated (say, from sitting out in the sun too long), which of the following patterns would you most likely see?
   a. Cutaneous vasodilation would tend to cause mean arterial pressure to drop, and cardiac output would increase to compensate.
   b. Cutaneous vasodilation would tend to cause mean arterial pressure to increase, and cardiac output would decrease to compensate.
   c. Cutaneous vasodilation would tend to cause mean arterial pressure to increase, and cardiac output would increase to compensate.
   d. Cutaneous vasoconstriction would tend to cause mean arterial pressure to drop, and cardiac output would increase to compensate.
   e. Cutaneous vasoconstriction would tend to cause mean arterial pressure to increase, and cardiac output would decrease to compensate.

21. Ions generally enter and leave the capillaries via
   a. diffusion through the capillary pores.
   b. simple diffusion across the endothelial membranes.
   c. active transport across the endothelial membranes.
   d. transcytosis across the endothelial membranes.
   e. Ions do not move in and out of capillaries.

22. Consider a child with an anatomical dead space of 100 ml taking breaths of tidal volume 300 ml at a rate of 15 breaths/min. Her alveolar ventilation rate would be
   a. 1500 ml/min.
   b. 3000 ml/min.
   c. 4500 ml/min.
   d. 6000 ml/min.
   e. 7500 ml/min.

23. Which of the following best describes the normal ventilatory response to an increase in arterial $P_{CO_2}$ of 5 torr?
   a. Ventilation will roughly halve.
   b. Ventilation will decrease by a small amount.
   c. Ventilation will increase by a small amount.
   d. *Ventilation will roughly double.*
   e. If you make me answer this question, I’ll hold my breath until I turn blue!

24. Enzymes responsible for digesting proteins in food are produced by
   a. the stomach.
   b. the pancreas.
   c. the small intestine.
   d. *Two of the above.*
   e. All of the above.
25. Increased secretion of secretin is most strongly associated with
   a. the presence of food in the stomach.
   b. a decrease in pH in the stomach.
   c. a decrease in pH in the small intestine.
   d. the presence of fat and proteins in the small intestine.
   e. the presence of carbohydrates in the small intestine.

26. Most of the water that enters the GI tract comes from
   a. food.
   b. water/drink.
   c. saliva.
   d. secretions into the small intestine.
   e. secretions into the large intestine.

27. Which of the following does not affect glomerular filtration rate?
   a. Changing shape of the podocytes covering the glomerulus.
   b. Contraction of Bowman’s capsule to increase pressure in the nephron.
   c. Release of paracrine agents by the macula densa.
   d. Myogenic regulation by the afferent arterioles.
   e. All of these affect glomerular filtration rate.

28. Without the countercurrent multiplier activity of the loop of Henle, we would be unable to
   a. generate any glomerular pressure.
   b. reabsorb any Na\(^+\) in the nephron.
   c. excrete any urea.
   d. create a hyperosmotic urine.
   e. transport any urine to the bladder.

29. Which of the following is not directly associated with increased release of anti-diuretic hormone?
   a. Low arterial blood pressure
   b. High blood osmolarity
   c. Low sodium levels in the urine
   d. Two of the above are not directly associated with increased ADH release.
   e. None of the above are directly associated with increased ADH release.
30. Respiratory acidosis arises when
   a. Hypoventilation leads to CO₂ reduction in the bloodstream, which leads to increased formation of H⁺ ions.
   b. *Hypoventilation leads to CO₂ buildup in the bloodstream, which leads to increased formation of H⁺ ions.*
   c. Hyperventilation leads to CO₂ reduction in the bloodstream, which leads to increased formation of H⁺ ions.
   d. Hyperventilation leads to CO₂ buildup in the bloodstream, which leads to increased formation of H⁺ ions.
   e. Hyperventilation leads to CO₂ reduction in the bloodstream, which leads to a loss of H⁻ ions.

31. Which of the following secondary sexual characteristics of women is promoted by androgens?
   a. Final development of the external genitalia
   b. Development of the breasts
   c. Growth of wider hips and narrower shoulders
   d. *The growth of pubic and axillary hair*
   e. The beginning of menstruation (menarche)

32. The last time an oogonium becomes a primary oocyte in a woman’s life is
   a. *before she is born.*
   b. during pre-pubescent childhood.
   c. during puberty.
   d. right before menopause.
   e. right before death.

33. Which of the following statements about estrogen production is most correct?
   a. Estrogen is made and released by the granulosa cells.
   b. Estrogen is made and released by the theca cells.
   c. Androgens are made by the granulosa cells and converted into estrogen by the theca cells.
   d. *Androgens are made by the theca cells and converted into estrogen by the granulosa cells.*
   e. Estrogen is made only by the corpus luteum.

34. Menstruation results directly from the decrease in levels of
   a. estrogen.
   b. luteinizing hormone.
   c. progesterone.
   d. *Two of the above.*
   e. All of the above.
35. During the first three months of pregnancy in humans, levels of estrogen and progesterone stay high due to
   a. continued high levels of follicle-stimulating hormone in the mother sustaining the corpus luteum.
   b. continued high levels of luteinizing hormone in the mother sustaining the corpus luteum.
   c. release of chorionic gonadotropin by the fetus/placenta sustaining the corpus luteum.
   d. release of estrogen and progesterone by the fetus/placenta into the mother’s blood.
   e. High levels of estrogen and progesterone do not occur during pregnancy.

36. The primary hormone involved in triggering uterine contractions during birth is
   a. chorionic gonadotropin.
   b. estrogen.
   c. oxytocin.
   d. progesterone.
   e. prolactin.

37. Interferon helps combat viral infections by
   a. digesting the protein coat of live viruses.
   b. serving as a decoy attachment site for viruses.
   c. preventing viruses from binding to cells.
   d. preventing viruses from injecting RNA into cells.
   e. shutting down the protein synthesis pathways used to make additional viruses.

38. Helper T cells are activated by
   a. encountering a receptor-matching foreign antigen floating in the ECF.
   b. encountering an infected body cell presenting a matching antigen bound to class I MHC.
   c. encountering a leukocyte presenting a matching antigen bound to class II MHC.
   d. encountering a matching antibody floating in the ECF.
   e. encountering a matching activated cytotoxic T cell.

39. The activation of cytotoxic T cells generally requires the presence of
   a. histamine.
   b. interleukin-1.
   c. interleukin-2.
   d. tumor necrosis factor.
   e. All of the above.
40. Antibodies binding to antigens results in all of the following except
   a. activation of apoptosis (programmed cell death) of infected cells.
   b. activation of components of the complement system.
   c. agglutination by sticking together clumps of antigen.
   d. neutralization by preventing the pathogen from being able to contact cells.
   e. opsonization of antigens to make them more attractive to phagocytes.

41. Which of the following cells may be involved in a secondary immune response?
   a. Memory helper T cells
   b. Memory cytotoxic T cells
   c. Memory B cells
   d. Two of the above
   e. All of the above

Note that there are 41 multiple choice questions on the exam, with the extra question providing the potential for an additional 3 points on your score. (The percentage score for the exam will still be calculated based on a 200 point total.)
Short answer: Write a concise answer to each of the following questions. Your answers should fit in the spaces provided. Diagrams may be used but must be accompanied by sufficient explanation to make the components clear. Each question is worth 8 points.

42. A new regulatory pathway for blood bromine levels is discovered. Answer the following questions based on this pathway, shown below.

![Pathway Diagram]

a. (For this question, pretend the parts of the pathway outside the dotted lines do not exist.) Is this a negative feedback loop, a positive feedback loop, or some other system? Explain your reasoning.

_This is a negative feedback loop, because a change in the level of a variable brings about responses that change the variable in the opposite direction._

b. (Again, pretend the parts of the pathway outside the dotted lines do not exist.) In the context of the answer you chose in a above, what role appears to be served by:

- The Reedy gland: _Some combination of sensor, afferent pathway, setpoint and integrating center._
- Reedy hormone: _Efferent pathway_
- The GI tract: _Effector_

- Shibata Gland: _Some combination of sensor, afferent pathway, setpoint and integrating center._
- Shibata hormone: _Efferent pathway_

- Kidney:
  - ↑ Br⁻ secretion
  - ↓ Br⁻ uptake

_c. (For this question, consider the entire pathway.) If a person with high blood Br⁻ levels is not secreting as much Br⁻ as he should be, what might be the possible causes in terms of hypo- or hyper-secretion of hormones, or hypo- or hyper-responsiveness? You do not have any information on the rate of Br⁻ uptake in the GI tract._

_There could be a problem with hyposecretion of either Reedy hormone or Shibata hormone, or hyporesponsiveness of the Shibata gland to Reedy hormone or the kidney to Shibata hormone._
43. Describe the process by which an AP arriving at a presynaptic neuron triggers a change in membrane potential in the postsynaptic neuron. Assume that ionotropic receptors are involved.

An action potential arriving at the presynaptic axon terminal changes the membrane potential, triggering the opening of voltage-gated Ca\(^{2+}\) channels. The resulting influx of Ca\(^{2+}\) releases the synaptic vesicles from the cytoskeleton, allowing them to attach to docking proteins and release the neurotransmitter they contain into the synaptic cleft. The neurotransmitter then diffuses across the cleft and binds to ionotropic receptors (ligand-gated ion channels) in the postsynaptic neural membrane. The opening or closing of channels that results will change the membrane potential. (This process ends as the neurotransmitter concentration goes down, due to diffusion, reuptake and/or enzymatic breakdown.)

44. Answer the following questions about the function of muscles.

a. Why does it take a muscle longer to begin shortening when lifting a heavy load than a light load, even when all fibers are stimulated in both cases?

Force production by a muscle increases over time before reaching its maximum value. A muscle cannot lift a load until the force produced exceeds the weight, and this will occur sooner for light loads than heavy loads.

b. How is the force production of a whole muscle controlled, so that the force exerted matches the force needed?

Whole muscles can produce different amounts of force through the activation, or recruitment, of different numbers and types of motor units. Each motor unit consists of all the muscle fibers innervated by a single motor neuron, and thus all these fibers must be activated at once. To lift a light load, a smaller number of motor units with fewer fibers can be activated. As the needed force increases, more and bigger motor units are recruited, until maximum force is produced when all motor units are active.
45. If a particular organ or tissue increases its oxygen consumption, what mechanisms help provide this additional oxygen? This question requires you to integrate ideas about both cardiovascular physiology and gas transport to provide a complete response. You can provide your answer in the form of a list.

At the level of the organ, increased oxygen can be delivered by a) moving more blood per minute through the organ, and b) extracting more $O_2$ per ml of blood. Increased flow normally depends on vasodilation in the organ – arteriole diameter will be increased. Increased extraction of oxygen happens to some degree automatically, because as tissues use more $O_2$, $P_{O_2}$ tends to drop, which causes more $O_2$ to unload from hemoglobin. Also, various changes associated with increased oxygen use tend to cause a right-shift in the oxygen saturation curve, which causes even greater unloading of $O_2$ at a given $P_{O_2}$. (If the increase in oxygen use by the organ is more than minimal, ventilation rates will have to increase to bring more $O_2$ per minute into the alveoli for loading the hemoglobin at the lungs.)

46. The following questions relate to ventilation:

a. Indicate the muscle(s) and/or forces that bring about

A resting inhalation: **Contraction of the diaphragm**

A resting exhalation: **After relaxation of the diaphragm, elastic forces in the lung result in exhalation.**

A deep, rapid inhalation: **The primary muscles involved are the diaphragm and the external intercostals.**

A full, rapid exhalation: **The internal intercostals (and to some extent the abdominals)**

b. Describe the change in pressure than occurs in the following spaces qualitatively (meaning you don’t have to give me exact numbers, just the general patterns) during a ventilation cycle.

Intrapleural fluid: **Intrapleural pressure starts negative when at rest after an exhalation, becomes progressively more negative during an inhalation, then less negative as exhalation occurs, returning to its original value.**

Alveoli: **The alveolar pressure starts at zero when at rest after an exhalation, becomes slightly negative as inhalation proceeds, then drops back to zero at the end of inhalation. During exhalation, it becomes positive, then returns to zero once exhalation ends.**