Human Physiology
Study Questions-2

Action potentials: Handout-8, Chapter 8

1. Explain the positive feedback component of an action potential—that is, how the opening of one voltage-gated sodium (or calcium) ion channel can lead to the opening of an adjacent sodium (or calcium) voltage-gated ion channel.

2. In a “classic” neuron, what types of ion channels are present and where are they located.

3. Go through the steps through which a stimulus at one end of a neuron can lead to the release of neurotransmitter at the other end?

4. Explain how, after firing, a nerve cell quickly resets to fire again. Furthermore, explain why a typical nerve cell can fire (an action potential) thousands of times after inactivation of its sodium-potassium pumps.

5. Explain how membranes leaky to sodium ions or calcium ions can result in a rhythmic production of an action potential. (Note: This question was not covered in class so just think about it.)

Nervous Pathway Basics: Handout-9, Chapter 8

1. What is a ganglion? From what you know so far, what type of neuron fits each of the below descriptions: carries signals into a ganglion from some other part of the body, is located within a ganglion, carries signals out of a ganglion to some other body part (commonly a skeletal muscle).

2. Arrange three neurons and one muscle fiber into an integrative nervous pathway. Don’t just look at, but play with different patterns of stimulation of the integrative figures (pages 4 and 5 of handout) to make sure you understand the logic of integrative nervous pathways. Also (although it was not discussed in class), make sure you understand the idea of temporal summation (Figure 8-27 3rd edition, 8-28 4th edition, 8-28 5th edition).

3. Know the following things about direct (fast) transmission (include the skeletal neuromuscular junction in your answers):
   • What is it?
   • What types of neurotransmitters are involved and where are they released?
   • What combinations of neurotransmitters and their receptors are stimulatory and which are inhibitory?
   • What are the different ways that transmission is turned off at the synapse?

4. Explain the statement: The effect of opening sodium ion channels is stimulatory, while the effect of opening potassium or chloride ion channels is inhibitory.

5. Arrange one neuron and one muscle fiber into a reflexive pathway. Next arrange two neurons and one muscle fiber into a simple reflexive nervous pathway through a ganglion. Then do the same thing for four neurons and two muscle fibers (from antagonistic muscles). Discuss the logic behind one branch of the sensory neuron’s axon directly innervating a motor neuron, and the other branch innervating an interneuron.

6. Make sure you understand the answers to all the questions on page 8 of this handout.

7. Know the following things about indirect transmission:
   • What is the difference between direct and indirect transmission
   • What are some potential advantages associated with indirect transmission?

8. What is the difference between transmission and modulation? Think about how modulation of a nervous system would ever be advantageous to the organism.
9. Use what was discussed in class to build some general scenarios as to how modulation could work.

10. Explain the connection between the following statement and the fact the bioamines commonly act as neuromodulators: Neurons that produce bioamines are found in only a few areas, mostly in the brain stem, but the axons of these cells extend to widespread areas throughout the brain.

11. What are some differences between neuropeptides and smaller molecules (either neuromodulators or neurotransmitters) released from axon terminals in terms of site of synthesis, recycling, effects, etc.?

12. Why does it make sense that steroid hormones more commonly act as modulators than water-soluble hormones?

13. What is retrograde signaling? What is it about endocannabinoids that makes retrograde signaling possible? What aspect of the general way the endocannabinoids seem to work seems unexpected given that these are lipid soluble molecules?

14. How might the capacity to learn benefit an organism? Explain the statement: Learning involves synaptic plasticity.

15. How are NMDA receptors different than AMPA glutamate receptors? Understand the basic scheme by which activation of NMDA receptors can lead to LTP.

16. What are some differences between early phase and late phase LTP.

17. Understand how LTP could be used to generate the type of learning known as classical conditioning.

**Mostly skeletal and some smooth muscle: Handout-10, Chapter 12**

1. What types of ion channels are located along the outer membrane of skeletal muscles (including the t-tubules) and where are these different ion channels located?

2. Understand the basic details by which myosin, through catalyzing the hydrolysis of ATP, leads to the contraction of an entire skeletal muscle fiber. (Note: Understanding the general anatomy of a muscle fiber will be needed to answer this question.)

3. A few questions about the movement of calcium ions into and out of a muscle fiber’s sarcoplasmic reticulum:
   a. Go through the steps through which an action potential moving down a motor neuron leads to the movement of calcium ions out of a muscle fiber’s sarcoplasmic reticulum?
   b. How does the movement of calcium ions out of the sarcoplasmic reticulum lead to contraction of the muscle fiber?
   c. How are calcium ions moved back into the sarcoplasmic reticulum?

4. Use the functional tradeoffs between large diameter and small diameter muscle fibers, between glycogen-lactic acid system and aerobic respiration, and between fast and slow isoforms of myosin, to explain the differences between the three types of muscle fibers outlined in Table 12-2, 5th edition (also found on the first page of the skeletal muscle (continued) handout).

5. Generate a list of ways that smooth muscles are similar to skeletal muscles. Generate a list of ways that smooth muscles are different than skeletal muscles.
1. Some questions about the development of the nervous system:

   a. How is the neural tube and neural crest tissue initially formed?
   b. How are neural crest tissue and the neural tube involved in the formation of sensory neurons, interneurons, motor neurons, preganglionic neurons, and postganglionic neurons?
   c. What is the difference between gray matter and white matter?
   d. Understand the basic organization of the gray matter within the spinal cord. For example, you should understand what regions are innervated by somatic sensory neurons (somatic afferent), visceral sensory neurons (visceral afferent), visceral preganglionic neurons (visceral efferent), and somatic motor neurons (somatic efferent).
   e. The rostral end of the neural tube develops into something that we call a brain. Through cell migration, gray matter in the brain region migrates into nuclei, and cortices (plural of cortex). What distinguishes cortices and nuclei from the gray matter organization found in the spinal cord?
   f. What are the three cortices in your brain? Which of these cortices is most highly expanded in us?

2. Explain in what sense the organization of the nervous system is segmental.

3. Discuss the basic neurological organization of a protective reflex (such as a withdrawal reflex).

4. What are some differences between the two forms of stretch receptors found in skeletal muscles? What is the functional significance of muscle spindles containing a contractible part (intrafusal fibers)?

5. What are some differences and similarities between a muscle spindle reflex and a golgi tendon reflex?

6. Explain how a nerve impulse moving down a gamma motor neuron can lead to contraction of the surrounding muscle?

7. Explain this statement: Brain nuclei innervated by sensory neurons coming from the skin can be thought of as being part of the spinal cord for the head.

8. Provide a simple explanation as to how a central pattern generator could produce the swimming motion of a fish? What types of motor outputs in you are likely controlled by central pattern generators?

9. How might putting a brain in charge of regulating—turning up or down—central pattern generators be advantageous to an organism?

10. Explain the basic means by which a brain can by-pass spinal cord generated reflexes and generate new patterns of motion.

11. Explain why it is impossible to be truly placed in a sensory deprivation chamber, and how that applies to creating a sense of “me-ness” or self.

12. In the spinal cord, sensory input is closely associated with motor output (in fact at times sensory neurons directly innervate motor neurons). Is this also true with special senses? Which are the so-called special senses associated with the head? Why can some of these be considered distance senses?

13. Explain this statement: The brain is a place where past sensory inputs and current sensory inputs can be integrated together to make decisions about the current course of behavior.

14. Explain the connection between the ability to generate plans and voluntary motion.

15. Why is the optic tectum (superior colliculus, midbrain roof) easy to see in a fish brain but hidden in your brain?

16. Know some basic brain anatomy, such as: frontal lobe, parietal lobe, occipital lobe, temporal lobe, cerebellum, thalamus, medulla, as well as other regions that we discuss in class.
1. Explain the distinction between a sense that starts with a sensory neuron, and one that starts with a specialized receptor cell. Provide some examples of each.

2. Explain the distinction between sense and subjective sense. Distinguish, within the subjective senses of vision, hearing, and smell, what is “real” and what is “subjective”. Comment on what, if anything, are subjective senses good for?

3. Must a sense become a subjective sense before it can initiate a motor response? Explain.

4. Use your understanding of subjective sense to answer the question: If a tree falls in the woods and there is nothing to hear it (no creature with the subjective sense of hearing is around) does it make a sound?

5. Taste buds are able to sense glucose, sodium ions, hydrogen ions, some alkaloids and glutamate. Suggest a benefit to monitoring each of these at the entrance to the digestive tract.

6. How many types of sensors are associated with the subjective senses of discriminative touch, hearing, smell, and vision?

7. I broke the conversion of sense to subjective sense into three basic steps: (1) focusing the external “image” on a 2-dimensional (or 1-dimensional) neural field, (2) through so called “parallel processing”, breaking the various aspects of the image into a topographic representation within the CNS, and (3) reassembling the image into a mental image.
   a. Explain how the first step occurs in discriminative touch, hearing, vision, and smell.
   b. Provide a basic explanation as to how the second step is accomplished in discriminative touch, vision, and hearing.
   c. Without knowing how it actually occurs, why would it make sense that convergent neural pathways play a role in constructing mental images?

8. Speculate as to how you could develop a taste aversion for some food item that is not harmful to you.

9. Explain how it might be possible for a deaf person to respond to the location of a sound? Will this be true for all deaf people? Explain

10. What types of stimuli could result in the orientation of one’s head toward the source of the stimulus? Explain.

Subjective sense: sensation, Handout-14, Chapter 10

1. Why should both images (e.g., I see red), and feelings (e.g., I feel hungry) be considered subjective senses?

2. What are some basic ways that feelings are are different than images? How is the biological role played by feelings different than images?

3. Explain why waiting until you are hypothermic is the wrong time to feel cold. Then relate your answer back to the concept of dissonance.

4. How might the insular cortexes, and spindle neurons play a role in the generation of feelings?

5. Explain how feeling confident or anxious can be a fundamentally different types of emotions than feeling cold or thirsty. How can feelings of confidence or anxious be biologically important. Also, might there be problems with feeling too much confidence and not enough anxiety, or vice versa?
6. In simplistic terms, how might changing levels of the wide spread neuromodulators serotonin, dopamine, and norepinephrine play a role in how we make decisions.

7. Explain why taking a shower in the morning can help you to wake up.

8. A too-involved-in-work physiologist made a valentine card containing the line: “My vasopressin levels are rising over you!” Explain this line. Further explain how this is an extrapolation from what has been demonstrated in another species of mammal—specifically, prairie voles. What sex is the physiologist? How would the line need to change if the physiologist was the opposite sex?

The connection between image and sensation: Handout-15. (see syllabus for relevant pgs.)

1. Why would it make biological sense for both images and feelings to interact in the formation of memories? (Why wouldn’t it make sense to remember everything that enters into consciousness?) How might the hippocampus be involved in this interaction?

2. Our thalamus and amygdala are connected by three pathways: a direct connection, and one that goes first to the cortex and then to the amygdala, one that goes to the cortex through the hippocampus and then to the amygdala. What might be the advantage of having all three of these pathways?

Descending tracts, Cerebellum, and Cerebral cortex: Handout-16, 17, & 18, (see syllabus for relevant pgs.)

1. Explain how the position of a descending motor tract (e.g., medial versus lateral) is related to the position of the muscles effected. Explain why the following is a false statement: Neurons in descending motor tracts originate somewhere in the brain and then their axons extend all the way to various skeletal muscles.

2. The vestibular nucleus receives inputs from the vestibular apparatus and the cerebellum, and has outputs that descend down the spinal cord (the vestibulospinal tract). What sort of activities would you suspect that these inputs and outputs are involved in controlling? Explain.

3. Explain the statement: The corticospinal tract makes it possible to by-pass cord patterns and create new patterns of motion. Provide a nervous system explanation as to why someone cannot play the piano with his or her toes (at least not very well).

4. This same physiologist from an above question decided to turn his word wizardry towards writing song lyrics. In that realm, he wrote a song entitled: “I am going to dance with my Sara Bellum”. Should this song have a slow or fast tempo? Explain. How might the physiologist’s cerebellum help him as he practiced playing the song on the piano? dancing with the song? (Note: Be sure to include the role that mossy fibers, deep cerebellar nuclei, inferior olive nuclei, climbing fibers, parallel fibers, and Purkinje cells, play in answering the above question.)

5. The axons carrying proprioceptive information from the body to the cerebellum (the ascending spinocerebellar tracts) conduct actions potential at the fastest recorded rate. Why does this observation make sense?

6. Know a general map of the functional areas of cerebral cortex, and some ways that the two sides of the cortex functionally differ. Speculate as to the advantage of having our “cerebral twins” create at least somewhat distinct perspectives of the world.