

Neuqua Valley Anatomy&Physiology Test

A note to graders: This being a free response test, you will need to take some liberties with the key to this test. Use your best judgement as to if an answer is valid or not. It is highly recommended that the grader of this test have experience with anatomy or biology. Please refer any questions, inaccuracies, or concerns to akabose11@gmail.com.

1) Action potentials

- a) The neuron at resting potential has a high intracellular concentration of one cation and a high extracellular concentration of another. What are they?

Intracellular: Potassium or K^+ (+1), Extracellular: Sodium or Na^+ (+1)

- b) What is the absolute value of the voltage across the ideal resting neuronal membrane?

70mV (+1)

- c) What is meant by the depolarization of a neuronal membrane?

When sodium channels in the cell membrane open, they cause an influx of Na^+ ions, decreasing the voltage across the membrane, which is known as depolarization.

+2 for explaining the role of sodium channels and voltage change

- d) When enough depolarization occurs to cause a certain voltage change at the axon hillock, what channels open? What is the name for the event that happens? How does this event progress through the axon?

When the axon hillock is depolarized significantly, voltage gated sodium channels open, causing depolarization. The event that happens in the axon is known as an action potential, and it progresses through a neuron by voltage changes opening more sodium channels, which cause voltage change further in the axon, which opens more voltage changes, and so on and so on.

+2 for axon hillock depolarization

+1 for naming as action potential

+3 for correct explanation of propagation

- e) When the event that occurs reaches the end of the axon, what chemicals are released? Where are they released?

Neurotransmitters are released into the synapse/synaptic cleft

+1 for neurotransmitters

+1 for synapse or synaptic cleft.

- 2) Wires are covered in insulation in order to prevent current loss. What is the analogue to this in the nervous system? What types of cells make it up? What makes it different than wire insulation?

Axons are often covered in myelin, a fatty substance which is produced by Schwann cells in the PNS and oligodendrocytes in the CNS, which acts as wire insulation. There are gaps in this insulation, known as nodes of Ranvier, which have voltage-gated ion channels that regenerate the action potential.

+1 for identifying myelin

+1 for mentioning Schwann cells in PNS

+1 for mentioning oligodendrocytes in CNS

+2 for identifying and describing function of Nodes of Ranvier

a) What disease can autoimmune destruction of these cells cause?

Multiple sclerosis (+2)

3) A heart attack is often prefaced by shoulder pain. Explain why the pain is at the shoulder.

Visceral pain fibers from the heart and pain fibers from the shoulder enter the same thoracic segment. Through the phenomenon of referred pain, tissue damage at the heart due to heart attacks is perceived as shoulder pain.

+1 for mentioning referred pain

+2 for explaining it

4) Divisions of the Nervous System

a) What are the two main divisions of the nervous system?

Central nervous system and peripheral nervous system +1

b) One of the above has two more divisions. Name them and discuss their function.

Somatic nervous system: Controls voluntary muscle movement and carries sensory information

Autonomic nervous system: Controls automatic, involuntary actions like heart rate

+1 for each correct identification

+1 for each correct function

+4 total

c) One of the above has two more divisions. Name them and discuss their function.

Sympathetic nervous system: Stimulates the fight-or-flight response during stress

Parasympathetic nervous system: Controls bodily actions during times of rest, such as feeding and sexual reproduction.

+1 for each correct identification

+1 for each correct function

+4 total

5)

a) Describe the physiology behind the absolute and relative refractory period following neuronal depolarization.

During the absolute refractory period, voltage gated sodium channels remain locked in an inactive configuration, causing a repolarization of the membrane. During the relative refractory period, the opening of potassium channels causes a hyperpolarization under the resting potential.

+1 for inactive configuration causing repolarization

+1 for hyperpolarization during relative refractory period.

b) Describe an evolutionary advantage for this.

The locking of sodium channels and the subsequent hyperpolarization of the membrane prevents two action potentials happening one after the other, applying a limit on the rate of action potentials in an axon.

+2 for something to this effect.

6) In 1953, Henry Molaison underwent a lobotomy that removed portions of his medial temporal lobes to mitigate his epilepsy. Speculate as to the possible effect this could have had on his memory.

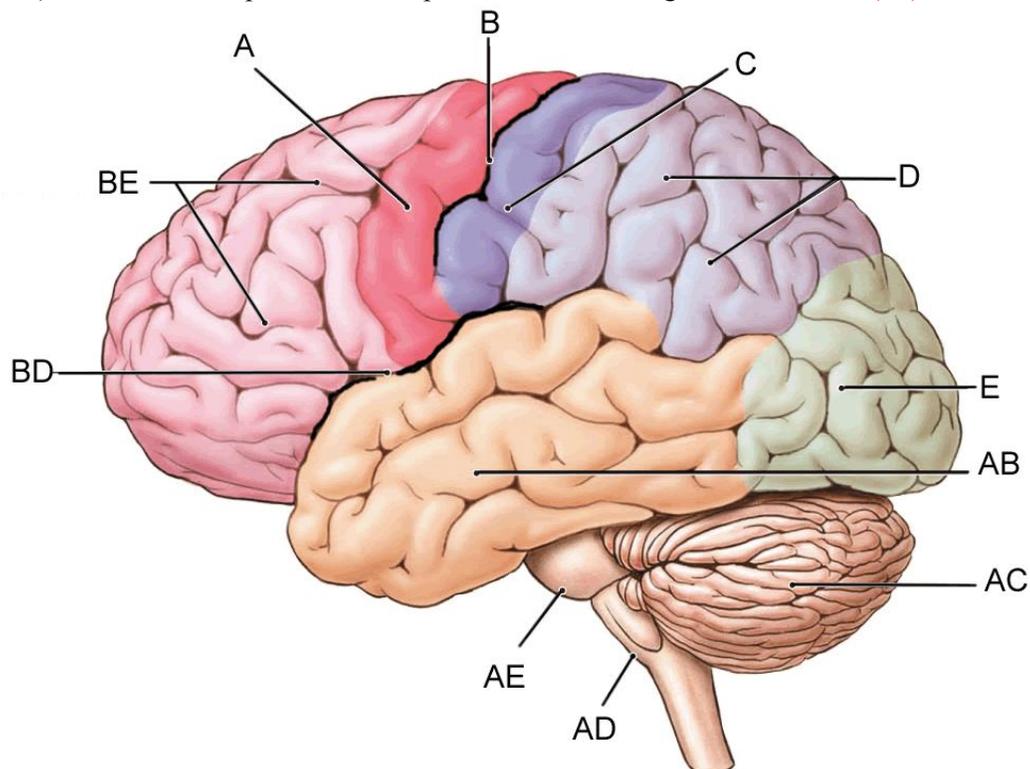
The lobotomy removed portions of the hippocampus, which disabled Molaison's ability to form new long term memories. He suffered from anterograde amnesia.

+1 for mentioning hippocampus

+2 for mentioning inability to form new long term memory

+1 for naming disorder as anterograde amnesia

a) What letters represent the temporal lobe on the diagram below? AB (+2)



7) Under which meningeal layer is most cerebrospinal fluid located?

Arachnoid mater (+2)

8) Describe the location and function of the general interpretive area of the cortex.

The general interpretive area of the cortex is located between the temporal, occipital, and parietal lobes. It integrates sensory information to allow for complex thought processing, for example, the understanding and usage of words

+1 for location

+2 for integrating sensory information

+1 for role in word understanding and usage

9) I poke you in the left arm with a pencil.

- a) What are the two types of fibers that carry pain, and what are the differences in their myelination? How do these differences account for different types of pain caused by an injury?

Pain is carried by A-delta fibers, which are myelinated, and C-fibers, which are unmyelinated. Functionally, this means that A-delta fibers carry fast, acute, localized pain, while C-fibers carry pain that is slow, diffuse, and lasts for a long time.

+2 for two types of fibers

+2 for differences in myelination

+2 for differences in pain felt

- a) What type of spinal tract does information regarding the pain go through to get to the brain?

Anterior spinothalamic tract/Ventral Spinothalamic fasciculus

+1 for anterior/ventral

+2 for spinothalamic

+3 total

- a) What area of the diencephalon will the information be transmitted to?

Thalamus (+1)

- i) Draw a circle on that part of the brain below (need not cover whole part)

- b) What cortical area is responsible for the sensation of pain? Be specific!

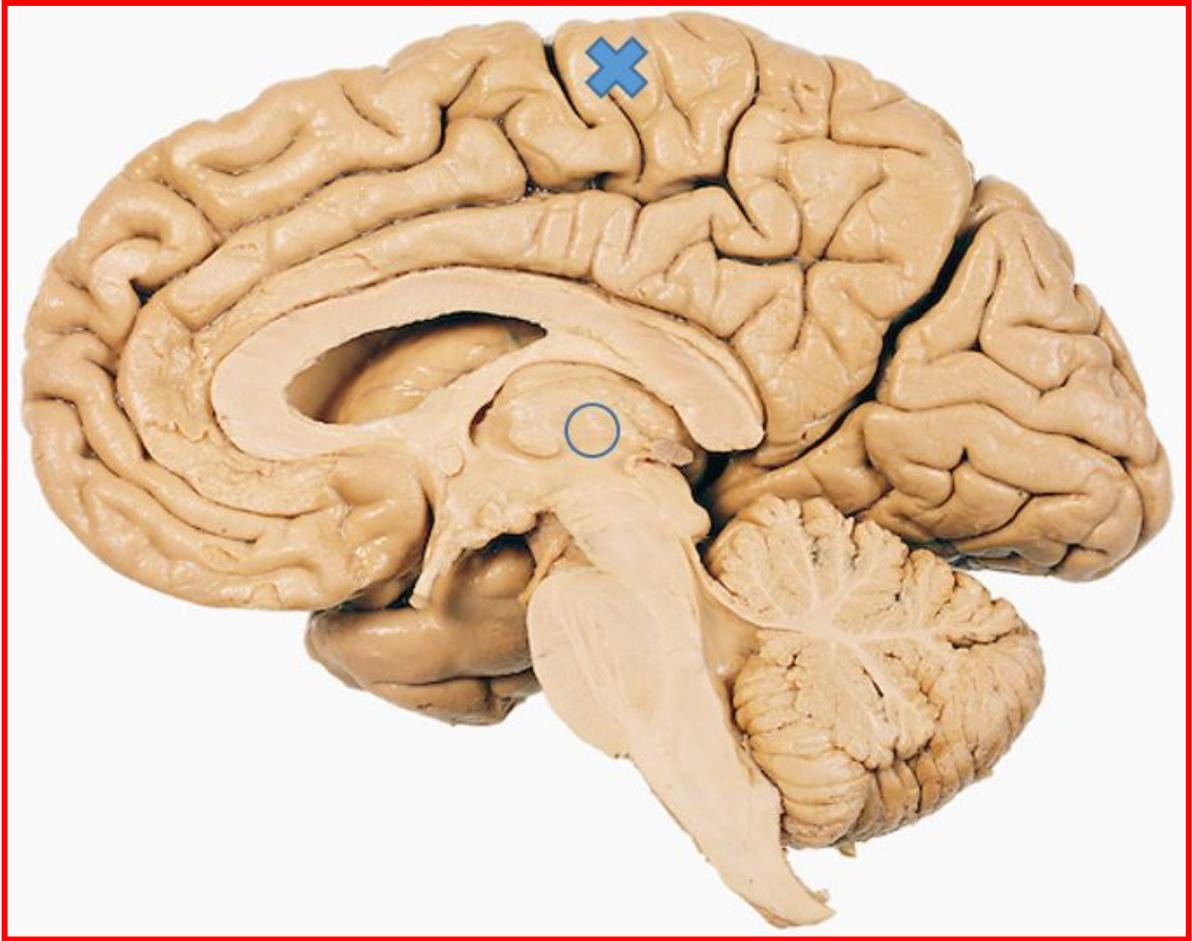
If parietal lobe is mentioned: +1

If postcentral gyrus/somatosensory cortex is mentioned: +2

+3 total

- i) Draw an x on that part of the brain below (may vary, use best judgement)

+2 each, +4 total



- c) The lobe that the answer to c is located in has an association function. What is this function?

The association area of the parietal lobe is responsible for interpreting sensory information and understanding speech.

+2 for interpreting sensory information or understanding speech

10) In response to being rudely poked with a pencil, you slap me.

- a) What part of the cortex was involved in making this decision? Be as specific as possible!

If frontal lobe is mentioned: +1

If prefrontal cortex is mentioned: +1

+2 total

- b) What part of the cortex will signal your arm to slap me? Be as specific as possible!

If frontal lobe is mentioned: +1

If precentral gyrus/motor cortex is mentioned: +2

+3 total

- c) What type of spinal tract will this information mainly go through?

Corticospinal tract +1

- d) Describe the process by which a neuronal impulse reaches a muscle fiber. You only need to discuss what occurs at the synapse between the two.

When an action potential arrives at the presynaptic terminal, voltage gated calcium channels open, causing an influx of calcium. This causes vesicles containing acetylcholine to be secreted from the synaptic terminal by exocytosis. It then binds to the nicotinic acetylcholinergic receptor on the motor endplate, causing a reversal of polarity there.

+1 for opening of voltage gated channels
+1 for mentioning acetylcholine release
+1 for binding to nicotinic acetylcholinergic receptor
EC: +1 for reversal of polarity at endplate.

- 11) I go to my doctor for a routine flu shot. He messes up and manages to bisect my corpus callosum through its sagittal plane and lesion my left somatosensory cortex. When I return, Richard manages to launch a crossbow bolt into my left palm.

- a) Can I feel it? Why?

Yes, I can feel it. The spinothalamic tracts that carry pain messages cross over to the right side of the brain in the medulla oblongata. The pain signal will be processed in the right somatosensory cortex.

+1 for correct answer
+1 for mentioning crossover

- b) Can I say anything about it? Why? Reference cortical areas in your answer.

No, I cannot. Broca's area, which is responsible for producing speech, is located in the left frontal lobe. The pain messages cannot be sent to this area due to the bisection of the corpus callosum.

+1 for correct answer
+1 for using the role of Broca's area
+1 for referencing bisection of corpus callosum

- 12) It is now 2:31 AM. The reason I am up so late writing this test because I made the grave mistake of drinking a cappuccino at 10PM.

- a) Describe the action of caffeine. What neuromodulator does it affect?

Caffeine is an adenosine antagonist, meaning that it blocks receptors for adenosine, a neuromodulator which promotes sleep and suppresses arousal.

+1 for adenosine
+1 for adenosine function
+1 for caffeine's antagonistic behavior

- b) Extra credit: How does this neuromodulator accumulate?

As ATP is used by the body, more adenosine accumulates, so as the body runs out of energy, adenosine accumulates and promotes sleep
EC: +2 for something to this effect

13) During a boxing match, I get a nice right hook to the eye from John Cena.

- a) Around the left eye, innervation to the superior oblique and lateral rectus muscles is severed. Which way will the eye tend to move? What cranial nerves were probably severed?

The eye will tend to move towards the midline/to the right. Cranial nerves IV (trochlear) and VI (abducens) were likely severed.
+1 for correct movement
+1 for each correct cranial nerve
+3 total.

- b) What is the white part of the eye called?

Sclera (+1)

- c) The injuries cause thickening and swelling of the cornea and lens. What condition will result, and why?

Myopia will probably result due to an increased focusing power of the refractive elements of the eye, causing light to be focused in front of the retina
+1 for naming myopia
+2 for stating why increased focusing power causes it

- d) The doctor I keep visiting decides an injection of rhodopsin into the central depression of the retina will be a good idea.

- i) What, biochemically, does rhodopsin do? What cells is it located in?

Rhodopsin is located in rods. In response to light, rhodopsin breaks down into opsin and retinal, and opsin activates transducin which activates phosphodiesterase, which breaks down the cGMP which holds open sodium channels. This causes a hyperpolarization which inhibits neurotransmitter release.
+1 for location in rods
+2 for role in hyperpolarization
+1 if they know each step in the pathway
+4 total

- ii) What is the center of the retina called? Why would injecting rhodopsin there not have as much effect as expected?

The central depression is called the fovea centralis. It lacks rods, which use rhodopsin, so injecting rhodopsin wouldn't do anything.
+1 for name
+2 for reasoning for lack of effect

- e) Since I cannot really see out of my left eye, what parts of my cortex will stop working?

No parts will stop working. Although it may seem as though the right occipital lobe will stop working, crossover between the nasal halves of optic tracts in the optic chiasma causes each hemisphere to receive visual input.

+1 for no parts

+2 for referencing crossover

+1 for referencing optic chiasma

14) Olfaction is a weird sense.

a) What type of receptors are responsible for olfaction?

A. Chemoreceptors (+1)

B. Nociceptors

C. Mechanoreceptors

b) What structural types of neurons are used to first sense stimuli, in general?

Unipolar neurons (+1)

i) Which type is used to sense olfactory stimuli?

Bipolar neurons (+1)

ii) Name the small projections of olfactory sensory neurons that actually pick up incoming stimuli

Cilia (+1)

c) What is weird about how olfactory signals are processed compared to other senses?

Olfactory signals are not processed in the thalamus, unlike the other senses. Olfactory signals go directly to the limbic system, which includes the hippocampus and amygdala.

+1 for not going through thalamus

+1 for limbic system

d) Extra credit: What is weird about the neurons which first receive olfactory input?

Olfactory sensory neurons can regenerate from the olfactory epithelium of the nose, unlike most other neuronal types.

+2 for regeneration

15) In the video game *Mortal Kombat*, Sub-Zero's fatality attack involves pulling out his opponent's spinal cord. One day, he pulls out some poor guy's spine, but goes to look at it in the local anatomy lab.

a) He sees two processes coming out below each vertebrae on each side. One has a bulge near the vertebrae. What is the bulge called?

Dorsal root ganglion (+2)

b) He then notices that the processes continue into long tendrils, but some of them, specifically above and below the chest, seem to tangle. What are these tangles called (general term)?

Plexuses (+2)

c) Extra Credit: Using his microscope, Sub-Zero takes a look at the sympathetic trunk of his victim. He noticed that within the paravertebral ganglia, proteins on the postsynaptic membrane are phosphorylated and have a different shape than any other such proteins he

has seen before. He knows that his opponent was a heavy smoker. Explain the phenomenon he is observing.

(This question is horrendously evil. Mad props if anyone gets it.)

The paravertebral ganglia contain synapses between the preganglionic and postganglionic fibers of the sympathetic nervous system. These synapses are characterized by nicotinic acetylcholine receptors on the postsynaptic fiber.

+2 for synapses in ganglia

+2 for nicotinic acetylcholine receptor/+1 if they say cholinergic receptor

Frequent use of nicotine desensitizes the nicotinic acetylcholine receptor, which manifests as phosphorylation and conformational change in the receptor. Thus the victim's heavy nicotine use caused these changes.

+3 for physical changes of protein in response to desensitization.

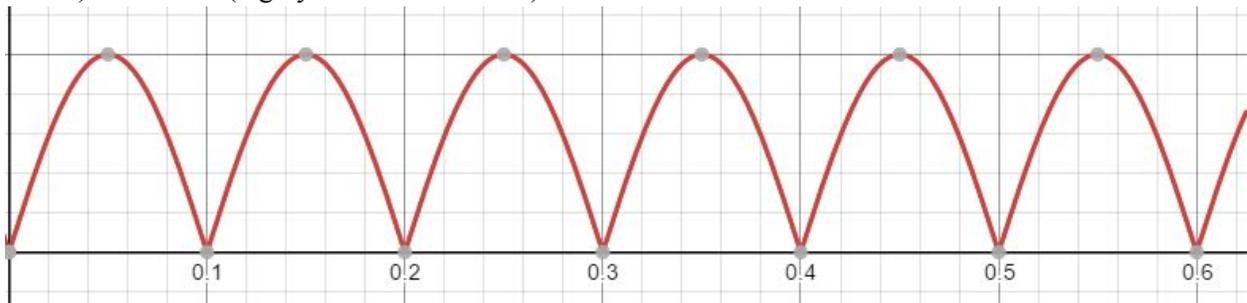
+7 extra credit total

16) I have a rare mutation which causes me to have fewer lamellated corpuscles. My girlfriend has a rare mutation that causes her to have fewer Merkel's discs. If we have children, what two sensations may they feel less?

They may feel less sustained touch and pressure.

+1 for each sensation

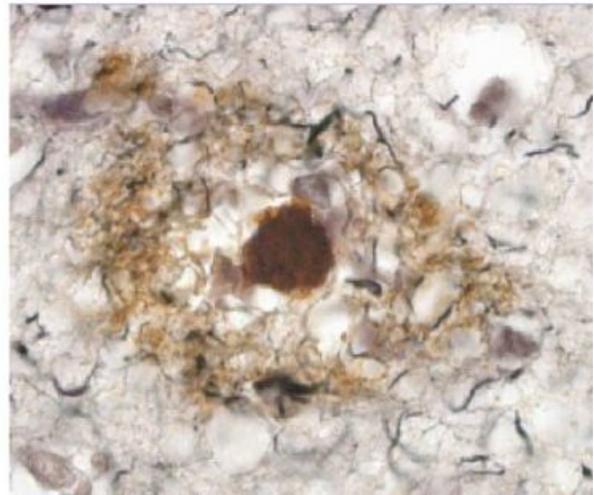
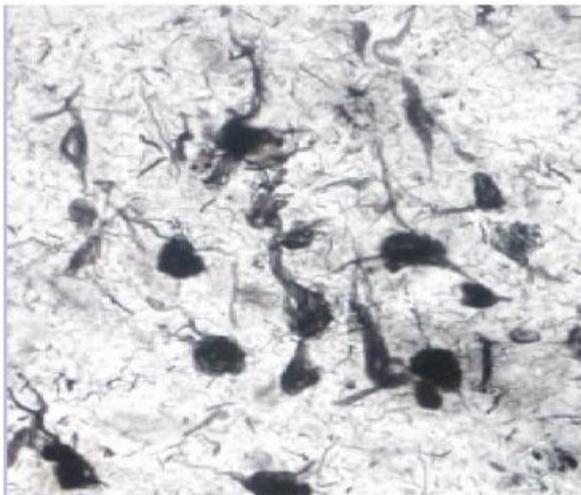
17) Below is a (highly fake and idealized) brain wave with the x-axis in seconds



Based on the frequency, identify the wave type and select a situation it would occur in:

- A. Beta wave, resting with eyes closed
- B. Beta wave, REM sleep
- C. Alpha wave, resting with eyes closed (+2)
- D. Alpha wave, REM sleep

18) In the hippocampus of an alzheimer patient the following images are taken:



Name the left and right features and describe what proteins they are composed of.

Left: neurofibrillary tangles made of tau protein
Right: neuritic plaques made of beta amyloid
+1 for each correct identification of feature and protein, +4 total
+2 if features are matched to protein, but not to correct image

19) I have this terrible headache, so I go to this doctor that I probably should be suing for malpractice by now. He takes out a snail-shaped structure in my head and announced that I was infected by a snail. I can't hear him. Discuss the role of this structure in hearing.

This structure is the cochlea. Sound waves cause the stapes in the middle ear to beat on the oval window, causing vibrations in the fluid of the cochlea which cause receptor cells of the organ of Corti on the basilar membrane to deflect against the tectorial membrane. This stimulates these cells.
+1 for identification as cochlea
+2 for mentioning vibrations in fluid stimulating receptor cells
+1 for receptor cells being on organ of Corti or basilar membrane
+4 total

20) What is the difference between plexuses and ganglia?

Plexuses are branching networks of nerves, which are collections of axons. Ganglia are collections of neuronal cell bodies in the autonomic nervous system.
+1 for each definition, +2 total

21. What is the difference between the nervous system and the endocrine system? Which system's signals generally last longer?

+1 for endocrine system uses hormones and nervous system uses action potentials and neurotransmitters
+1 for endocrine system's signals generally last longer

22. What are the two classes of steroid hormones?

+1 for corticosteroids
+1 for sex steroids

23. Where are the receptors for non-steroid peptide hormones located? Why are they there?

+1 for stating that the receptors are on the plasma membrane
+2 for stating that peptide hormones cannot cross the membrane, so their receptors must be on the membrane.

24. Chemically, are hormones generally more amino-acid based or cholesterol based?

+1 for amino-acid based

25. What does the hypothalamus regulate?

+1 for saying it regulates metabolic processes
+1 for saying it stimulates or inhibits the secretion of pituitary hormones

26. What is the HPA Axis?

+1 for saying it is a set of relationships and signals that exist between three endocrine glands
+1 for saying the hypothalamus is a part of it
+1 for saying the pituitary gland is a part of it
+1 for saying the adrenal gland is a part of it

27. What is the purpose of hormone cascades?

+1 for saying it amplifies a signal
+1 for saying it activates/ can activate/deactivate other pathways as well (or something to that regard)

28. Why does the pancreas have both exocrine and endocrine tissue?

+1 for the exocrine cells produce enzymes to help with the digestion of food
+1 for the endocrine cells release hormones into the bloodstream
+1 for saying the hormones released help control blood sugar (glucose) levels

29. What type of cells does the thymus aid with the differentiation of?

+1 for T-cells

30. Which gland produces the hormone melatonin? What does melatonin do?

+1 for the saying the pineal gland produces it
+1 for saying melatonin regulates sleep cycles
+2 for addressing a biological reason why/how melatonin works (ie how light decreases production, thus preparing a person to wake up, etc)

31. Describe the differences in structure between the anterior pituitary and the posterior pituitary.

+1 for saying the posterior pituitary is not a gland
+1 for saying the posterior pituitary is a projection of the hypothalamus
+1 for saying the posterior pituitary is primarily a collection of blood vessels and neural pathways leading from the hypothalamus to the anterior pituitary
+1 for saying that the cells of the anterior are endocrine cells
+1 for saying that the cells of the posterior are neural cells

32. A student is sky diving. When in the air, his parachute would not deploy. His pupils dilate and his heart and breathing rate go up. He tries one more time and the parachute finally works. No harm befalls the lucky student. What type of endocrine system stimulus did he receive that caused the eye dilation and breathing and heart rate increase?

+1 for saying neural stimulus
+2 for stimulus from the sympathetic nervous system

33. What hormones are responsible for the fight-or-flight response? Where are they released from?

+1 for adrenaline or epinephrine
+1 for noradrenaline or norepinephrine
+2 for being released from adrenal medulla.

34. Describe two differences between diabetes type 1 and 2.

+2 for saying that type 1 is mostly genetic while type 2 is due to lifestyle
+2 for saying that type 1 is an inability of the pancreas to produce insulin, while type 2 is an impaired ability of body cells to respond to it
+4 total

35. Ayusha, a 25 year old woman, has been extremely anxious for the past three years. She has lost weight without changing her diet or exercise regime and feels her heart beating irregularly. Her eyes have become puffy and she has not menstruated in two years. What diagnosis would you give Ayusha? What causes her disease?

+1 for saying Ayusha has Graves Disease
+1 for saying it is a disorder of the thyroid
+1 for saying it occurs when the thyroid produces too many hormones

36. Robert Wadlow was the tallest person in history, having a recorded height of 8'11". This was due to hyperplasia in his pituitary gland. Speculate what hormone imbalance caused this abnormal growth, how this hormone works, and three of its functions.

+1 for saying Wadlow had an excess of HGH (human growth hormone)
+3 for listing any three of these: increases calcium retention, strengthens and increases the mineralization of bone, increases muscle mass through sarcomere hypertrophy, promotes lipolysis, increases protein synthesis, stimulates the growth of all internal organs excluding the brain, plays a role in homeostasis, reduces liver uptake of glucose, promotes gluconeogenesis in the liver, contributes to the maintenance and function of pancreatic islets, stimulates the immune system, increases deiodination of T4 to T3.