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50 minute written exam

Test takers allowed one sheet of notes 8.5" by 11" and two non-graphing calculators

Nervous:

1. The brain – major regions and their functions
2. Identification of simple encephalographic wave forms and why they occur
3. Neural impulses – cellular anatomy and physiology of neurons and supporting cells, synapses and neurotransmitters, action potential generation and propagation, ionic basis of the cellular membrane potential, types of neural synapses
4. Central nervous system – organization of the spinal cord, brainstem, and cranial nerves, purpose/functions of sleep
5. Peripheral nervous system – neural ganglia, action and physiology of sensory and motor neurons, action and physiology of sympathetic and parasympathetic neurons, understand differences in and purposes of parasympathetic, sympathetic, somatic, and sensory systems, reflex arcs and proprioception, nerve structure
6. Disorder: epilepsy, alzheimer's disease, multiple sclerosis, parkinson's disease, cerebral palsy, shingles (herpes zoster), stroke, amyotrophic lateral sclerosis
7. Effects of the drugs: alcohol, caffeine, nicotine, and marijuana on the nervous system

Sensory:

1. Types of sensory receptors, general senses vs special senses
2. Mechanisms for the general sense of touch, pressure, pain, temperature, itch, and proprioception
3. Sense organs – regions of each of the Special Sense Organs and their functions
4. Physiology of sight, hearing, balance, smell, and taste
5. Disorders: myopia, hyperopia, presbiopia, nyctalopia, astigmatism, conjunctivitis, color blindness, otitis media, types of deafness, Anosmia/dysosmia, dysgeusia

Endocrine:

1. The three classes of hormones – steroids, peptides, and amines
2. Mechanisms of hormone action – nuclear vs cytoplasmic
3. Endocrine related problems – hypersecretion, hyposecretion
4. Hormone producing glands, their hormones and the function of each
5. Disorders: diabetes mellitus, hypoglycemia, graves' disease, hashimoto's disease, goiter, cretinism

Anatomy and Physiology – EXAM

2022 UMD Invitational

Team Number: _____

Team/School Name: _____

No abbreviations / PRINT LEGIBLY

Student Names (First & Last): PRINT LEGIBLY

1. _____

2. _____

Total Points Possible (written test): **insert total # of points**

Total Points Earned: _____

Multiple Choice

Sensory System

1. Not all of the 5 main sensory receptors (touch, smell, taste, vision, hearing) rely directly on action potentials to propagate electrical signals. Some cells transduce environmental stimuli into chemical signals first. Which of the following sensory receptor cells release neurotransmitters without generating an action potential? [Select all that apply] [3 points]
 - a. Hair Cells
 - b. Free Nerve Endings
 - c. Olfactory Receptors
 - d. Rod Cells
 - e. Gustatory Cells
2. Many individuals wear contact lenses to correct their vision. Choose the answer that best describes how contact lenses correct an individual's vision [2 point]
 - a. Contact lenses alter the amount of light hitting the pupil which allows the retina to properly focus.
 - b. Contact lenses help the iris properly adjust the size of the pupil which allows for proper adjustment of the pupil
 - c. Contact lenses reflect light onto the cornea where rod and cone cells can become stimulated and thus send the proper signals to the brain.
 - d. Contact lenses make the cornea clearer which decreases the blurriness of the image seen.
 - e. Contact lenses refract light so it is more focused on the retina where it is transduced.
3. Spicy food often triggers sensations of pain and heat. On the other hand, menthol and minty food often is associated with coolness. Part of the reason why this occurs is because of a special ion channel that responds to both temperature and chemicals. What family of receptor is this? [2 point]
 - a. TPC Family
 - b. TRP Family
 - c. KAT Family
 - d. FGY Family
 - e. AST Family
4. Circle the characteristics that best describe free nerve endings in the skin. [Select all that apply] [3 point]
 - a. Myelinated
 - b. Unmyelinated
 - c. Thick
 - d. Thin
5. Our sense of head rotation depends on the semicircular canals in our vestibular system. What type of receptors measure this? [2 point]

- a. Hair cells
 - b. Free nerve endings
 - c. Pressure sensitive free nerve endings
 - d. Fluid volume receptors
 - e. Cupula receptors.
6. Otoliths are also crucial for our vestibular system to function. What role do they play? [2 point]
- a. They are small particles that stimulate vestibular system receptors.
 - b. They create pressure gradients that can be measured by our vestibular system receptors.
 - c. They produce the fluid hemolymph in the semicircular canals which is crucial for their function.
 - d. They make up the walls of the semicircular canals and produce a gel-like substance that lubricates the sensory receptors allowing more precise sensation.
 - e. They are a special type of cell that removes foreign debris from the semicircular canals. They are a part of the immune system.
7. Which area described below has the greatest number of Merkel disks? [2 point]
- a. Back
 - b. Legs
 - c. Arm
 - d. Lips
 - e. Forehead
8. Which of the following areas of skin is not glabrous [select all that apply]. [3 point]
- a. Palms
 - b. Fingertips
 - c. Dorsal side of the hand
 - d. Arms
 - e. Armpits
9. What part of the cochlea will respond to sound with a frequency of 19,000 Hz? [2 point]
- a. Apex
 - b. Middle (Closer to Apex)
 - c. Middle (Closer to Base)
 - d. Base
10. True or False, the back part of our tongues are most sensitive to bitterness. [2 point]
- a. True
 - b. False
11. What is the name of the liquid-gel like substance that only remains in the posterior part of the eye and does not freely flow between the two parts of the eye? [2 point]
- a. Aqueous Humour
 - b. Vitreous Humour

- c. Bellacious Humour
- d. Vinaceous Humour
- e. Eccentric Humor

12. Which of the following are true about our vision? [2 point]

- I. It is inverted
- II. It is virtual
- III. It is reduced in size
- a. I only
- b. II only
- c. III only
- d. I and II
- e. I and III
- f. II and III
- g. I, II, and III

Short Answer

Fill in the blank: [2 points each]

- 13. When someone is suffering from near-sightedness, the official term for their condition is: **myopia**
- 14. Color Blindness is an inherited disorder. Which chromosome (list by number or letter) is color blindness inherited through? **X**
- 15. Which type of cone cell is most common in humans? **Red**
- 16. What are the names of the three bones of the middle ear which transmit signals from the tympanic membrane to the cochlea? Please list the official scientific names. **Stapes, Incus, Malleus**
- 17. What is the name of the condition in which a constant ringing is perceived even when no such ringing may actually be occurring? **Tinnitus**
- 18. Which type of sensory receptor in our skin is responsible for sensing coldness? **Krauss End Bulbs**
- 19. What is the name of the small protrusions that stick out from our tongue and house tastebuds? **Lingual papillae (accept papillae)**
- 20. Which functional group is typically responsible for the sour sensation detection by our taste buds? **Carboxylic acids/Carboxyl**

Long Answer

- 21. This question will ask you to investigate the anatomy and physiology of the eye. [19 points]
 - a. Outline at least 2 differences between rod and cone cells. [4 points]
 - i. **Rod cells detect brightness, Cone cells detect color**
 - ii. **Rod cells are much more prevalent, cone cells are more limited**
 - iii. **There is only one type of rod cell, there are multiple types of cone cells**
 - iv. **Accept other valid answers**
 - v. **Point Breakdown: 2 point for each right answer**
 - b. In order for our rod and cone cells to properly detect light, it must first be focused. Explain how the amount of light is controlled and how it is focused. Include important

anatomic features including but not limited to the cornea, the ciliary body, the iris, and the lens. [8 points]

- i. The cornea and lens work together to bend the light so it becomes focused.
- ii. The ciliary body is the muscle that controls the size of the iris, when it contracts, the iris becomes smaller. This limits the diameter of the pupil letting in less light
- iii. Point Breakdown: 2 points for correctly identifying that cornea and lens refract light so it becomes focused on the fovea, and the ciliary body controls the size of the iris (contracting means less light) and the iris is the size of the hole which limits the light.

c. Some part(s) of the eye are damaged when someone has a cataract. Identify what part of the eye is damaged when someone has a cataract and how so. Then explain how this damage affects someone's vision. [4 points]

- i. The lens becomes cloudy when someone has a cataract.
- ii. Symptoms of cataracts: Clouded, blurred or dim vision, Increasing difficulty with vision at night, Sensitivity to light and glare, etc
- iii. Point Breakdown: 1 point for identification of the lens, an additional 1 point for describing its cloudiness. 2 points for identifying the symptoms. Do not award any points if the lens is not correctly identified, even if the symptoms listed are correct.

d. Identify 2 potential treatments for cataracts. If you list a surgical procedure, please explain what it does. [3 points]

- i. Surgery on the cataract to remove and replace the cloudy lens
- ii. Phacoemulsification
- iii. Extracapsular extraction
- iv. Corrective lenses
- v. Point Breakdown: 1.5 points for each correct treatment method

22. This question will ask you to investigate the connections between our sensory organs and the nervous system [15 points]

a. Many of our sensory systems have central cranial nerves that transmit signals directly to the brain. Name the nerves that carry these signals below. If no such nerve exists, write NA: (5 points)

- i. Visual System: Optic Nerve
- ii. Hearing System: Vestibulocochlear nerve
- iii. Taste System: Glossopharyngeal nerve/Vagus nerve/Facial Nerve
- iv. Smell System: Olfactory Nerve
- v. Balance System: Vestibulocochlear nerve
- vi. Point breakdown: 1 point each

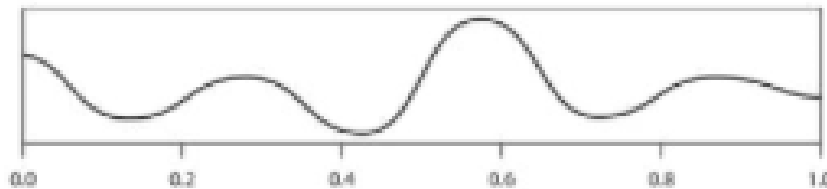
b. Once each of these signals are received, they are typically processed by unique regions of the brain. However, almost all senses first must travel through an "integrating" area of the brain. What part of the brain is responsible for integrating sensory signals. And which sense bypasses this integrating region? [4 points]

- i. The thalamus integrates sensory system signals and passes them along to the cerebral cortex.
- ii. Our sense of smell bypasses the thalamus in integration of responses.

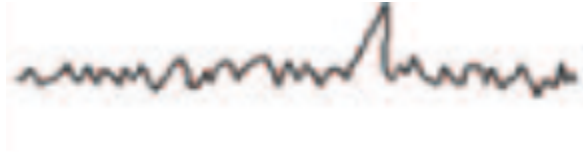
- iii. Point breakdown: 2 points each.
- c. Sometimes, we must respond to stimuli without processing in the brain. What is the name of this “without thinking” response and how does it occur? [6 points]
 - i. Reflex arc. Sensory neurons sense a stimulus, they are integrated via interneurons in the spinal cord, they then lead to motor neuron responses without analysis in the brain.
 - ii. Point Breakdown: 1.5 points for each underlined section

Nervous System

1. Calculate the equilibrium membrane potential at 37 degrees Celsius with the concentration of $[Na^+]_{outside} = 150mM$, $[Na^+]_{inside} = 15 mM$, and $RT = 62mV$ at 37 degrees Celsius
 - a. +62 mV
 - b. +37 mV
 - c. 0 mV
 - d. -37 mV
 - e. -62 mV
2. What type of membrane channels set up the membrane potential in a resting neuron
 - a. Sodium Potassium Pump
 - b. Potassium Leak Channels
 - c. Chlorine Voltage Gated Channels
 - d. Sodium Voltage Gated Channels
 - e. Potassium Voltage Gated Channels



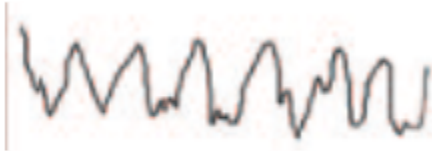
3. What type of brain wave is seen in the diagram above. (each tickmark is 0.2)
 - a. Beta
 - b. Alpha
 - c. Theta
 - d. Delta
 - e. Gamma



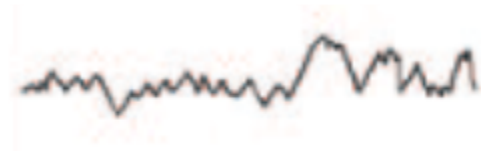
A



B



C



D

4. During REM sleep, what type of brain wave would you expect to see?
 - a. A
 - b. B
 - c. C
 - d. D

5. Which neurotransmitter would you expect to find in the substantia nigra which is negatively affected by Parkinson's disease?
 - a. Serotonin
 - b. GABA
 - c. Dopamine
 - d. Glutamate

6. Which of the following types of cells make up the myelin sheath in the peripheral nervous system?
 - a. Oligodendrocytes
 - b. Astrocytes
 - c. Schwann Cells
 - d. Ependymal Cells
 - e. Microglial Cells

7. Which of the following is not a response from the sympathetic nervous system? [Select all that apply]
 - a. Increased heart rate
 - b. Dilated Pupils
 - c. Vasoconstriction
 - d. More rapid breathing
 - e. Increased digestion

8. Which of the following are a part of the limbic system? [Select all that apply]
 - a. Amygdala

- b. Hippocampus
 - c. Substantia Nigra
 - d. Cingulate Gyrus
 - e. Dentate Gyrus
9. Which of the following best describes why there is a refractory period from a mechanism perspective?
- a. The sodium channels remain open after hyperpolarization preventing a depolarization from occurring until the sodium channels close.
 - b. The chlorine channels lead to secondary messenger cAMP binding to sodium channels locking the sodium channels from opening after a depolarization preventing hyperpolarization.
 - c. Calcium channels release calcium ions which lock onto ligand gated potassium channels preventing the potassium channels from opening.
 - d. The sodium channels remain locked after hyperpolarization preventing sodium ions from depolarizing the cell.
 - e. The potassium channels remain locked after depolarization preventing potassium ions from hyperpolarizing the cell.
10. Which of the following neurotransmitters is gaseous?
- a. Dopamine
 - b. GABA
 - c. Serotonin
 - d. Nitric Oxide
 - e. Acetylcholine
11. Which of the following sections of the brain is most responsible for interpreting a command that your teachers yells at you?
- a. Broca's Area
 - b. Somatosensory Cortex
 - c. Wernicke's Area
 - d. Sylvian Fissure
 - e. Postcentral Gyrus
12. Which of the following genes, when abnormal, is associated most closely with Alzheimer's disease?
- a. CF
 - b. APOE
 - c. HTT
 - d. BAMY
 - e. TRP

Short Answer

Fill in the blank: [2 points each]

23. What disease is a consequence of not having myelin sheath around central nervous system neurons with an autoimmune attack etiology: **Multiple Sclerosis (MS)**
24. Which branch of the nervous system is responsible for regulation of movement of digestive material during periods of rest? Be as specific as possible. **Enteric System**
25. Which type of supportive nerve cell plays the biggest role in immune response in the CNS? **Microglia**
26. What is the name of the tissue that connects the left and right brain? **Corpus Callosum**
27. What type of neuron/synapse is impacted by cocaine? **Dopaminergic Neuron/Synapse**
28. Identify the number of cranial nerve pairs there are. **12**
29. What part of the brain controls coordination, balance, and posture? **Cerebellum**
30. What is the name of a small change in the membrane potential that is the result of various inputs from different neurons? **Graded Potential**

Long Answer

31. While investigating what you believe to be a neuron like cell in a plant, you discover a variety of ion channels to be present. You measure some characteristics of the ion channels and you discover the following, answer the questions regarding the below information [17 points]

Ion Channel	Concentration Outside (mM)	Concentration Inside (mM)	Membrane Permeability (mM/msPa)
Sodium	10	100	0
Potassium	100	10	0.1
Chlorine	75	20	1

- a. Which of the ions shown above is most likely setting the membrane potential? Be sure to include your reasoning to receive points [4 points]
 - i. **The chlorine ion is most likely setting the membrane potential. This is because it has the greatest membrane permeability so it mimics the leak channels which determine the membrane potential in our bodies.**
 - ii. **Point Breakdown: 1 point for identifying potassium correctly. 1 point for listing the membrane permeability as the correct factor. 2 points for relating it to leak channels. Award no points where potassium is not chosen.**
- b. Using what you know about membrane potentials, will the membrane potential of this neuron like cell be positive or negative? How do you know? [6 points]
 - i. **This cell likely has a negative membrane potential. Potassium ions want to flow into the cell meaning positive charges want to enter the cell. Sodium has 0 membrane potential so it will not contribute to the membrane potential. Chlorine ions will want to enter the cell meaning a more negative charge, but the**

membrane potential is much higher so it will have a greater influence on the membrane potential, this mimics our own bodies.

- ii. Point Breakdown: 1 point for identifying negative charge, 2 points for correctly explaining potassium result on charge, 2 points for correctly explaining the chlorine result on charge, 1 point for explaining the sodium lack of impact.

- c. Showing your work, calculate the combined membrane potential that is contributed by these 3 ions in this plant like neuron using the Goldman Equation. Use $RT = 62\text{mV}$ at 37 degrees Celsius. [5 points]

- i. Use the Goldman equation:

$$E_{ion} = 62\text{mV} * \log \left(\frac{P_K [K]_{out} + P_{Na} [Na]_{out} + P_{Cl} [Cl]_{in}}{P_K [K]_{in} + P_{Na} [Na]_{in} + P_{Cl} [Cl]_{out}} \right)$$

- ii. Final Answer:

- iii. Point Breakdown: 4 points for the correct equation, 1 point for the correct answer. If there are slight inconsistencies in the equation, take off 1 point per inconsistency.

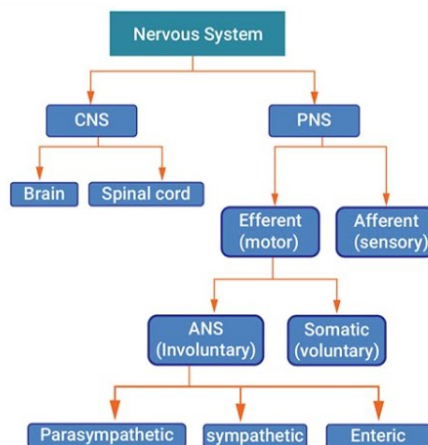
- d. Given all of the answers you have found above, give the most likely mechanism of neuron firing if it follows a similar sequence of events as the human neuron. [2 points]

- i. Potassium channels open first (low permeability suggests they are the voltage gated channels) this depolarizes the cell. Then chlorine channels open hyperpolarizing the cell. Sodium channels play no role.

- ii. Point Breakdown: All or nothing point system.

32. This question will ask you to investigate the central and peripheral nervous system. [13.5 points]

- a. Outline the subdivisions of the peripheral nervous systems and the organs of the central nervous system. Be sure to include all subdivisions in the PNS. [4.5]



- i.

- ii. Point Breakdown: 0.5 points for each correct box below the CNS and PNS

- b. One disease of the peripheral nervous system is Guillain-Barre syndrome. Explain the etiology of this disease and at least 2 symptoms. Then give a similar disease that affects the central nervous system. [5 points]

- i. GB syndrome is caused when the immune system attacks neurons in the PNS. It is characterized by sensations of pain, muscle weakness, respiratory failure, etc.
 - ii. A similar disease of the CNS is multiple sclerosis.
 - iii. Point Breakdown: 1 point for identification of etiology, 1 point for each symptom, 2 points for the identification of CNS disorder.
- c. The nervous system is fundamentally intertwined with many of the other organ systems in our body. The endocrine system is another signalling system that immediately comes to mind. State which organ/tissue is responsible for bridging the gap between the nervous system and endocrine system. Then outline at least 2 differences between how the nervous system and endocrine system function. [4 points]
 - i. Hypothalamus
 - ii. The nervous system is faster at signalling
 - iii. The endocrine system relies on chemical messengers while the nervous system uses electrical signals
 - iv. Accept other differences that are valid
 - v. Point Breakdown: 2 points for hypothalamus, 1 point for each difference

Endocrine System

Multiple Choice - Each 2 points

1. Which hormones bind to receptors on the surface of the cell?
 - a. Steroid hormones
 - b. Peptide hormones
 - c. Amine hormones
 - d. Thyroid hormones
 - e. None of the above
2. Which of the following does not cause Goiter?
 - a. Iodine deficiency
 - b. Broken bones
 - c. Graves' disease
 - d. Thyroid cancer
 - e. None of the above
3. _____ of the growth hormone leads to gigantism.
 - a. Hypersecretion
 - b. Hyposecretion
4. What gland produces corticosteroids?
 - a. Thymus
 - b. Pituitary

- c. Adrenal
 - d. Thymus
 - e. None of the above
5. What is the main function of norepinephrine?
- a. Release melatonin
 - b. Regulate adrenocorticotropin release
 - c. Stimulates contraction of the uterus and milk ducts
 - d. Maintains blood pressure
 - e. None of the above
6. Which gland produces melatonin?
- a. Pineal gland
 - b. Hypothalamus
 - c. Pituitary gland
 - d. Adrenal gland
 - e. None of the above
7. Graves' disease is caused by
- a. A sodium deficiency
 - b. A problem with genetics
 - c. Lack of vitamin A
 - d. A thyroid hormone deficiency
 - e. None of the above
8. What gland produces the hormone prolactin?
- a. Hypothalamus
 - b. Anterior lobe of the pituitary gland
 - c. Thalamus
 - d. Posterior lobe of the pituitary gland
 - e. None of the above
9. Which endocrine gland produces oxytocin?
- a. Pineal gland
 - b. Thyroid gland
 - c. Hypothalamus
 - d. Pituitary gland
 - e. None of the above
10. What type of gland is the pancreas?
- a. Endocrine gland
 - b. Exocrine gland
 - c. Both endocrine and exocrine
 - d. Neither endocrine or exocrine

11. Which neurotransmitter passes through the neuromuscular junction between a motor neuron and a skeletal muscle?
- a. Serotonin
 - b. Epinephrine
 - c. Norepinephrine
 - d. **Acetylcholine**
12. Patients with Parkinson's disease have low levels of which neurotransmitter?
- a. **Dopamine**
 - b. Epinephrine
 - c. Acetylcholine
 - d. Norepinephrine

Short Answer

13. Describe what happens to a person's insulin levels if they are affected by Type II diabetes. [2 points]
- a. **With type 2 diabetes, hyperglycemia occurs since organs are insulin resistant in type 2 diabetes. This means that there is still a normal amount of insulin produced, but that insulin is ineffective in bringing down blood sugar.**
 - b. **Point breakdown: 1 point for connecting type 2 diabetes and hyperglycemia. 1 point for stating that organs are insulin resistant in type 2 diabetes.**
 - c. **Total points: 2**
14. Describe the function of second messengers [1 point]
- a. **Intracellular molecules that transmit signals from cell membrane receptors to within the cell**
 - b. **Point breakdown: 1 point for the above or similar to the above**
15. What is the half-life of a hormone? [1point]
- a. **The time it takes for a hormone to lose half of its physiological activity.**
 - b. **Point breakdown: 1 point for the above or similar to the above**
16. Which gland is the "master" gland of the endocrine system? [1 point]
- a. **Pituitary gland or hypothalamus**
 - b. **1 point for pituitary or hypothalamus, 0 if any other gland is written**
17. Name a disorder that is a result of Hypersecretion [1 point]
- a. **Gigantism**
 - b. **Graves' Disease**
 - c. **Hypoglycemia**
 - d. **Cushing's syndrome**
 - e. **Point breakdown: 1 point maximum, if any of the above are written then they get 1 point**

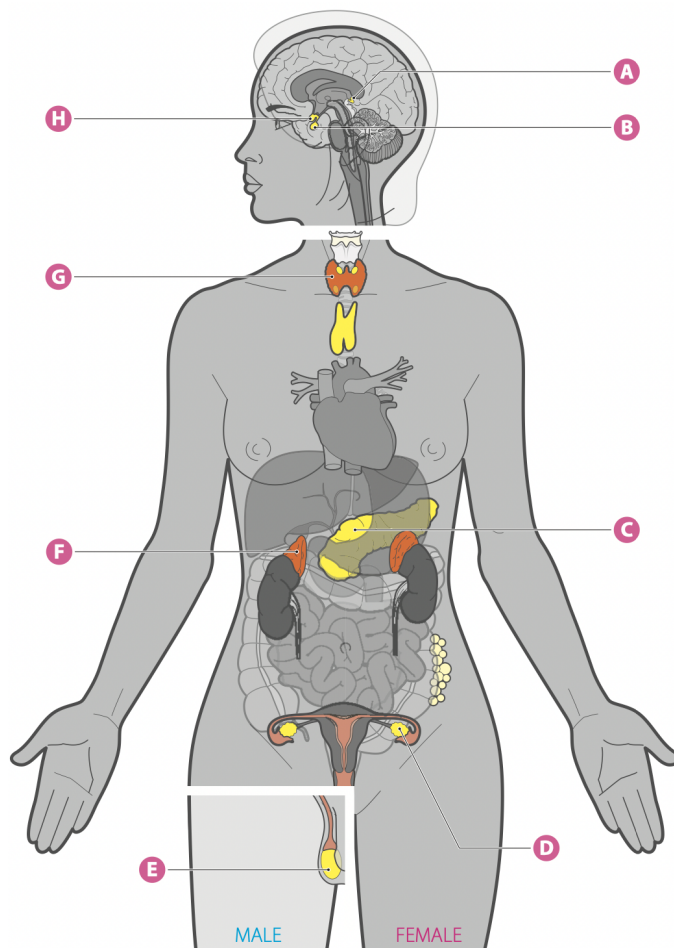
Write the hormone that most fits the description (2 points each)

18. Stimulates milk production **Prolactin**
19. Stimulates kidney tubule cells to reabsorb water **Antidiuretic hormone**

20. Raises blood pressure by increasing the amount of water and sodium reabsorbed into the bloodstream **Aldosterone**
21. Lowers blood Ca^{2+} levels **Calcitonin**
22. Raises blood Ca^{2+} levels **Parathyroid hormone**
23. Stimulates uterine contractions and initiates labor **Oxytocin**
24. Manages stress and metabolizes glucose and fat **Cortisol**
25. Stimulates ovarian follicle maturation and estrogen production in females; stimulates sperm production in males **Follicle stimulating hormone**

Diagram

For the following diagram, label parts A - H and state which hormones each of the glands produces. [16 points]



- A: pineal gland: melatonin
 B: pituitary gland. Posterior: neurohormones, anterior: growth hormone, TSH, ACTH, FSH, prolactin
 C: pancreas: glucagon, insulin, somatostatin
 D: ovary: oestrogens, progesterone
 E: testis: androgens
 F: adrenal gland: adrenaline (and noradrenaline), cortisol, aldosterone
 G: thyroid: T3 (triiodothyronine), T4 (thyroxine)
 H: hypothalamus. Releasing hormones: TRH, GnRH, CRH, GHRH, dopamine. Neurohormones: ADH, oxytocin

Scoring: 1 point for the correct gland, 1 point if they named at least one correct hormone.
 Maximum points: 16

Total: 62 points for endocrine system