BMED 3100: Systems Physiology
Test 3, February 23, 2009

_____
Last Name

Honor Pledge
All students are required, when requested, to attach the following statement to any material turned in for a grade in any course at Georgia Institute of Technology:
On my honor, I pledge that I have neither given nor received inappropriate aid in the preparation of this assignment.

_____KEY_____
Signature

_____
Name (Printed)

Be brief in your answers.
Write clearly.
Backs of pages will not be graded.

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Multiple Choice: Write the *best* answer on the line to the right. (2 pts each)

1. The receptor potential ___E_____
   A. is an action potential.
   B. may trigger action potentials.
   C. varies in magnitude with stimulus strength.
   D. Both A and C are correct.
   E. Both B and C are correct.

2. One reason you can distinguish between a needle prick on the foot and an ice cube on the wrist is that ____C_____
   A. the ice cube stimulates a different class of receptors than the needle prick, even though both signals go to exactly the same location in the brain.
   B. the nerve impulse from the needle prick is inherently different from the impulse generated by the ice cube.
   C. the region of the brain to which one receptor pathway leads is different from the region to which the other pathway leads.
   D. the needle prick generates a stronger action potential in any one neuron than an ice cube does.

3. Lateral inhibition in the somatic sensory system serves to ____B___
   A. reduce the intensity of nerve signals sent to the somatosensory cortex.
   B. enhance the precision of locating a stimulus by increasing the contrast between wanted and unwanted information.
   C. alter pain sensation by simultaneously activating other sensory systems.
   D. Both A and B are correct.
   E. Both B and C are correct.

4. Which of the following statements regarding sensory pathways is correct? ___A_____
   A. All somatic sensory information that reaches the cerebral cortex is first processed in the thalamus.
   B. Somatic sensory information from the left side of the body is projected to the left side of the somatosensory cortex.
   C. All somatic sensory information travels together in a single tract in the spinal cord.
   D. Stimulation of any neuron in a specific ascending pathway will convey information about only one stimulus type.
   E. None of the choices are correct.

5. Which of the following symptoms would a patient with a lesion (injury) on the right side of the spinal cord in the region of the neck be most likely to experience? ____D____
   A. Loss of both pressure sense and pain in the right foot.
   B. Loss of both pressure sense and pain in the left foot.
   C. Loss of pressure sense in the right foot and pain in the left foot.
   D. Loss of pressure sense in the left foot and pain in the right foot.

6. A person with bilateral damage to the hippocampus will probably ____C____
   A. suffer from aphasia.
   B. develop symptoms of Parkinson's disease.
   C. suffer impairment of consolidation of declarative memory.
   D. have difficulty learning new physical skills.
   E. experience all of the choices.

7. Acetylcholine is the neurotransmitter for _____E____
   A. preganglionic sympathetic neurons.
   B. postganglionic sympathetic neurons.
   C. motor neurons.
   D. preganglionic sympathetic neurons and postganglionic sympathetic neurons.
   E. preganglionic sympathetic neurons and motor neurons.

8. The portion of the peripheral nervous system that is composed of nerve fibers that innervate skeletal muscle is the ____D_____
   A. afferent nervous system.
   B. sympathetic nervous system.
   C. parasympathetic nervous system.
   D. somatic motor nervous system.
   E. autonomic nervous system.

9. The region of the brain most closely associated with homeostasis and survival of the individual is ____E____
   A. the thalamus.
   B. the hippocampus.
   C. the cerebrum.
   D. the cerebellum.
   E. the hypothalamus.

10 Thick filaments in skeletal muscle are composed of ____B_____
   A. actin.
   B. myosin.
   C. troponin.
   D. calmodulin.
   E. tropomyosin.

11 Which of the following statements regarding the shortening of a ____C_____ skeletal-muscle fiber is *not* true? When a skeletal-muscle fiber shortens, the
   A. sarcomeres shorten.
   B. distance between Z lines decreases.
   C. myofilaments shorten.
   D. myofilaments slide past each other.
   E. length of the A bands remains the same.

12. In skeletal muscle, calcium facilitates contraction by binding to ____C____
    A. tropomyosin.
    B. actin.
    C. troponin.
    D. myosin.
    E. the thick filament.

13. The removal of calcium ions from the cytosol of skeletal muscle causes ____D____
    A. the myosin binding sites on actin to be uncovered by tropomyosin.
    B. tropomyosin to change conformation and thereby move troponin molecules over cross-bridge binding sites.
    C. troponin to change conformation and thereby expose cross-bridge binding sites.
    D. the myosin binding sites on actin to be covered by tropomyosin.
    E. None of the choices are correct.

14. "Motor unit" refers to ____A____
    A. a single motor neuron plus all the muscle fibers it innervates.
    B. a single muscle fiber plus all of the motor neurons that innervate it.
    C. all of the motor neurons supplying a single muscle.
    D. a pair of antagonistic muscles.
    E. all of the muscles that affect the movement of any given joint.

15. The transverse tubules in a skeletal-muscle fiber ____C____
    A. store calcium ions.
    B. form the Z lines.
    C. provide a means of transmitting an action potential in the muscle plasma membrane to central portions of the fiber.
    D. store ATP.
    E. run in parallel with the myofibrils.

16. Smooth muscle contraction is mediated by the phosphorylation of____ which occurs as a result of a chain of biochemical events including the binding of calcium ion to _____ ____E____
    A. ADP, calmodulin
    B. calmodulin, myosin
    C. actin, tropomyosin
    D. myosin, troponin
    E. myosin, calmodulin

17. Excitation-contraction coupling ____E____
    A. in skeletal-muscle cells requires the influx of extracellular calcium ion.
    B. in smooth-muscle cells requires the influx of extracellular calcium ion.
    C. in all kinds of muscle requires the release of calcium ion from the sarcoplasmic reticulum.
    D. Both A and B are correct.
    E. Both B and C are correct.

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18. You are walking barefoot on a rocky beach.

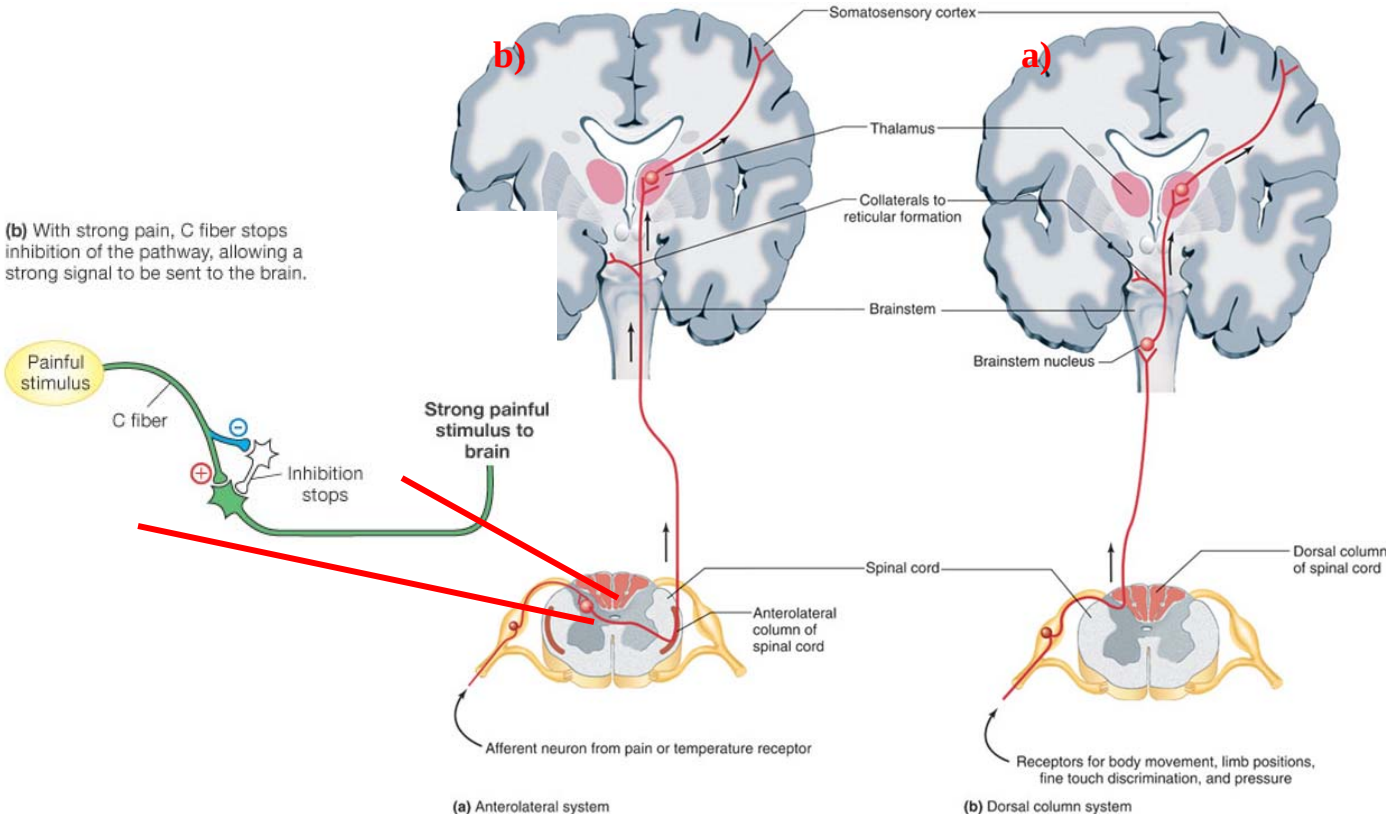
a) What are the components and steps in the somatosensory pathway (from receptor to brain) that tells you that the surface is bumpy.

1-mechanoreceptors in foot are activated and reach receptor threshold.
2-signal goes from receptor to afferent nerve (Aβ fiber) to the dorsal root to the dorsal portion of the spinal cord.
3-signal travels up the spinal cord on the ipsilateral side, crosses at the medulla, relays in the thalamus and goes to the somatosensory cortex
4-perception takes place in the association areas

b) All a sudden you hit a sharp rock that causes you to scream in pain. What are the components and steps in the somatosensory pathway (from receptor to brain) that tells you that this is a nociceptive stimulus and allows you to perceive pain.

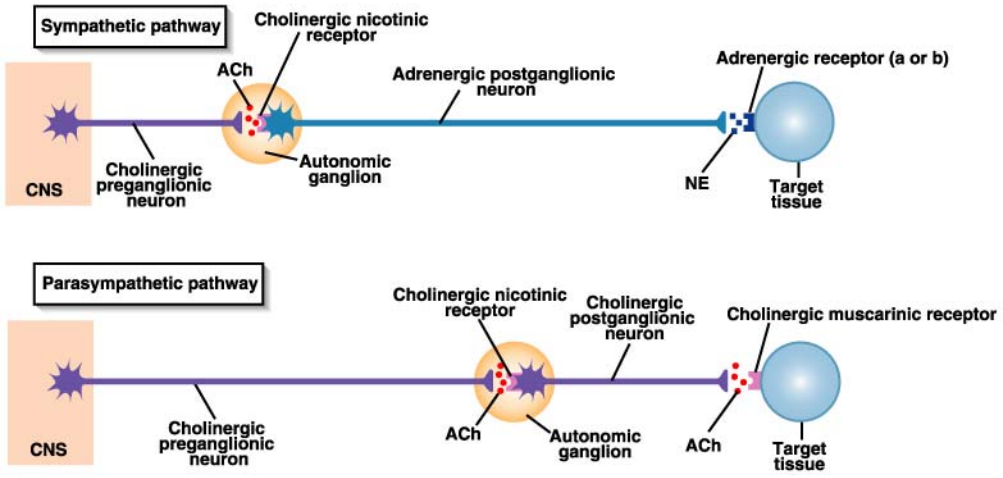
1-nociceptors in foot are activated and reach receptor threshold.
2-signal goes from receptor to afferent nerve (c fiber) to the dorsal root to the dorsal portion of the spinal cord, stopping inhibition and allowing passage of the signal.
3-signal crosses to the contralateral side of the spinal cord, travels up the cord, relays in the thalamus and goes to the somatosensory cortex
4-perception takes place in the association areas

Use <u>anatomical diagrams and flow charts</u> in your answer. (20 pts)



19. **a)** Draw and label the two neuron chain for a typical sympathetic and a typical parasympathetic pathway, including neuron type, neurotransmitters, and receptors. (8 pts)
b) Assuming you had an agonist and an antagonist for every autonomic transmitter receptor, how could you determine which receptor types exist in any autonomically controlled effector (suggestion: construct a table to answer the question). (8 pts)

a)



b)
Problem: unknown receptor
Tools to identify:

1) α-adrenergic agonist
~~2) α-adrenergic antagonist~~
3) β-adrenergic agonist
~~4) β-adrenergic antagonist~~
~~5) Nicotinic agonist~~
~~6) Nicotinic antagonist~~
7) Muscarinic agonist (M_2) inhibitory
8) Muscarinic agonist (M_3) excitatory
~~9) Muscarinic antagonist (M_2) excitatory~~
~~10) Muscarinic antagonist (M_2) inhibitory~~

If you want to determine whether a particular receptor is present, you should administer an agonist of the transmitter that normally binds to that receptor.

An antagonist can only block the effects of transmitters *that are being released at the time the drug is administered*. An antagonist would reduce or eliminate effects that were being produced by the ongoing transmitter secretion and it would reduce or eliminate the effects that the transmitter-receptor complex causes. If no transmitter were currently being released, however, an antagonist would have no effect. Therefore, even if a receptor for that transmitter were present, you would not know. Antagonist may be used for confirmation, but may be inconclusive.

In contrast, if an effector has a receptor, administering an agonist that binds to the receptor will always produce the change in activity that the transmitter normally produces
NOTES:
α-adrenergic agonists generally produce the opposite effects of β-adrenergic agonist when receptors for both are present on an effector cell. Similarly, α-adrenergic agonist generally produces the opposite effects of muscarinic agonists when receptors for both are present (sympathetic / parasympathetic antagonistic effects).
The response to agonists that have the same or opposite actions on an effector may have quite different sensitivities.
Nicotinic receptors are located in autonomic ganglia on the postsynaptic neurons for both sympathetic and parasympathetic pathways; because the postganglionic neurons tend to have opposite effects at the target, the overall action of nicotinic agonist may resemble the effects of either sympathetic or parasympathetic stimulation. The response depends on the relative strengths of their actions and will be difficult to determine.
Sample table below. Assumes a single type of receptor. E=excitatory; I=inhibitory

Receptor type	**α_1-agonist**	**α_2-agonist**	**β_1-agonist**	**β_2-agonist**	**M_2 Muscarinic agonist**	**M_3 Muscarinic agonist**	**Nicotinic agonist**
α_1-adrenergic	**E**	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT
α_2-adrenergic	NO EFFECT	**I**	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT
β_1-adrenergic	NO EFFECT	NO EFFECT	**E**	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT
β_2-adrenergic	NO EFFECT	NO EFFECT	NO EFFECT	**I**	NO EFFECT	NO EFFECT	NO EFFECT
Muscarinic (M_2)	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	**I**	NO EFFECT	NO EFFECT
Muscarinic (M_3)	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	**E**	NO EFFECT
Nicotinic (autonomic)	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	INCON-CLUSIVE
Nicotinic (somatic)	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	NO EFFECT	**E** SKELETAL MUSCLE

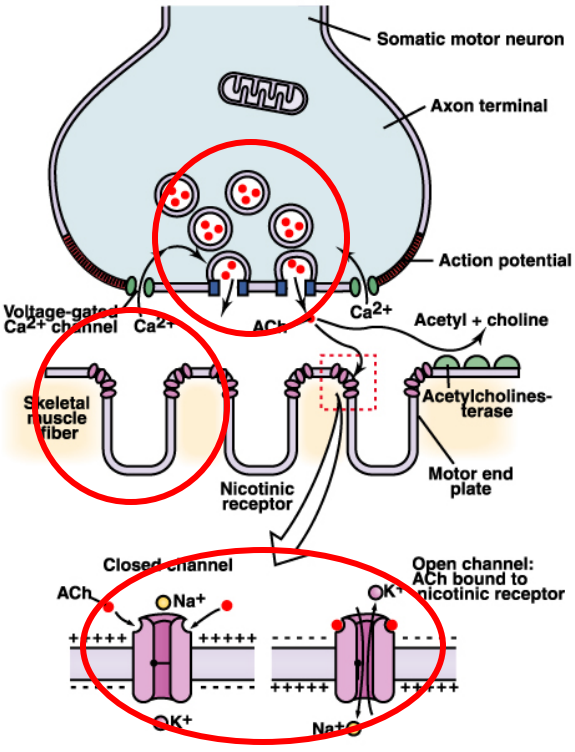
20. A patient presented to his doctor complaining of muscle weakness (20 pts)

a) **List** the loci along the complete motor pathway where some defect may cause these symptoms (10 pts)

b) Upon testing the patient the following observations were made: **1**-repetitive voluntary activity was associated with normal action potential activity in the motor nerve, although the patient's muscle rapidly fatigue and muscle force declined, and **2**-direct, repetitive electrical stimulation of the muscle resulted in normal sustained force without fatigue. Assuming that a single site of pathology is present, where along the motor pathway is this patient's problem. EXPLAIN your answer using both a diagram and a written explanation. (10 pts)

a) **Loci in complete motor pathway**: (full credit does not require info in parentheses)
1-Motor cortex (including primary and secondary motor areas)
2-Descending spinal cord axons (through the thalamus, crossing at the medulla, down the spinal cord)
3-Spinal cord motor neurons (from ventral horn, where cell bodies are)
4-Axon terminals of motor neurons (at the target skeletal muscle fiber)
5-Motor end plate (AchRs, ion channels)
6-Sarcolemma (down T-tubules)
7-Sarcoplasmic reticulum (release of Ca2+)
8-Myosin – actin crossbridges (possible by Ca-troponin-tropomyosin interaction)
9-Force generation mechanism (power stroke)

b) **The problem lies in the neuromuscular junction.** Because voluntary motor effort elicited normal action potential in the motor nerve, the connection between the motor cortex and the motor neurons must be functioning. Stimulating the muscle directly yielded normal muscle function. Therefore, all the elements from the sarcolemma to the force generating mechanism must also be intact. What remains are the structures from the motor axon terminals through the motor end plate. Possible defects (see red circles) could be inadequate neurotransmitter (Ach) synthesis or release, a defect in the AchRs (such as abnormal structure or number of receptors), or a defect in the transducer function of the receptor (e.g., opening of the cation channel). The data do not permit distinction between these alternatives. The disease is likely myasthenia gravis (diagnosis not required for credit).



21. **Name** the parts of the brain stem and <u>one main function</u> of each (6 pts)

1) Medulla
Regulates blood pressure and respiration (w/ pons) (involuntary function)

2) Pons
Relay station between cerebrum and cerebellum; coordination of breathing

3) Midbrain
Control of eye movement, motor control of skeletal muscles
Relay for auditory and visual systems

22. **List** the four cortical lobes (4 pts)

1) **Parietal**
2) **Frontal**
3) **Occipital**
4) **Temporal**

BONUS (5 PTS) Autonomic dysreflexia (increased heart rate / increased blood pressure) often occurs in chronic spinal cord injured patients when the spinal cord attempts to regenerate. Explain why.

Regenerating axons sometimes sprout and form abnormal connections or become re-routed. If autonomic nerves connect to the heart or to blood vessels, this can cause excess sympathetic stimulation, leading to increased heart rate (through excess stimulation to the heart) and increased blood pressure (by constricting blood vessels via smooth muscle contraction).

Questions	Possible points	Points correct
Multiple choice	34	
p. 5	20	
p. 6	16	
p. 7	20	
p. 8	10	
TOTAL	100	