Exam #:_____

Physiological Foundations Spring 2005: Final Examination
May 17, 2005

Name:_____

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EXTRA CREDIT_____/4

TOTAL _____/67

1. (2 pts) **Circle the correct answer.** When a limb muscle is stretched, which of the following events takes place**:**

(A) Spindle afferents of the stretched muscle fire strongly and excite the alpha motor neurons to the same muscle.
(B) Spindle afferents of the stretched muscle fire strongly and excite the gamma motor neurons to the same muscle.
(C) Golgi tendon organ afferents of the stretched muscle respond to the increased force in the muscle as it is being stretched, fire and excite the alpha motor neurons of the same muscle.
(D) A and C.
(E) B and C.

2. (1 pt) **Circle the correct answer.** Suppose that a volunteer practices throwing darts at a dart board. After a period of practice, they become quite good and throw accurately every time. Now the volunteer puts on prism glasses. Their throws now land to the right of the center. After a period of practice, they again learn to throw accurately. Now you ask them to remove the prism glasses and throw at the dart board. You find:

(A) They throw accurately at the center.
(B) They once again throw to the right of the center.
(C) They now throw to the left of the center.

3. (4 pt) What is the difference between the auditory and visual system in the makeup and arrangement of their receptors?

4. (4 pt) When you see and hear a loud speaker located 45 degree above horizon, 45 degree toward your right, the position of the speaker is encoded by both your visual system and auditory systems in parallel. What is the difference between the nature of these two representations? Why? Explain clearly how you arrive at your answers.

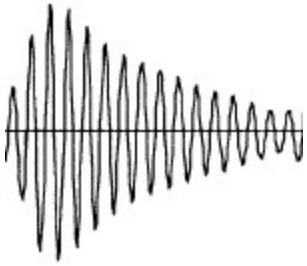
5. (4 pt) Explain (with graphs and words) how a vertical bar on the left visual field and a horizontal bar on the right visual field (both away from the midline) are represented by neurons in the right primary visual cortex (V1).

6. (2 pts) **Circle the correct answer.** What is the width of an action potential produced by a neuron in the mammalian CNS:

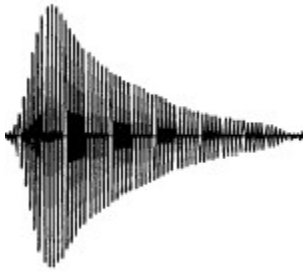
(A) 0.01 msec
(B) 1 msec
(C) 10 msec
(D) 100 msec
(E) 200 msec

7. (1 pt) How would you go about acquiring a "motor map" from the cortex of an animal?

8. (4 pt) The following graph shows the acoustic stimulus used to evoke responses of an auditory-nerve with low-frequency selectivity. The carrier frequency of the stimulus is about 2 kHz. Sketch the period histogram of the neuron's responses to this stimulus. Explain important features of the period histogram you draw and why.



9. (4 pt) The following graph shows the acoustic stimulus used to evoke responses of an auditory-nerve with high-frequency selectivity. The carrier frequency of the stimulus is about 10 kHz. Sketch the period histogram of the neuron's responses to this stimulus. Explain important features of the period histogram you draw and why.



10. (2 pt) **Circle the correct answer.** In a Kohonen self-organizing map, all neurons lie on a two-dimensional grid. They all receive the same inputs but with different synaptic weights, which are updated according to an unsupervised learning rule. Which one of the following statements about the self-organizing map is false?

(A) The update rule observes a neighborhood relationship such that neurons that are very close on the map tend to update their weights similarly.
(B) After training, the final weights can become topology-preserving in the sense that similar inputs will best excite neurons that are close by on the map.
(C) In order to generate a topology-preserving map, the initial weights before training need to be chosen in an orderly manner without much randomness.
(D) Although the neurons lie on a two-dimensional grid, the inputs are not required to be two-dimensional.

11. (2 pt) Name the receptors of the auditory system (in the afferent or ascending pathway). How is frequency selectivity established in the auditory system?

12. (4 pt) Using the primary visual cortex as an example, explain (A) what is a functional sensory map and (B) how it is related to a topographic sensory map.

13. (2 pt) Name the receptors of the visual system (in the afferent pathway). How does the visual system identify color at the receptor level?

14. (4 pts) **Mark the statements below as either true (T) or false (F).** You are recording from two cells in the left hemisphere of a monkey. One cell is located in the premotor cortex while the other is located in the primary motor cortex. The monkey uses his arm to move a large joystick that in turn moves a cursor on the screen. You control fixation by having the monkey always fixate a spot on the screen. You note that both cells fire maximally when the monkey moves the cursor toward the target at 0 degrees.

___ **(A)** The preferred direction of the premotor cortex cell will remain unchanged when you change the fixation spot.
___ **(B)** The preferred direction of the motor cortex cell will remain unchanged when you change the fixation spot.

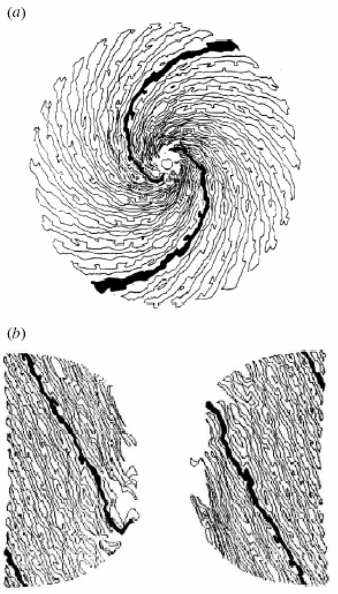
Suppose you now attach some springs to the joystick so that the monkey now needs to produce considerably more force to move the cursor to the target.
Mark the statements below as either true or false.

___ **(C)** For a given direction of motion, the activity in the premotor cortex will remain unchanged.
___ **(D)** For a given direction of motion, the activity in the motor cortex will remain unchanged.

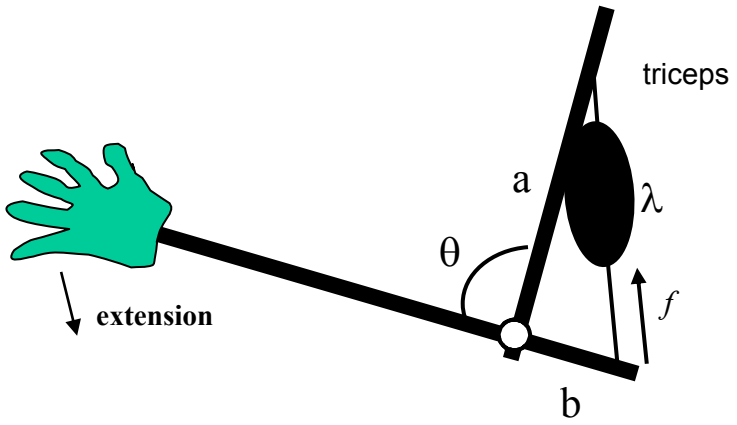
15. (4 pts) The rat motor cortex is mapped, we see that there are regions where activations cause forelimb movements, regions where activations cause vibrissae movements, and regions were activations cause eyelid movements. After peripheral nerve damage to the motor nerve that serves the vibrissae, we now notice that the forelimb motor map has enlarged. Draw a diagram and explain the cortical mechanism of how this change could have happened.

16. (2 pt) **Circle the correct answer.** The diagrams on the right were generated according to the geometric relationship between the visual field and its representation in the primary visual cortex. What are these diagrams supposed to show?

(A) A straight line in the visual field is always mapped to a straight line in the visual cortex.
(B) A straight line in the visual cortex is always mapped to a straight line in the visual field.
(C) Straight lines of visual pattern in both sides of the visual field correspond to spiral activity pattern in the visual cortex.
(D) Parallel waves of activity in the visual cortex correspond to spiral visual pattern.



17. (5 pts) Use the principle of virtual work to compute the torque that is generated by the force produced by this muscle. The muscle's length is λ.



18. Circle the correct answer. (2 pts) When a person is sleep, the medullary reticulospinal tract is:

(A) Highly active.
(B) Weakly active.
(C) Inhibiting limb muscles.
(D) A and C.

19. (2 pt) Sketch a "psychometric function" that describes a subject's performance in detecting the presence of a tone in background noise. Assume that the loudness of the noise is constant (over long term). The intensity (loudness) of the tone varies from a scale of 0 (no sound) to 10.

20. (4 pt) If Subject-a has a better hearing and is more sensitive to tone than Subject-b and Subject-c is less sensitive than Subject-b, sketch the psychometric functions of all three subjects on the same graph.

21. Circle the correct answer. (2 pts) Gamma motor neurons:

(A) Innervate extra-fusal muscle fibers and help generate force in the muscle.
(B) Innervate intra-fusal muscle fibers and control sensitivity of muscle spindles.
(C) Innervate the tendon region and control sensitivity of Golgi tendon organ afferents.
(D) Respond to a muscle stretch by increasing their discharge.

22. (2 pts) Name the major descending tract that originates from the motor cortex and sends axons to the spinal cord. Are the axons in this tract relatively slow or relatively fast conducting (as compared to other descending tracts from the brain)?

23. (4 pts) We are examining a cell's output in the posterior parietal cortex. The animal is fixating a dot on the screen in front of him (say at a location that we name 0cm). We flash a light at 5 cm (i.e., to the right of the fixation) and note the response of the cell. We continue to flash lights at 4, 3, 2, 1, -1, -2, -3, -4, and -5cm. We note that this cell has a receptive field that has its center at -1cm.

(1 pt) Draw a receptive field for this cell.

(1 pt) Now we move the fixation spot to the 2cm mark on the screen. Where on the screen would you expect to find that a flash of light produces the maximum response in the cell?

(2 pt) Suppose we compare the firing rate of the cell in two conditions: when the animal was fixating at 0cm and we flashed a light at 1cm (condition 1), and when the animal was fixating at 2cm and we flashed a light at 3cm (condition 2). We find that the firing rate in condition 1 is half of the firing rate in condition 2. What would be the firing rate in condition 1 with respect to condition 2 if in condition 1, we had flashed the light at 2cm and in condition 2 we had flashed the light at 4cm? Explain.

EXTRA CREDIT

(2 pt) Posterior Parietal Cortex neurons have fixation-centered receptive fields. Briefly explain and draw what this means and how a target in the same visual space may affect this type of neuron differently depending on fixation.

(1 pt) What is Phantom Limb Pain? (1 pt) What is the cause of this pain?