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Biology 3330, midterm#2, Fall 2005

1) (5pts) Describe the two mechanisms by which the central nervous system controls muscle force (2-3 sentences). In your answer, explain how Ohms law plays a role in this process.

(1) (1)
- Recruitment of motor neurons - size princ. V=IR ∴ larger EPSP for smaller cells (higher R)
- (1) Increased frequency of Firing of motor neurons.

2) (6pts) Reflexes function to stabilize/smooth motor behavior. Many reflexes can be 'gated' or modulated. Give an example of reflex gating or reflex modulation; in your answer, explain what is meant by the term.

eg. Insect Flight reflexive steering movements of abdomen (corrective steering) - in response to turbulence/wind - is gated by behavioral state of Flight (legs must not be touching GND

3. Matching (8 pts)

C Supplementary motor cortex

E Red Nucleus

B Pontine and medullary reticular N.

A Semicircular Canals

K Vestibular Nuclei

D Otolithic organs

G Mesencephalic locomotor region

F Primary motor cortex

A. Senses angular acceleration

B. Important for control of posture

C. Planning of complex movements, active during imagined movements.

D. Sense linear acceleration and gravity.

E. Controls distal musculature of limbs.

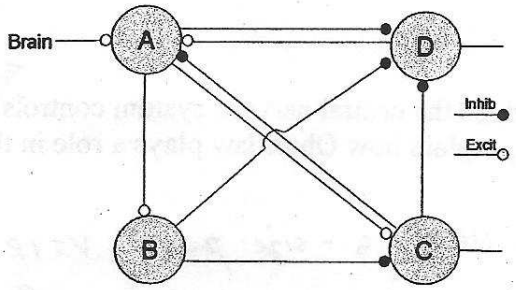
F. Active prior to voluntary movements, particularly the hands and fingers.

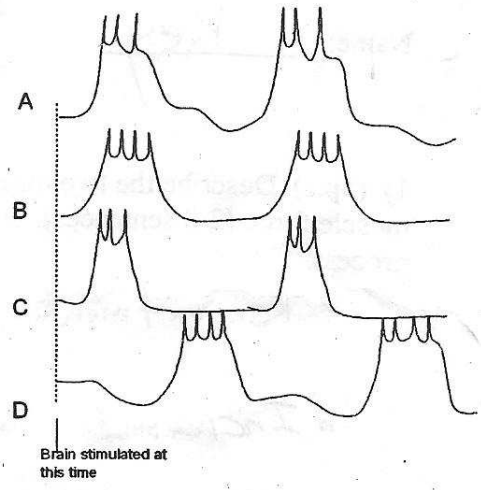
G. Command center for swimming in fish

H. Project to spinal cord and oculomotor nuclei.

19)

4. (10pts) The neural circuit shown below is a central pattern generator. A rhythmic output can be triggered by stimulating input from the brain.



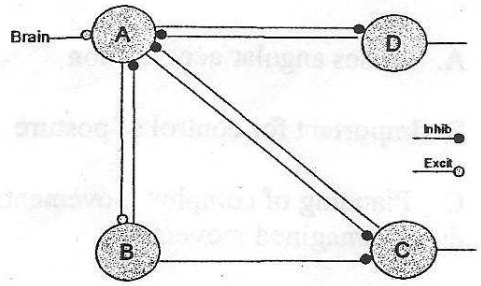


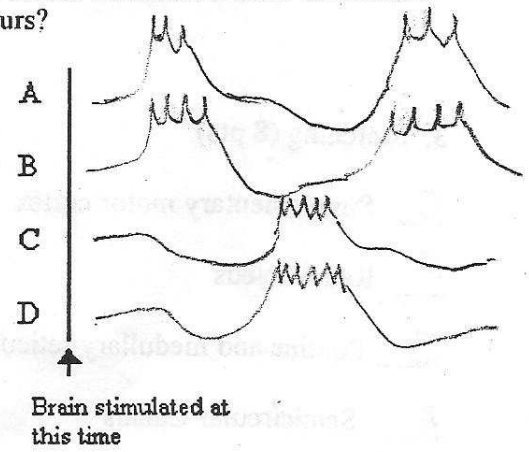
a) Based on your knowledge of central pattern generators, what mechanism is likely to underlie the generation of this rhythm? What experiment could you perform to test this hypothesis? (2 sentences). 'pacemaker' neurons) - endogenous bursting properties must exist. Test by laser ablating cells, isolate individual neurons & see if rhythmically active

3

You find that this network receives input from a dopaminergic neuron. When this cell is stimulated, the functional connectivity of this network is transformed to that shown below and the rhythm is slowed.

b) Draw the voltage recordings that you would expect to see. In addition to the decrease in oscillation frequency, what other major change occurs?





c) You find that loading neuron A with a Ca chelator (Ca binding molecule) disrupts its rhythmic firing properties, and stops the pattern generation. Explain this result (what does it suggest concerning mechanisms of rhythmic firing?).

3

Basis of Endogenous Bursting

A Ca^{+2} dependent K+ g may be is responsible for the repolarization phase - Ca+ enters during the depol. phase, builds up, K+ channels open causing repolarization.

10

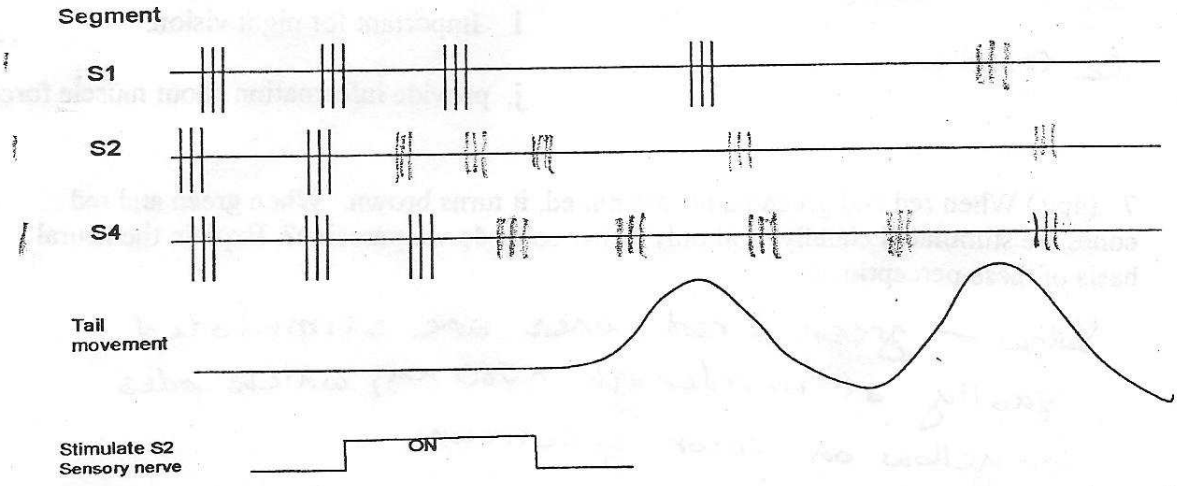
5. (8pts) Early research aimed at understanding the neural basis of rhythmic behaviors focused on whether rhythmic motor output was a consequence of sensory feedback or the activity of central pattern generators.

a) . What network property was thought to be responsible for pattern generation? Why is this network property alone insufficient for rhythmic pattern generation?

2 • Reciprocal inhibition

Fails to sustain oscillatory activity

b) Using the example of the neural basis of dogfish (shark) swimming, demonstrate the roles of sensory feedback and central pattern generators by drawing (completing) the patterns of activity of motor neurons for spinal segments S1, S2, and S4. Note that the sensory nerves to segment #2 are stimulated prior to the onset of the tail movement. Segments 3 & 4 were deafferented at the beginning of the experiment. Other experimental conditions are as described in the book. Briefly explain your placement of the bursts of spikes.



S1

1 . Sensory Feedback from tail motion slows the CPG

1 . Activity in S2 lags that of S1, but stim. of sensory Nerves speeds up (spinal) CPG

1 . S4 - No sensory (ray/event) Feedback ∴ Oscillatory rhythm is not influenced by tail motion.

8

6. (10 pts) Match the sentence on the right with the corresponding term on the left: one letter per space.

_c_ Meissner's corpuscle

_i_ Rods

_d_ hair follicle receptors

_a_ free nerve endings

_h_ neuromast

_b_ muscle spindle organs

_j_ Golgi tendon organs

_f_ Pacinian corpuscle

_g_ Ruffini's endorgan

_e_ Cones

a. temperature and pain sensation, tickle

b. stretch receptors that signal disparities between expected and actual muscle length

c. sensitive to light touch, in hairless skin

d. sensitive to light touch

e. mediate color vision

f. vibration sensors

g. pressure sensor, slowly adapting

h. receptors in the lateral line of fishes

i Important for night vision.

j. provide information about muscle force

7. (4pts) When red and green paints are mixed, it turns brown. When green and red cones are stimulated equally (and only) what color do we perceive? Explain the neural basis of these perceptions.

Yellow — green & red cones are stimulated equally at wavelength ~560 nm, which codes for yellow on color spectrum.

8. (4pts) Differentiate between exafferent and reafferent sensory information. Give an example of each.

exafferent ~ sensory input from outside world

ex: Wind in your face from AC

reafferent ~ sensory input from your own actions

ex: Wind in your face while running

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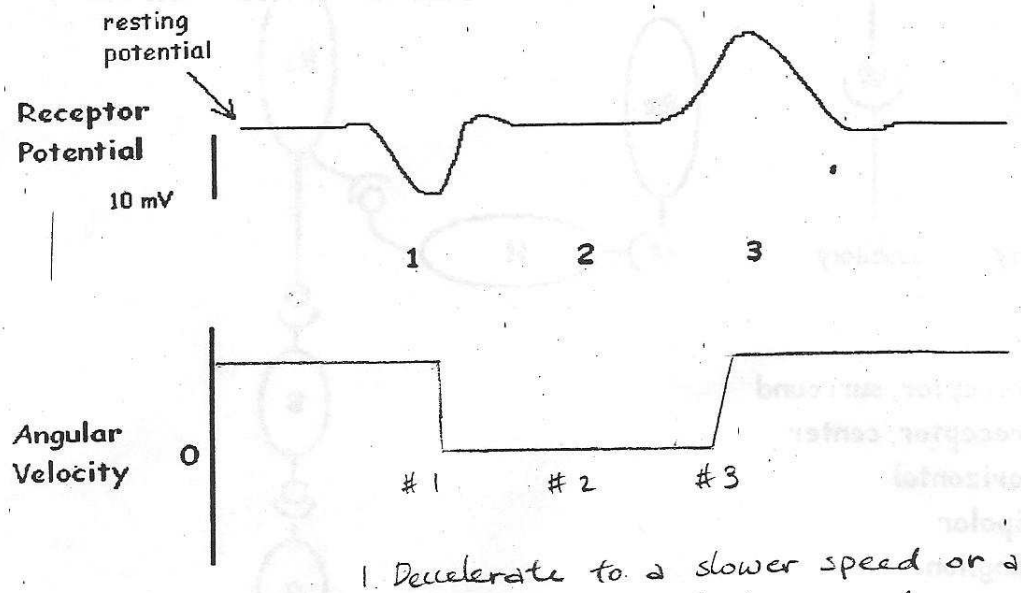
9. (6pts) Below is a receptor potential of a vestibular receptor during a "merry-go-round" ride.



1. Decelerate to a slower speed or a complete stop
2. Remain at the slower speed or stay motionless
3. Accelerate to a higher speed

The receptor hyperpolarizes, adapts, depolarizes, then adapts again. Draw the corresponding plot of the angular velocity of your head during the ride. Explain your rationale at each of the numbered sections of the curve.

10. Visual Pathway

a) (5pts) Match the property of the visual system with the location at which it first occurs.

C Center-surround receptive fields	A. MT
A Specialized for image motion analysis	B. visual cortex
B Complex cells	C. retina
E Separation of position and motion	D. temporal cortex
D Face recognition	E. LGN

b) (6pts) Transformation of visual information occurs between the LGN and visual cortex. Describe this transformation (i.e. - the effective stimulus in neurons in these regions). In your answer, include whether this is hierarchical (serial) or parallel processing.

Processing is hierarchical (serial).

LGN responds to spots of light (center - surround fashion)

Visual cortex responds to bars of light at a particular orientation. This is due to input from many LGN neurons - New info extracted at higher layers

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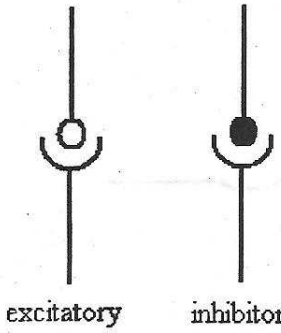
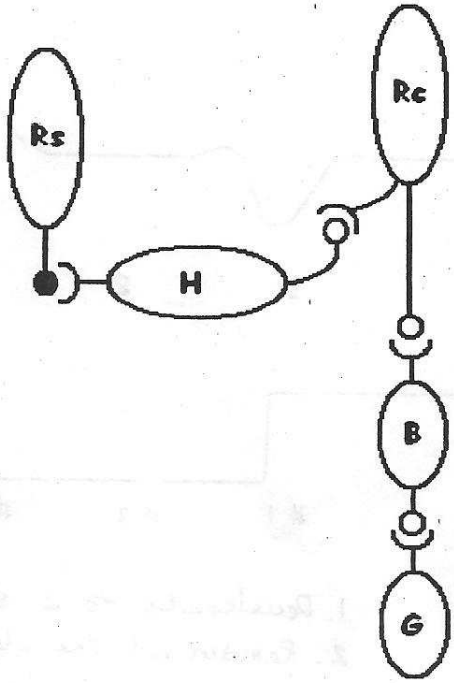
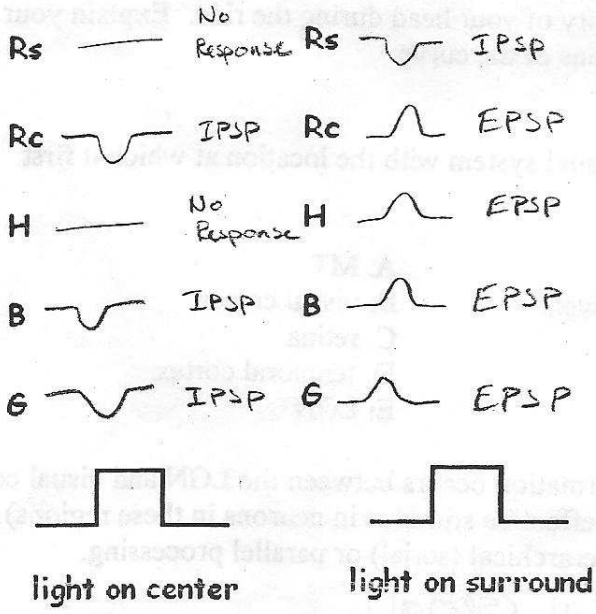
11. (5pts) Draw the receptor potentials (EPSP/IPSP) you would expect to record from each cell in response to light.





Rs = receptor, surround
Rc = receptor, center
H = horizontal
B = bipolar
G = ganglion



5

12. (11pts)

a) You have learned that 2nd messenger systems are important in synaptic transm These 2nd messenger pathways are also important in stimulus transduction in the gustatory and olfactory systems. Complete the chart showing how sensory stimul transduced by filling the blanks. Each blank can have more than one answer, and answers can be used more than once.

Stimulus	Enzyme Activated	2nd messenger effects	Action	Membran
visual--light	F	G	N, I	H
gustatory--sugar	A	O	K	D
olfactory--odor	A, M	O, E	J, P	D
gustatory--bitter	M	C, E	B, L	D

A. Adenylyl cyclase
B. Increase Ca2+ release
C. Increased DAG
D. Depolarization
E. Increased IP3
F. PDE
G. Decreased cGMP
H. Hyperpolarization
I. Na+ channels close
J. Cyclic nucleotide gated channels open
K. PKA phosphorylates K+ channel, closing it
L. PKC phosphorylates K+ channel, closing it
M. PLC
N. Decreased Ca2+ entr
O. Increased
P. Ca2+ cha open

b) (4pts) In the gustatory system, "sour" and "salty" are transduced in a non-2nd messenger method. For each of the following, describe a non-2nd messenger mei transduction. In your answer, include which type of channel is affected.

- Sour Presence of H^+ closes ligand sensitive K^+ [illegible] of K^+ depolarizes the cell

- Salty Presence of Na^+ causes a large influx of through [illegible]

13. a) (2pts) How does a computational map differ from a noncomputational map?

computational map requires 2 parameters, mapped in non-spatial organization

non-computational is mapped in periphery, spatial organization

b) (6pts) For each of the following, state whether it is a computational map or noncomputational map. Explain briefly.

- Tonotopic map

Noncomputational

frequency is mapped in the periphery, therefore, tonotopic in CNS is not a result of computation

- Relative target velocity map in bats

Computational

ex. Doppler shift in bat's echolocation

two parameters, the bat's cry frequency & the frequency of the cry's returning call compared

- Retinotopic map

Noncomputational

- Visual field already mapped in retina