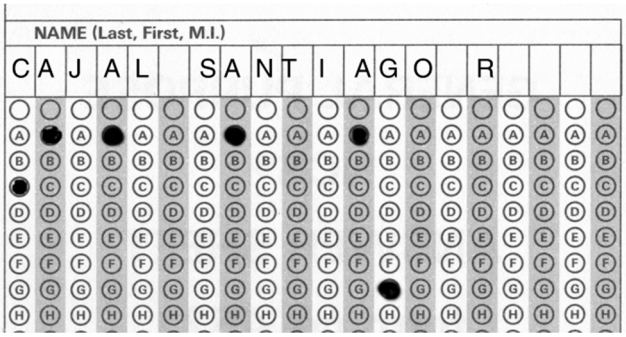
Last name:_____ First:_____ MI:___ Cornell ID number:_____

Exam 2 - KEY

BioNB 2220: Introduction to Neuroscience

1. Write your name on this exam **AND** on your scantron sheet.
2. Answers to all multiple choice questions should be recorded on the **SCANTRON** in pen/pencil. Short answer questions should be written on this EXAM PAPER IN PEN. The examples to the right show you how to fill in the scantron "bubbles" properly.



3. **Write legibly. If we cannot read your answer, we cannot grade it.** Use ONLY the space provided. Do NOT use calculators or any other electronic device.
4. Check to see that your exam paper is complete. This exam packet has **9** pages.
5. Fill the answer circles completely. If you make a mistake either erase completely **OR put an X over the incorrect bubble**.

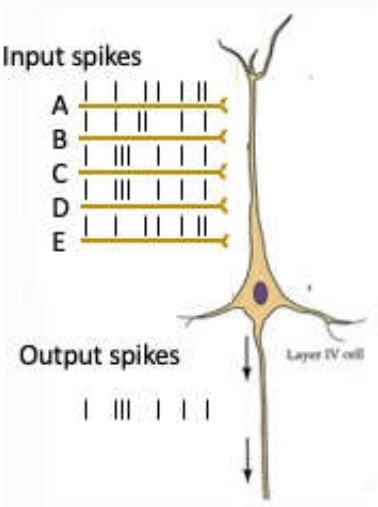
"By signing below, I acknowledge that I am abiding by Cornell University's Code of Academic Integrity."

Signature: _____

Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	SA	MC	TOTAL
9	**8**	**8**	**7**	**7**	**5**	**9**	**7**	**60**	**40**	**100**

MULTIPLE CHOICE (5 points each)

1. The neuron in the figure to the right shows a cell in the visual cortex receiving visual input. During development, some of these synapses will become stronger and some synapses will be pruned away. Which synapses are likely to become stronger based on the pattern of action potential firing shown in the pre and postsynaptic cells?



   a) Neurons A and B
   b) Neurons A and E
   c) Neurons B and C
   d) Neurons B and D
   e) Neurons C and D

2. If the extracellular space were depleted of Mg^{2+}, NMDA receptors would:

   a) Be always open
   b) Lose their voltage dependence
   c) Let Cl^- ions into the cell
   d) Be closed even when glutamate was binding
   e) Open to let Ca^{2+} in at higher voltage than normal

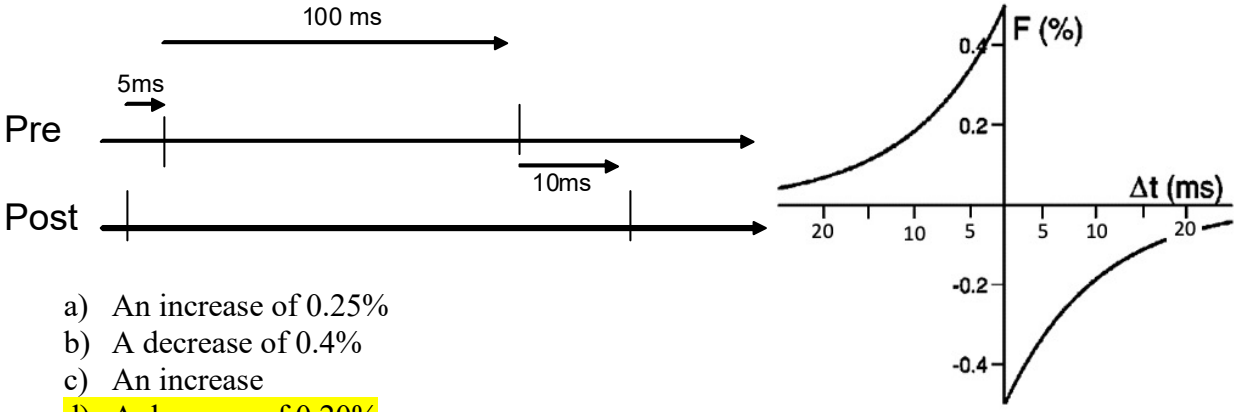
3. If a neuromodulator depolarized both the pre and postsynaptic cells by 10mV, how would LTP at the synapse between these cells be affected, assuming the stimuli to the pre and postsynaptic cells are the same?

   a) There would be no change
   b) LTP would decrease
   c) LTP would increase
   d) There would be LTD instead
   e) None of the above

4. You are a scientist studying amphibian brain regions involved in parental care. Which of these is the fastest and most direct way to identify cells that become active during parental care behaviors?

   a) Brain slice recordings
   b) Optogenetics
   c) Immediate early genes
   d) Nissl stain

5. Given the spike trains below and the STDP curve below, what change in synaptic plasticity would you expect? Note that 100 ms far enough apart that spikes will not affect each other.



a) An increase of 0.25%
b) A decrease of 0.4%
c) An increase
d) A decrease of 0.20%
e) No change

6. The neuron whose activity is shown in the histogram below is likely coding for:

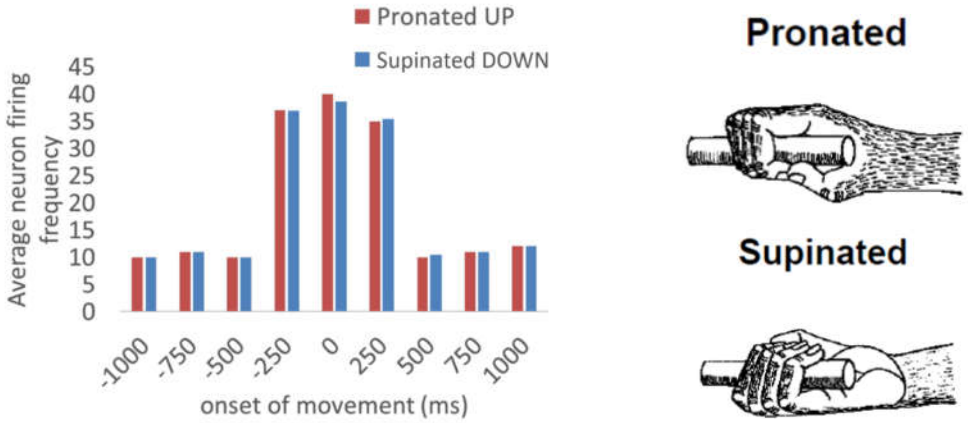
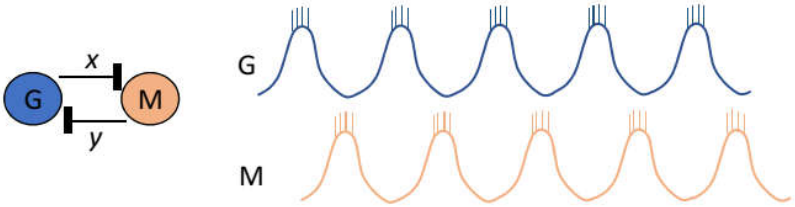


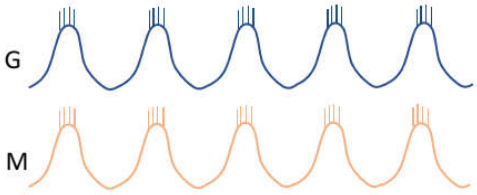
Fig: Pronated hand (red) moves bar UP, Supinated hand (blue) moves bar DOWN

a) Kinetics
b) Kinematics
c) Affordance
d) All of the above
e) None of the above

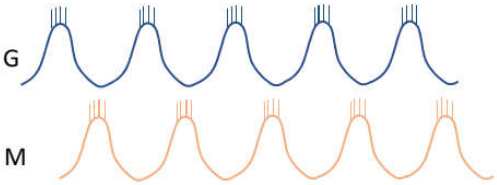
7. The diagram below shows the firing patterns of two neurons G and M with reciprocal inhibition, *neither* of which is intrinsically bursting. What would happen to the firing pattern of both neurons if a synaptic blocker selectively blocked <u>inhibitory synapse *y*</u>?



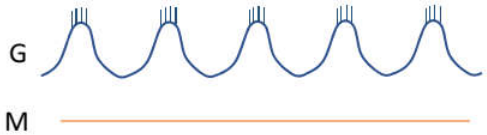
a)



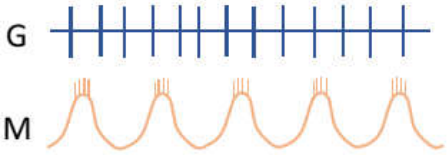
b)



c)



d)



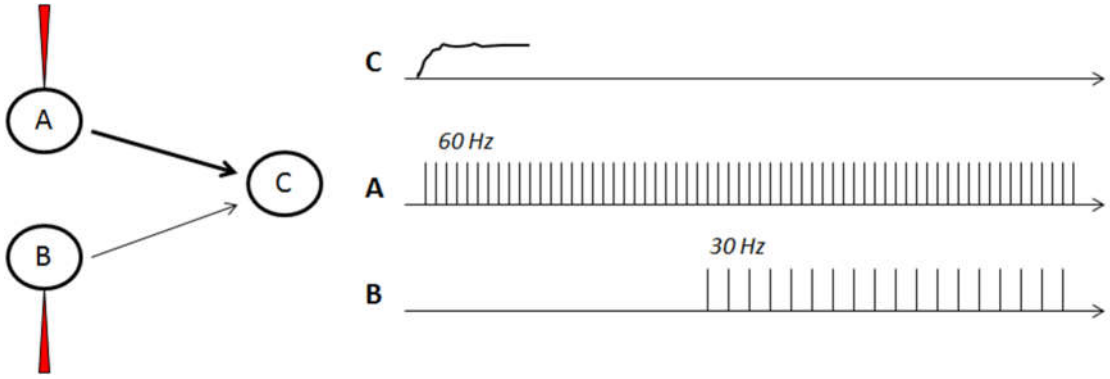
e)

8. Which of the following about circuitry within the cerebellum is true?

   a) There are two main inputs (Parallel fibers & Climbing fibers) and two main outputs (Purkinje cells & Granule cells)
   b) Purkinje cells are innervated by several thousand parallel fibers and one mossy fiber
   c) There is one main output (Purkinje cells) and two main inputs (Climbing fibers & Mossy Fibers)
   d) Mossy fibers directly connect to Purkinje cells that innervate parallel fibers

SHORT ANSWER

9. (9 pts.) Neurons A, B and C are being studied in vitro. Neuron A has a strong excitatory synapse with Neuron C. Neuron B has a weak excitatory synapse with Neuron C. Neuron A is strongly stimulated with 60Hz pulses. During this stimulation, Neuron B also begins to receive constant stimulation at 30Hz. Ignore STDP and see the figure below for illustration.



a) Continue the trace C showing the membrane voltage in cell C during this experiment.

Trace would continue or get higher when B is stimulated

b) Do you think this experiment increased, decreased, or maintained the synaptic strength between Neurons B and C? Briefly explain your reasoning.

Circle one: Increase Decrease Maintain

Rapid stimulation of A depolarizes neuron C such that Mg+ can be released. When B is stimulated, Glu is released. At that moment in time, the post synaptic cell is depolarized when the pre synaptic cell fires and there is LTP.

10. (8 pts.) You have found a new autoimmune disorder that reduces the effectiveness of a protein required for calcium removal from the inside of a cell.

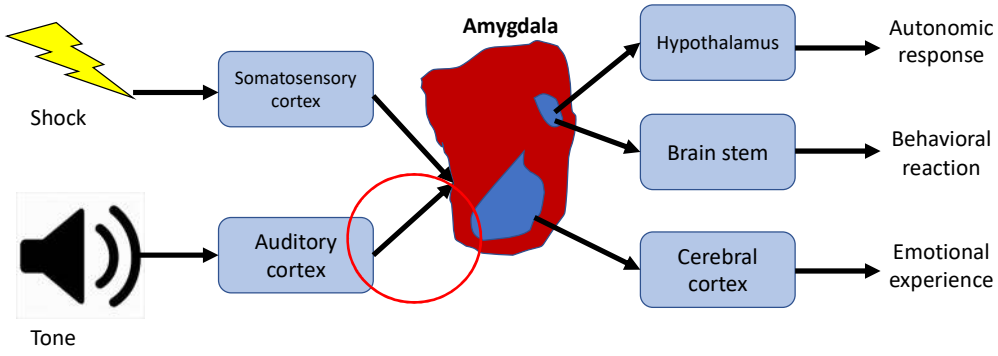
a) What effect would this disorder have on synaptic plasticity if the protein is only in the presynaptic terminal and why? Justify your answer (1-2 sentences).

A reduction in Ca removal from the presynaptic terminal would lead to an increase in facilitation, because residual calcium would combine with calcium influx triggered by the AP to bind to calcium sensors and promote vesicle release. Credit may be given for other, logically argued hypotheses.

b) What effect would this disorder have on synaptic plasticity if the protein is only in the postsynaptic terminal and why? Justify your answer (1-2 sentences).

A reduction in Ca removal from the postsynaptic terminal would tend to increase the Ca concentration and tip the balance from LTD to LTP.

11. (8 pts.) In fear conditioning, animals learn to freeze in response to a conditioned stimulus (tone) when the tone is paired with a shock. Given the current knowledge on fear conditioning circuitry shown in the figure below:



a) Clearly circle which synapse in the graph should be affected by fear conditioning.
Red circle on the graph

b) This synapse will have (circle one): Increased OR Decreased synaptic strength.

c) Explain your answer to (b) (1 sentence):

After animal is well-trained, the brain forms the association between tone and freeze response by forming a LTP in the synapse between auditory cortex and amygdala. The former is involved in tone detection and the latter is involved in driving freezing response. Critical concept: the key association is between sound and fear, so that synapse is where the action is.

12. (7 pts.) a) What is runaway synaptic plasticity (1 sentence)?

As the strength of the connection of a synapse increases, the postsynaptic cell's firing rate will increase and will cause other presynaptic partners, whose activity has hitherto been uncorrelated with the postsynaptic cell's activity, to become correlated and formed LTP with postsynaptic firing. In the end, most synpases in the network are strengthened. For full credit it is necessary to mention how positive loop strengthens OTHER neighboring synapses of the same postsynaptic neuron)

b) How would it damage/disrupt memory (1-2 sentences)?

If runaway synaptic plasticity did occur, the relative synaptic weights to a postsynaptic neuron cannot be preserved and eventually all synapses would become maximally potentiated. The change in relative weights of synapse would result in mismatching irrelevant associations and false memory, and the lack of differing weights of synapses would result in loss of the encoding of the memory. For full credit it is necessary to mention mismatched association.

c) How can it be prevented? Name **one** mechanism the brain could use to reduce runaway synaptic plasticity, and explain how it would work (1-2 sentences).

Possible answer 1: Synaptic scaling (pruning) occurs after periods of chronically elevated neural activity in a neural circuit by decreasing the strength of each synapse in the circuit by the same factor so that the relative weighting of each synapse is preserved. (AMPA receptors reduce in the postsynaptic neurons.)

Possible answer 2: Spike Timing Dependent Plasticity can prevent runaway plasticity to happen

Possible answer 3: Any mechanism that weakens the synaptic strength, such as LTD. Any mechanism that reduces release from presynaptic neuron and suppress the presynaptic firing, such as endocannabinoid.

Possible answer 4: Co-release or retrograde release of of inhibitory transmitters or modulators to maintain the relative weights among synapses.

13. (7 pts.) a) Briefly explain the concept of Hebbian assembly (1 sentence).

A network in which stimuli are represented in a distributed manner and neurons that fire together will see their synapses become stronger.

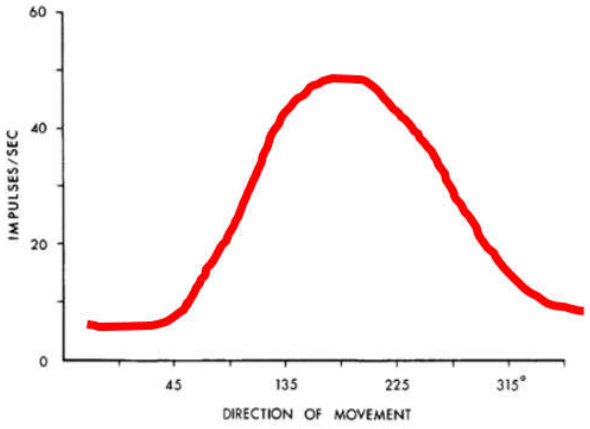
b) Explain how you can recall a memory when you are shown only part of the original stimulus (1 sentence).

Because previously neurons activated by a common stimulus created strong synapses between them, even a partial or distorted stimulus will reactivate the original neurons.

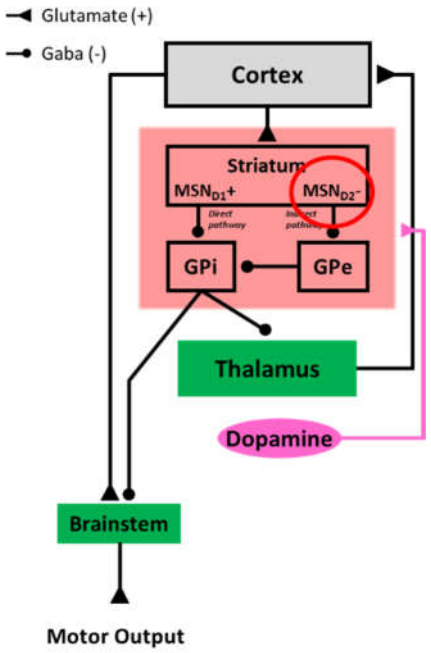
c) Explain how such a network can be resilient to some loss of synapses and neurons (1 sentence).

Because each neuron receives input from many neurons and information is distributed even when some neurons are lost there is still enough information

14. (5 pts.) You are recording from a single neuron in the motor cortex of a thirsty monkey performing the center-out reach task. This neuron showed strong direction selectivity for 180 degrees. In the following graph, draw a likely result from your data.



15. (9 pts.) Draw the basal ganglia microcircuit in the space below, including the direct and indirect pathways. After drawing the picture, circle the type of MSN that could cause a hyperkinetic disorder if lesioned. Explain your answer (1 sentence).

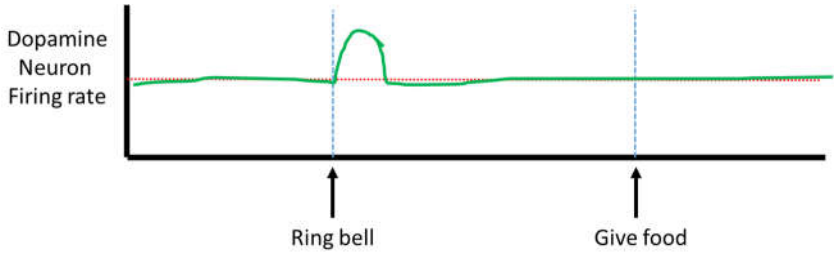


Explanation:

If MSN D2 neurons are lesioned they can't inhibit GPe, so GPe is active, which inhibits GPi. Thus GPi is inhibited, so brainstem and thalamus are disinhibited and can activate motor regions, causing hyperkinesis.

16. (7 pts.) You have trained your dog over several years that every time you ring a bell, you give him food 5 seconds later. In the graph below, draw the response you expect to see in one of your dog's midbrain dopamine neurons. Explain your answer in the space below (1-2 sentences). (dashed red line indicates baseline dopamine firing rate, blue vertical lines indicate the timing of each event)

Key:



Explanation:
Dopamine neurons increase firing after unexpected positive outcomes. The bell ringing is unexpected and positive because it is already associated with a positive event (food), so dopamine neurons increase firing upon hearing the bell ring. When food is delivered, that outcome is as expected, and not better than or worse than the expectation, so dopamine firing rate remains at baseline.

End of Exam 2