

7.013 Problem Set 6 FRIDAY April 9nd, 2004

Problem sets will NOT be accepted late.

Question 1

A. Boston Red Sox Fran No. 1 has dissected the following neuron and needs your help to label its parts. Use the words from Column A below.

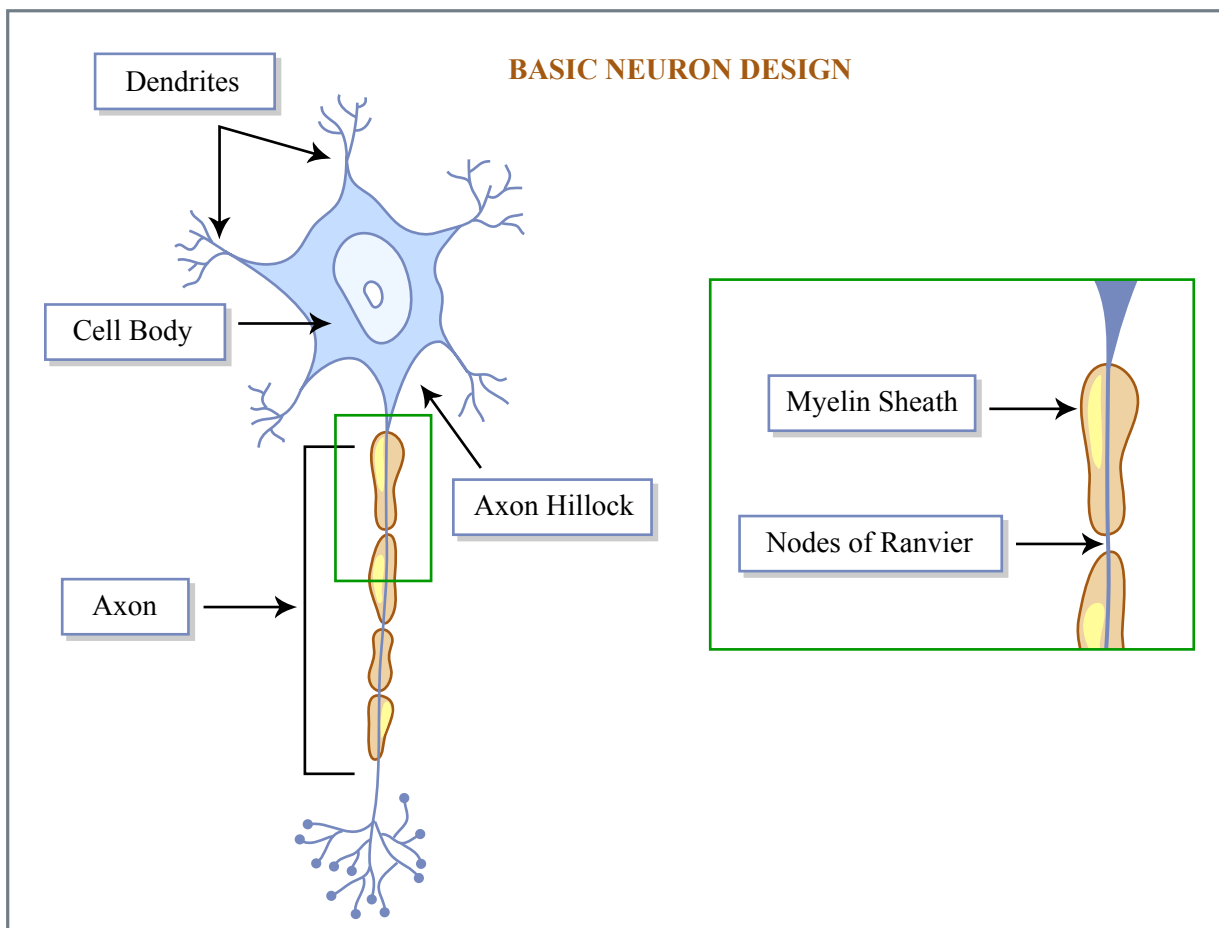


Figure by MIT OCW.

B. Match the following terms in Column A with their corresponding functions in Column B

Column A	Column B
___a___ Axon Terminal	a) Part of a neuron that transmits an electrical signal to another neuron
___f___ Nodes of Ranvier	b) Short, highly branched fiber that carries signals toward the cell body of a neuron
___d___ Cell Body	c) Layers of Schwann cells that coat the Dendrites axons of many neurons and help to conduct electrical impulses along axons.
___c___ Myelin Sheath	d) The part that contains the nucleus and most of the cytoplasm and organelles.
___b___ Dendrite	e) The part of the neuron where action potentials are generated.
___g___ axon	f) A gap between two of the Schwann cells that make up an axon's myelin sheath; serves as a point for generating a nerve impulse
___e___ axon hillock	g) region along which the axon potential propagates

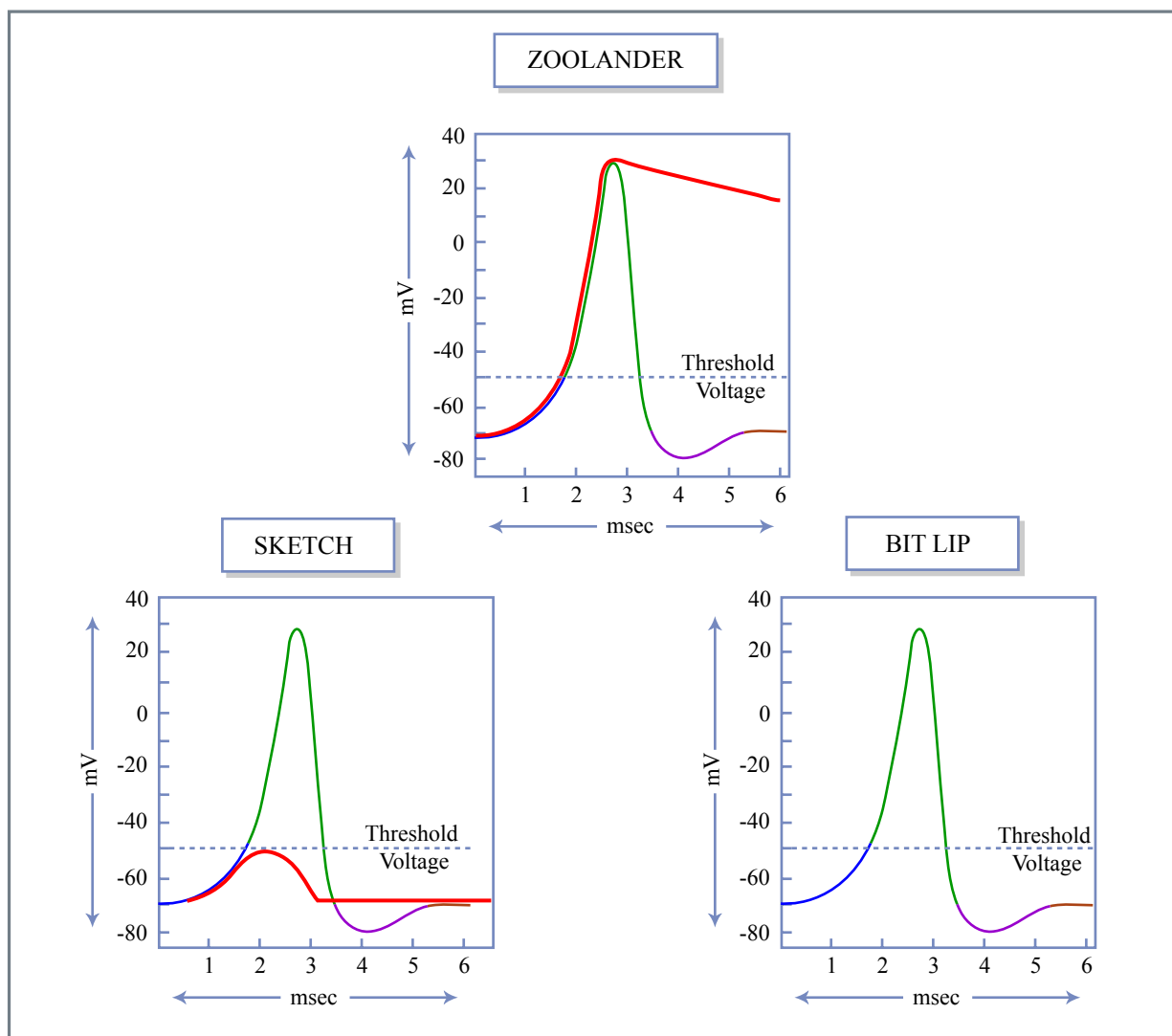
Question 2

Jon Cucabura with a PhD in Logarithmic Mutations is studying three mutant neurons named *Zoolander*, *Sketch*, and *BitLip*. Below is a diagram of a representative action potential. Using this diagram as a template carefully draw any change(s) that would occur in the structure of the action potential as a result of the mutations.

Zoolander: mutation resulting in a cell lacking the voltage-gated K^+ channel

Sketch: Mutation resulting in a cell lacking the voltage-gated Na^+ channel

BitLip: Mutation that completely blocks the neuron terminus voltage-gated Ca^{++} channel pump.



Figures by MIT OCW.

Question 3

SlowMo is a nerve gas that works by irreversibly interacting with a serine residue in the active site of acetylcholinesterase, the enzyme responsible for removing acetylcholine (ACh) from the synaptic cleft. SlowMo causes death by affecting the muscles involved in breathing. Explain, at the molecular level, how this might occur.

By eliminating AChase, the neurotransmitter ACh is not removed from the synaptic cleft. Therefore, ACh continually binds its receptors on the muscle, causing continual contraction of the muscle and spastic muscle paralysis. Too much ACh around-muscles always contracting --> rigid paralysis.

Question 4

A. Answer True or False. **All true.**

1. Cone cells sense colors and Rod cells sense black, white and depth.
2. A neuron cannot refire during the refractory period.
3. Neuron guidance is aided by both attractive and repulsive chemotaxes.

B. Multiple Choice

1. During chemical synaptic transmission, which of the following sequences of events occurs in a presynaptic neuron?

Depolarization of the terminal --> Ca^{2+} entry --> AP in axon --> vesicle fusion --> transmitter release.

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2. Which of the following substances is capable of functioning as a neurotransmitter?

- a. acetylcholine
- b. glutamic acid
- c. nitric oxide
- d. glycine
- e. aspartic acid
- f. epinephrine
- g. all of the above function as neurotransmitters.

3. "Sodium inactivation" refers to

- a. **the inability of sodium to move across the membrane.**
- b. the expulsion of sodium from the neuron by the sodium pump.
- c. the movement of sodium during presynaptic inhibition.
- d. the closing of the sodium channels a short time after they have opened.

4. Nodes of Ranvier are

- a. places where two neurons can communicate.
- b. **the gaps in the myelin sheath of a neuron.**
- c. points of contact between a neuron and a glial cell.
- d. swellings on an axon where transmission can take place.

5. IPSP (Inhibitory postsynaptic potential) stimulates a neuron to

- a. depolarize.
- b. repolarize.
- c. **hyperpolarize.**
- d. stay in resting state

6. Binding between a transmitter substance and a receptor molecule

- a. requires ATP.
- b. can take place only in the presence of calcium ions.
- c. **is a temporary association that breaks spontaneously.**
- d. is a stable association that must be broken by specialized enzymes.

7. Temporal summation is made possible by

- a. the fact that postsynaptic potentials spread some distance from their point of origin.
- b. **the fact that postsynaptic potentials last some time after their instance of generation.**
- c. the increase in size of postsynaptic potentials in a series.
- d. the nature of the ion channels that open at the synapse.

8. The all-or-none principle of nerve action states that

- a. the entire length of the nerve conducts an action potential or no part does.
- b. **an action potential always reaches its maximum strength or it doesn't appear at all.**
- c. all available ions contribute to the rise and fall of the action potential or none do.
- d. all synapses on a neuron must be active in order for them to excite another neuron or muscle.

9. In the growing embryo, neurons migrate along paths "paved" with

- a. ephrins
- b. ephrin receptors
- c. **laminin**
- d. netrin

Question 5

Early one morning, two scientists Chil and Praig are sharing chocolate chip pancakes at IHOP, after a long night of intense experimentation with a protein called Joi-NT (a neurotransmitter) in their laboratory. When the waitress, MoAss, brings them the check, they scramble for their wallets, and soon realize that they must have forgotten them in the lab. Not knowing what to do, and having a tendency to act impulsively, they come up with a plan to race out of the IHOP when MoAss goes into the back kitchen, since they're the only customers at the restaurant.

As soon as she leaves the seating area, Praig leaps out of his seat, sprints to the door, and starts making his way through the parking lot and down Peter Pan Ave. Chil, acting rather chill, calmly walks out of the IHOP, confident that he's too good to get caught. Just as the door shuts behind him, MoAss sees that no money has been left on the table and that they have already left. She immediately drops the dishes in her hands, and starts running after the two scientists. Surprise! Chil hears her coming, and takes off sprinting towards Praig. Chil and Praig run all the way to their lab, JoiNTville.

During their sprint home, the two scientists notice that their hands get sweaty, their hearts begin to race, their blood pressures increase, the hairs on the necks are sticking upright, they are breathing faster, and their pupils get dilated (they look at each others eyes).

Explain what type of autonomic neurological response is described in the paragraph above, and compare it to the type of response that was active as the scientists were eating pancakes at IHOP. In your answer, be sure to explain what triggers each response and indicate any characteristics associated with each response (except for those described in the previous paragraph).

Exposed to outside stress, such as the chase by the waitress, the body shifts into a "defense mode", maximally activating its sympathetic system. □The sympathetic system (mainly adrenaline based) focuses on short-term survival. It shuts down "unnecessary" functions like bowel activity and gears everything up for fighting or running away (the two basic responses that our forebears had when confronting a sabre-toothed tiger). □lood is diverted from the bowel to muscles. □The pupils dilate in order that smaller changes in light intensity and movement can be more quickly seen. The heart beats faster to get oxygen and energy to the muscles faster. The airways dilate so that oxygen can get into the blood stream quicker and more efficiently.

In contrast to defense behavior, there is feeding behavior. □As the scientists were eating pancakes at IHOP, parasympathetic impulses prevail. □Attention is withdrawn from the surroundings. □People become sleepy, intestinal activity increases, and the abdomen with its digestive organs receives more blood. Circulation in the skeletal muscles decreases, as do blood pressure and heart rate, the pupils constrict. □Here, the organism does not contract, but expands energetically outwards and is in a state of relaxation. □On the other hand, attention is directed inwards.