Active Membrane:

1- Looking at the following IV curves for Na$^+$ and K$^+$, obtained under voltage-clamp configuration.
   a. Explain the events happening at points: A, B, C, D, E and F on the curve.
   b. Where would point D be located if the concentrations for Na$^+$ had been $[\text{Na}^+]_{\text{out}}=500\text{mM}$; $[\text{Na}^+]_{\text{in}}=50\text{mM}$, at the time the measurements were done? And where if the concentrations of K$^+$ had been: $[\text{K}^+]_{\text{out}}=50\text{mM}$; $[\text{K}^+]_{\text{in}}=500\text{mM}$?
   c. How would the curve of $I_{\text{Na}^+}$ look like, if before doing the measurements:
      i. We applied TTX to the bath.
      ii. We added pronase to the inside of the cell.

2- Voltage gated Sodium channels have 3 possible conformations. Which are they? What triggers the transition between them?
   a. Draw the plot of current vs time for the Na$^+$ current in response to a constant voltage step going from –60mV to 0mV and show at which state is the channel in the different points of the curve.
   b. How would the curve look like if you injected pronase into the cell before doing your measurements? Draw the curve and explain the similarities and differences with the curve of (a).
**Action Potential Propagation:**

1- The following is a diagram of a snapshot of a propagating action potential:

![Direction of Propagation](image)

- **c.** Draw the flow of current in the 3 areas delimited by the dotted lines. What ions are carrying these currents?
- **d.** What is the significance of the last segment for the direction of propagation of an action potential?
- **e.** What is meant by ‘Displacement Current’? What is it responsible for?

2- This is a portion of a squid giant axon that is at rest. With an electrode, you inject depolarizing current into the midpoint of the axon.

![Current](image)

- **a.** Draw the flow of current.
- **b.** If enough current is injected so that the axon’s membrane is brought to threshold, the axon will be capable of firing an action potential. Which direction will this action potential follow? Why?
3- Using intracellular electrodes, you initiate action potentials simultaneously at the two ends of a long, giant squid axon. The action potentials propagate towards the midpoint of the axon. What will happen when (and after) they reach the mid-point? Explain your answer in terms of the mechanisms underlying action potential generation/propagation.

4- Define and explain time and space constant. What do they depend on?

5- Mark True or False:
   a. Action potential conduction down the axon involves passive current flow.
   b. Poisoning the Na-K ATPase pump in a neuron would lengthen the refractory period.
   c. Oligodendrocytes secrete the myelin that surrounds the neurons in the peripheral nervous system.
   d. While action potential conduction is in ‘jumps’ (Saltatory Conduction) in myelinated axons, conduction in non-myelinated axons is continuous.

**Synaptic Transmission:**

1- Define/Explain:
   a. Synaptic Cleft
   b. Neurotransmitter
   c. Chemical synapse
   d. Electrical synapse
   e. Neuro-Muscular Junction
   f. Quanta. (in relation to synaptic transmission)

2- What are GAP JUNCTIONS? What is their role in synaptic transmission? Explain how they are structured.

3- What are the main differences and similarities between chemical and electrical synapses?

4- The leech is a very powerful experimental model for the study of the single synapse and network properties. Since it has a very small number of neurons, people have been able to label each individual neuron and study how they are connected. Two of these neurons are called P and AP and are involved in mechanosensation. While you know that P and AP cells are connected, you do not know what type of synapse underlies their communication. In order to study these, you isolate both neurons and place them in culture where in time, you hope they will form synapses. (Many times, when researchers want to study the properties of the synapses between two individual neurons, they place these neurons in petri dishes with a medium appropriate for their survival (‘cultured neurons’).)
When you stimulate with either stimulating electrode you see the following responses in the opposite cell:

Stimulate with electrode 1

Stimulate with electrode 2

a. Are these cells synaptically connected? What evidence do you have?
b. If they are connected, what type of synapse could be connecting these two cells?
   i. Do you have enough information to distinguish between the two possibilities?
   ii. What parameters in the postsynaptic response could you look at to help you?
   iii. Suggest at least 2 experiments that you could do to differentiate between the 2 possibilities.