Univ. of Illinois, Urbana-Champaign
Bio/Neuro 303

EXAM I Study Questions

107. A good definition of a nerve impulse is

*a. a transient change in the charge on the membrane of the cell which moves along the length of the neurite.
b. a sudden influx of sodium ions.
c. a sudden influx of potassium ions.
d. a change in membrane potential with a definite time course.

108. 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 it.

109. One reason that action potentials are all-or-none is that

a. they are always the same size in a given neuron.
b. axonal membranes do not allow partial electrical responses to electrical stimuli.
c. they must travel long distances without decrement.
*d. once the membrane potential is past threshold, the influx of Na^+ keeps driving it more positive until the maximum number of Na^+ channels is open.

110. In a given neuron, action potentials are always the same size under normal conditions. This statement

*a. is true because the concentrations of the inward and outward flowing ions don't change appreciably over time in normal cells.
b. must be false because it is known that AP's change size during facilitation.
c. is true because action potentials are never recorded the same size twice extracellularly.
d. must be false because the flow of ions during one AP changes the concentration gradients enough to the affect the size of the next AP.

111. A typical intracellularly recorded resting potential for a neuron is

a. about +54 mV
*b. about -60 mV
c. indeterminate, because you cannot determine the resting potential from the Nernst equation, which would apply to the intracellular recording situation.
d. nothing, because you cannot record a resting potential by using intracellular recording.

112. Hodgkin and Huxley

a. demonstrated the quantal nature of neuromuscular transmission.
b. described the physiological properties of synaptic transmission.
*c. revealed the quantitative movements of ions across the membrane that lead to an action potential.
d. studied the quantitative relation between ion movements and the post synaptic potential in a squid.

113. The conductance of an ion depends on

*a. the density of open channels for that ion in the membrane.
b. the concentration and electrical gradients of the ion.
c. the total number of all channels for that ion in the membrane.
d. all of the above.

114. A voltage sensitive ion channel is a channel

*a. whose conductance to an ion changes as the membrane potential changes.
b. that allows different ions to pass through when the membrane potential is near zero than when it does when the membrane potential is near resting level.
c. that desensitizes when the neuron depolarizes.
d. that becomes non-functional when the membrane becomes inside positive.

115. During the rising phase of an action potential the current flow is dominated by

a. an inward K^+ current.
b. an outward K^+ current.
*c. an inward Na^+ current.
d. an outward Na^+ current.

116. The main ionic carrier of inward current flow during the rising phase of the action potential is

a. K^+.
b. Ca^{2+}.
c. Cl^-.
*d. Na^+.

117. The rapid depolarization of an axonal membrane during the rising phase of the action potential is due to

a. an increase in sodium resistance.
b. an increase in sodium connectance.
*c. an increase in sodium conductance.
d. an increase in the sodium equilibrium potential.

118. The refractory period occurs because

a. the neuron cannot fire again until the membrane potential returns to below threshold.
b. pre-synaptic inhibition prevents over-firing and cellular exhaustion.
c. sodium and potassium concentrations must be restored, and the "battery" recharged, before another action potential can be generated.

*d. voltage-gated channels become inactivated for a short time following an action potential.

119. When cation gates (for positive ions) open during the rising phase of the action potential, the influx of the ion is due to

a. the ion's concentration gradient, the membrane potential, the action of an ion exchange pump and the energy imparted to the ions as they pass through channels in the membrane.
b. the ion's concentration gradient, the membrane potential and the action of an ion exchange pump, only.
*c. the ion's concentration gradient and the membrane potential, only.
d. the ion's concentration gradient only.

120. During the action potential the nerve cell can be considered a sodium battery <u>because</u>

a. there is movement of sodium across the membrane.
*b. the membrane potential at the peak of the action potential is mainly determined by the external concentration of Na^+.
c. sodium must be pumped out again later.
d. more sodium rushes in than potassium rushes out.

121. Suppose you insert a single electrode into the middle of a squid giant axon and apply a supra-threshold stimulus. The result will be

a. a single action potential traveling <u>toward</u> the cell soma, <u>away from</u> the end of the axon.
b. a single action potential traveling <u>away from</u> the cell soma, <u>toward</u> the end of the axon.
*c. two action potentials traveling in opposite directions along the axon.
d. no action potential, since supra-threshold stimuli must be applied at the soma to be effective.

122. In neurons, a voltage clamp device is used to measure

a. the resting membrane potential.
*b. current flow under certain experimental conditions.
c. the currents flowing at the peak of the action potential.
d. the potential at the peak of the action potential.

123. Which of the following is NOT an important factor in the generation of and recovery from an action potential in a squid giant axon?

a. The increase in sodium conductance.
b. The efflux of potassium.
c. Depolarization of the membrane to a potential above threshold.
*d. The influx of calcium.

124. In a voltage clamp device, the variable that is measured is

a. the current flowing into the cell only.
b. the current flowing out of the cell only.
c. the K^+ current only.
*d. the net current flowing across the membrane in either direction.

125. Voltage clamp devices work by

- a. controlling the flow of ions across the cell membrane.
- b. stimulating the cell until it responds.
- *c. generating current to oppose that which flows through the cell's open ion channels.
- d. shutting down certain ion channels so no current can flow through them.

126. Measurement of the net current flowing across the membrane of a neuron can be made with

- a. an intracellular microelectrode.
- b. an extracellular electrode.
- *c. a voltage clamp device.
- d. none of the above.

127. In a voltage clamp experiment, the quantity that the experimenter wants to determine is

- a. the total resistance of the membrane due to passive ion channels.
- b. the capacitance of the membrane due to the lipid bilayer.
- c. the voltage across the membrane due to ion concentration differences.
- *d. the current flowing across the membrane through active and passive channels.

128. In a voltage clamp experiment, the quantity that the experimenter wants to determine is

- a. the total resistance of the membrane due to passive ion channels.
- b. the capacitance of the membrane due to the lipid bilayer.
- c. the voltage across the membrane due to ion concentration differences.
- *d. the current flowing across the membrane through gated and non-gated channels.

129. The movements of sodium and potassium ions during the action potential do not cancel each other out because

- a. the ions are moving in opposite directions.
- b. the ions are moving in the same direction.
- *c. potassium conductance changes more slowly than does sodium conductance as membrane potential changes.
- d. sodium conductance changes more slowly than does potassium conductance as membrane potential changes.

130. The theoretical limit to the peak of the action potential is

- *a. $E_{Na}+$
- b. E_K+
- c. $E_{Na}+$ - E_K+
- d. E_K+ - $E_{Na}+$

131. The ionic basis for an action potential is usually the opening of

- a. Na^+ channels alone.

b. K^+ or Cl^- channels alone.
c. Na^+ and K^+ channels simultaneously.
*d. Na^+ channels first, followed by K^+ channels.

132. A reduction in the size (peak potential) of an action potential can be brought about by

a. increasing the external K^+ concentration.
b. increasing the external Na^+ concentration.
c. decreasing the external K^+ concentration.
*d. decreasing the external Na^+ concentration.

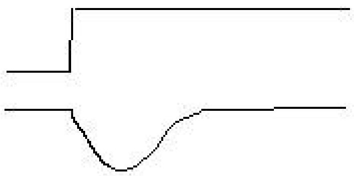
133. Halving the external sodium concentration around a neuron would do what to an action potential?

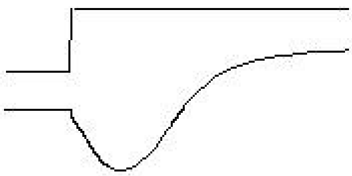
*a. Reduce its amplitude.
b. Increase its amplitude.
c. Eliminate it.
d. Leave it unchanged.

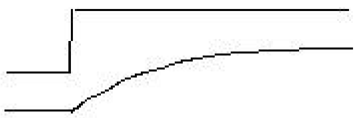
134. Raising substantially the <u>internal</u> concentration of sodium in an axon would do what to an action potential?

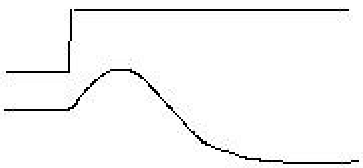
a. Increase its amplitude.
*b. Reduce its amplitude.
c. Prevent its development by blocking ion channels from the inside.
d. Leave it unchanged.

135. After infusing Tetraethylammonium (TEA) into the intracellular axoplasm of a squid giant axon to selectively block K^+ channels, you perform a voltage clamp experiment on the axon, starting at a resting potential of -60 mV and stepping to a potential of 0 mV. Which of the following diagrams best represents the voltage and current traces you would observe?

*a. 

b. 

c. 

d. 

136. "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, independent of the membrane potential.

137. During the absolute refractory period of a neuron, the threshold of the neuron is extremely high because

a. it can not be depolarized, due to a temporary increase in Cl^- conductance.
b. an action potential has just passed by.
*c. sodium inactivation has closed the sodium channels temporarily so they do not open in response to reductions in membrane potential.
d. all the external sodium has entered the neuron and must be pumped out before the nerve can fire again.

138. Suppose you apply electrodes to the middle of a squid giant axon and apply a supra-threshold stimulus. The result will be

*a. two action potentials, one traveling toward the cell soma, one traveling toward the end of the axon.
b. no action potential, since supra-threshold stimuli must be applied on a dendrite to be effective.
c. a single action potential traveling <u>toward</u> the cell soma, <u>away from</u> the end of the axon.
d. a single action potential traveling <u>away from</u> the cell soma, <u>toward</u> the end of the axon.

139. The repolarization of the membrane during an action potential is due largely to

*a. an increase in K^+ conductance.
b. the passive influx of Cl^- ions inside the neuron.
c. the opening of Na^+ channels.
d. action of the ATP-dependent Na-K pump, which recreates the ion gradients.

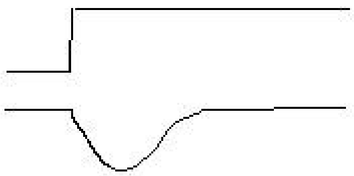
140. The process of conduction of an action potential involves the following steps

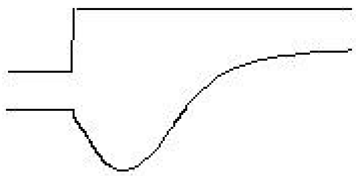
*a. depolarization --> increase Na^+ conductance --> increased K^+ conductance and Na^+ inactivation --> decreased K^+ conductance.
b. increased Na^+ conductance --> depolarization --> increased K^+ conductance and Na^+ inactivation --> decreased K^+ conductance.
c. depolarization --> decreased K^+ conductance --> increased Na^+ conductance --> increased K^+ conductance and Na^+ inactivation.
d. increased Na^+ conductance --> decreased K^+ conductance --> increased K^+ conductance and Na^+ inactivation --> depolarization.

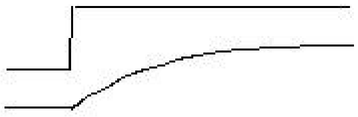
141. In the patch clamp method,

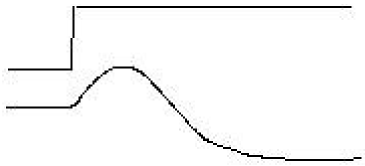
a. a spring-loaded pair of electrodes are used, which "clamp" a nerve to obtain better recordings of small action potentials.
b. a micropipette is used to iontophoretically adjust ion concentrations to "clamp" membrane potentials.
*c. a micropipette is applied by suction to a small area of cell membrane for study of the properties of individual ion channels.
d. a tiny clamp is applied to a small area of cell membrane to stabilize it for detailed molecular analysis.

142. Tetrodotoxin (TTX), a toxin extracted from the tropical puffer fish, has the property of selectively blocking Na^+ axonal channels. After infusing TTX in the extracellular bath (normal salt water), you perform a voltage clamp experiment on a squid giant neuron. Which of the following diagrams best represents the current flow you would measure?

a. 

b. 

*c. 

d. 

143. Hodgkin and Huxley came back from a visit to Gully's to do a demonstration of their voltage clamp experiment. Unfortunately, they accidentally clamped the squid axon at -80 mV instead of 0 mV, in normal saline. The result was an initial

a. net outward current produced by the cell due to the efflux of both K^+ and Na^+ ions.
b. net outward current produced by the cell due to the efflux of Na^+ ions and some influx of K^+ ions.
c. net inward current produced by the cell due to the influx of Na^+ ions and some efflux of K^+ ions.
*d. net inward current produced by the cell due to the influx of both K^+ and Na^+ ions.

144. Which of the following statements is true for most dendritic membrane AND for axonal membrane just after an action potential has passed (i.e., during the refractive period)

a. There are receptor sites available to bind with transmitter substance.
*b. There are no voltage-sensitive sodium channels in an operational state.
c. There are no voltage-sensitive potassium channels in an operational state.
d. The membrane has high permeability to calcium ions.

145. Most dendritic membrane cannot carry an action potential because

a. it is not myelinated.
b. most dendrites are stimulated by chemical transmission rather than electrical currents, and since an action potential is electrical, dendrites can not carry one.
c. it lacks a spike initiation zone.
*d. it lacks voltage-sensitive (sodium) channels.

146. Most dendritic membrane cannot carry an action potential because

a. the currents generated by the action potential in the pre-synaptic terminal are carried away in the extracellular fluid and thus do not cross the post-synaptic dendritic membrane.
b. dendrites are usually too short.
*c. it lacks voltage-sensitive sodium channels.
d. the internal resistance of dendrites is too great to allow current to spread far.

147. Most dendritic membrane cannot carry an action potential because

a. dendrites are too small in diameter.
*b. it lacks voltage-sensitive sodium channels.
c. dendrites are too far from the spike initiation zone.
d. its space constant is usually too small to let a post-synaptic potential reach threshold.

148. Action potentials travel relatively slowly along unmyelinated axons that have small diameters because

a. the Na^+/K^+ exchange pump cannot pump out Na^+ fast enough to restore the membrane potential quickly.
b. there are relatively few ion channels per mm^2 in the axonal membrane.
*c. the internal resistance of the axoplasm is higher, retarding the spread of electrical charges along the axon.
d. the electrical resistance of the axonal membrane is higher, slowing down the rate at which the membrane can depolarize.

149. Patch clamping refers to a technique

*a. for manipulating the voltage across a restricted patch of membrane so that the ion flow through single channels can be studied.
b. for grasping a patch of membrane tightly, to make it possible to penetrate small, hard-to-record-from cells in the CNS.
c. used by Hodgkin & Huxley to determine resting potentials in squid giant axons.
d. used by Hodgkin & Huxley to determine which ions carry the action potential in squid giant axons.

150. In the patch clamp method,

a. a spring-loaded pair of electrodes are used, which "clamp" a nerve to obtain better recordings of small action potentials.
b. a glass microelectrode is used to iontophoretically adjust ion concentrations to so as to hold membrane potentials at pre-selected values.
*c. a glass microelectrode is applied by suction to a small area of cell membrane for study of the properties of individual ion channels.
d. a tiny clamp is applied to a small area of cell membrane to stabilize it for detailed molecular analysis.

151. Saltatory conduction describes

a. the transmission of action potentials in a chain of excitatory synapses.
b. the fact that the electrical charges generated on dendrites have to jump to the axon hillock to trigger an action potential.
*c. the appearance of action potentials at discrete places along a

myelinated axon.
  d. the jumping of ions from one side of the membrane to the other during an action potential.

152. In two axons of the same diameter, a myelinated axon will conduct impulses faster than an unmyelinated one because

  a. the channels through which ions flow are larger in the myelinated axon, allowing more rapid depolarization.
  b. there are more sodium channels per mm^2 of membrane in the myelinated axon.
  *c. currents due to the presence of the action potential spread farther along the length of the myelinated axon before they cause generation of a new action potential.
  d. myelinated axons have a lower internal resistance to the flow of ionic currents.

153. As a rule, saltatory conduction is faster than non-saltatory conduction because

  a. myelinated neurons have a lower internal resistance than do non-myelinated ones, thereby leading to faster conduction.
  *b. the insulation provided by myelin forces the depolarizing current farther down the axon, thereby allowing the AP to skip parts of the membrane.
  c. myelinated axons are bigger than non-myelinated ones, and larger diameter axons conduct faster.
  d. the concentration of sodium channels at the nodes generates much larger than normal Na^+ currents, which generate faster conduction.

154. Saltatory conduction is the jumping of

  a. the membrane potential during the action potential.
  b. the membrane potential during an EPSP.
  *c. an action potential from node to node of a myelinated nerve.
  d. ions across the membrane during the action potential.

155. Functionally, the presence of myelin around an axon

  *a. increases the conduction velocity of action potentials in that axon.
  b. decreases the conduction velocity of action potentials in that axon.
  c. has no effect on conduction velocity.
  d. increases the conduction velocity of action potentials traveling in one direction, but not in the other.

156. Consider two axons with similar electrical properties and physical dimensions. If axon A has twice as many nodes of Ranvier per cm of length, then the conduction velocity of action potentials in A ______ relative to the velocity of the AP in the other axon.

  a. will be greater
  *b. will be smaller
  c. will be the same
  d. can not be determined

157. Subjecting a neuron to a metabolic poison will over the short term not affect the ability of the neuron to conduct an action potential. This shows that

a. the Na^+/K^+ pump is not required for an action potential to be generated.
b. no metabolic energy is required to drive the movement of ions during the action potential.
c. the energy of the action potential comes from stored (potential) energy.
*d. statements a, b, and c above are all true.

158. Ouabain is a drug that inhibits the Na^+-K^+ pump in a nerve cell. Applying the drug to a squid giant axon would within 10 minutes destroy the cell's ability to generate an action potential because

a. Ouabain blocks the voltage-sensitive Na^+ channels needed to generate action potentials.
b. Ouabain blocks the voltage-sensitive K^+ channels needed to recover from action potentials.
c. Stopping the pump quickly allows the inward leak of Na^+ and the outward leak of K^+ to depolarize the cell to 0 mV so no action potential can be generated.
*d. ... the premise is wrong. The cell's ability to generate an action potential will not be affected in the first 10 minutes.

159. The immediate energy required for an action potential is

a. stored in the form of ATP.
*b. the potential energy of the ion imbalances across the membrane.
c. the energy contained in the structure of the cell membrane.
d. none of the above.