Weeks 1 and 2 Questions
Neurons and Glia, Resting Membrane Potential, Action Potential, Synaptic Transmission

2005-1

1. You inject a RETROGRADE tracer into the cerebral cortex of a little horse named Peter. AXOPLASMIC TRANSPORT will carry the tracer to the _____ of neurons that have _____ near the site of injection.

a) axon terminals / cell bodies
b) axon terminals / dendrites
c) cell bodies / axon terminals
d) cell bodies / dendrites

2. Which of the following is correct about glia?

a) glia reside only in the frontal lobe
b) glia make up 90% of the cells in the brain
c) glia fire action potentials
d) the brain can function normally without glia

3. A guy got fired from your lab for not keeping his notebook up to date. Your job is to analyze the slides he prepared. Under the microscope you see scattered, beautiful, fully labeled neurons. You conclude that he used:

a) a nissl stain
b) a golgi stain
c) a cajal stain
d) a professor Stein

4. The Neuron Doctrine was championed by _____, and the Reticular Theory was supported by _____.

a) Nissl, Cajal
b) Golgi, Nissl
c) Cajal, Golgi
d) Penrose, Darwin

5. Which of the following would you expect to see in the brain of a patient with Alzheimer's Dementia?

a) Neurofibrillary Tangles
b) Tau Proteins dissociated from microtubules
c) Axon degeneration
d) All of the above
e) none of the above

6. Dendrites differ from axons because:
a) Dendrites are uniform in diameter whereas axons taper
b) Axons can have spines or be smooth, whereas dendrites always have spines.
c) On average, dendrites are shorter in length whereas axons are longer
d) Axons can be postsynaptic surfaces whereas dendrites cannot
e) The dendrite is a die hard supporter of the Yankees, whereas the axon is just obsessed with the Red Sox

7. In making neuronal proteins:
a) DNA must first be translated into mRNA
b) Ribosomes assemble the proteins from amino acids
c) Ribosomes attached to the Golgi apparatus fold proteins
d) Gene expression is defined as the assembly of amino acids into proteins
e) All of the above

8. Dr. Evil has injected you with a toxin whose only effect is to open ion channels. The presence of the toxin causes neurons to ***depolarizes***. Based on what you know about ion channels, this drug
a) opens Chloride channels
b) opens Sodium channels
c) opens Potassim channels
d) is similar to what you get when you eat some Japanese blowfish with fresh ripe scorpion covered in dinoflagellate cream sauce

9. Ion Y is negatively charged and more concentrated inside the cell. The equilibrium potential for this ion is:
a) Positive
b) Negative
c) cannot be determined
d) only the little horse named Peter knows

10. Which of the following statements are true about ion channels?
a) Ion channels are proteins
b) Ion channels are selectively permeable to different ions
c) Ion channels can be gated
d) A,B and C
e) B and C

11. You attend a competition that the neuroscience department is sponsoring. The first person who creates a cell with a resting membrane potential that is ***more*** negative than the regular resting membrane potential wins an A in BN1. How would you go about doing this?
a) Increase the concentration of extracellular sodium (add NaCl outside)
b) Increase Chloride permeability at rest
c) Increase the concentration of intracellular potassium (add KCl inside)
d) Decease the concentration of extracellular potassium. (remove KCl outside)
e) More than one of the above

12. All of the following are necessary in order for there to be a net flux (movement) of sodium across the membrane EXCEPT
a) a membrane that is permeable to Na
b) $(V_m - E_{Na})$ does not equal zero
c) a membrane potential that is negative.
d) There are no exceptions, all of the above are necessary in order to have a net movement of sodium.

13. Neurons are incapable of firing action potentials during the refractory period. This is a result of the ____ of _____channels.
a) inactivation / Na^+
b) deinactivation / Na^+
c) inactivation / delayed rectifier
d) deinactivation / delayed rectifier

14. Ion X^+ is in equal concentration outside and inside a typical neuron. The neuron is at a resting potential of –65 mV. If the membrane were made permeable to ion X^+, the cell would
a) depolarize.
b) Hyperpolarize
c) neither depolarize or hyperpolarize

15. The rising phase of the action potential:
a) depends on the activation of 'delayed rectifier' channels
b) is associated with an increase in sodium permeability
c) ends when sodium channels de-inactivate
d) takes membrane potential to values closer to the equilibrium potential for potassium

16. All of the following statements about the falling phase of the action potential are true EXCEPT:
a) it is partially based on the inactivation of sodium channels
b) it is partially based on the opening of potassium channels
c) it involves delayed rectifier channels that stay open as long as the membrane is depolarized
d) it causes a ten fold change in the intracellular concentration of potassium

17. During what part of the action potential is membrane potential closest to the equilibrium potential of potassium?
a) rising phase
b) falling phase
c) overshoot
d) undershoot
e) turkey shoot

18. When the neuronal membrane is at rest:
a) the driving force on sodium is high and the conductance is low
b) the driving force on sodium is high and the conductance is high
c) the driving force on sodium is low and the conductance is low
d) the driving force on sodium is low and the conductance is high
e) sodium shouldn't be driving if it is high

19. Saltatory conduction
a) explains how action potentials jump from one neuron to the next
b) requires the presence of gaps in the myelin sheath
c) helps enhance spatial summation in dendrites
d) shortens the length constant

20. How can neurons signal an increase in stimulus strength?
a) By increasing the maximum voltage reached during an action potential
b) By decreasing the duration of the action potential
c) By increasing the rate of firing of action potentials
d) By transiently increasing myelination around the axon
e) By decreasing the action potential threshold

21. You decide to take your chances and have some of that amazing puffer fish you've heard so much about. Unfortunately, your sushi chef got his license from a questionable online university and he leaves in too much tetrodotoxin (TTX). The sensory neurons in your lips stop firing action potentials and your lips go numb because:
a) the TTX blocks potassium channels, hyperpolarizing the membrane
b) the TTX blocks sodium channels, preventing the membrane from hyperpolarizing
c) the TTX blocks sodium channels, preventing the membrane from depolarizing
d) the TTX opens sodium channels, depolarizing the membrane
e) of the amazing kiss from the sushi chef

22. All of the following are true statements about equilibrium potential (Eq) EXCEPT:
a) it is calculated from the Nernst equation
b) the Eq for one ion depends on the concentration of all ions inside and outside the membrane
c) it is the membrane potential at which diffusion and electrical forces are balanced
d) it is a unique value for each ion

23. Gap Junctions:
a) transform electrical signals into chemical signals
b) are more common in neurons than glial cells
c) let electrical signals pass through, but block the flow of ions
d) all of the above
e) none of the above

24. If a neuron did not have vesicular transporters, synaptic vesicles could not be loaded and therefore
a) the neuron could NOT fire action potentials or release neurotransmitters
b) the neuron could fire action potentials, but NOT release neurotransmitters
c) the neuron could NOT fire action potentials, but could still release neurotransmitters
d) the neuron would still be able to fire action potentials and release neurotransmitters

25. Which of the following are characteristics of peptide neurotransmitters?
a) They are stored in dense core vesicles
b) They are synthesized in the soma
c) They are not released as quickly as amino acid neurotransmitters
d) All of the above
e) None of the above

26. All of the following are criteria for classifying a molecule as a neurotransmitter EXCEPT:
a) It is synthesized and stored in neurons
b) It is released when the presynaptic cell is stimulated
c) It is the only molecule released at the synapse
d) It always evokes the same post-synaptic response
e) It is degraded or removed from the synapse

27. Feedback inhibition in the synthesis of the neurotransmitter norepinephrine:
a) opposes the action of end product inhibition
b) modulates the activity of the rate limiting enzyme, tyrosine hydroxylase
c) is higher if the neuron is more active
d) blocks the production of epinephrine from norepinephrine
e) is an exception to Dale's principle

28. All of the following statements about presynaptic Ca^{++} action are correct EXCEPT:
a) the terminal bouton has a high concentration of Ca^{++} channels
b) Ca^{++} channels open when the membrane depolarizes
c) the Ca^{++} concentration is higher inside than outside the cell membrane
d) Ca^{++} binds to synaptotagmin and consequently SNARES pull vesicles to fuse with the membrane
e) with catecholamine neurotransmitters, the Ca^{++} channels are next to presynaptic vesicle docking locations

29. In discovering vagusstoff, Otto Loewi demonstrated that:
a) the vagus nerve releases GABA when stimulated
b) there are exceptions to Dale's principle
c) nerve stimulation causes the release of a chemical transmitter
d) a single neurotransmitter can be both excitatory and inhibitory
e) Kermit has a big loving heart

30. Which permeability changes ALL lead to membrane depolarization?
a) Na+ permeability up, K+ permeability down, Cl- permeability down, Ca++ permeability up
b) Na+ permeability up, K+ permeability down, Cl- permeability up, Ca++ permeability down
c) Na+ permeability up, K+ permeability up, Cl- permeability down, Ca++ permeability up
d) Na+ permeability up, K+ permeability up, Cl- permeability up, Ca++ permeability down
e) Na+ permeability down, K+ permeability up, Cl- permeability down, Ca++ permeability up

31. In the phosphoinositide signaling team, which of the following is not a second messenger?
a) IP3
b) Na+
c) Ca++
d) DAG

32. All the following statements about G-protein coupled receptors are true EXCEPT:
a) This transduction pathway is faster than the pathway for ligand gated channels
b) This pathway leads to signal amplification
c) The ultimate result of the 2nd messenger cascade is to change the shape of a protein and affect its activity
d) The signal generally lasts longer than that for ligand gated channels
e) This pathway can be regulated in more diverse ways than pathways using ionotropic receptor

33. You are studying neurons in the hippocampus and you suspect that glutamate excites them by activating the ***cAMP*** second messenger system. Of the following experimental results which is the ***best*** support for your hypothesis?
a) Blocking protein kinase C activity in the hippocampus blocks the excitatory effects of glutamate.
b) Blocking protein kinase A activity in the hippocampus blocks the excitatory effects of glutamate
c) Injecting activated G-protein causes excitatory effects in neurons in the hippocampus.
d) Blocking calmodulin blocks the excitatory effects of glutamate.

34. Opening Chloride channels in a dendrite produces shunting inhibition. This will
a) increase the length constant
b) decrease the length constant
c) not change the length constant - it's constant!

35. When one synapse is activated the postsynaptic cell does not reach threshold. When three synapses are activated simultaneously the postsynaptic cell reaches threshold and fires an action potential. This is an example of
a) Spatial summation
b) Temporal summation
c) Dale's Decree
d) Loewi's Law

36. Neurotransmitters can be cleared from the synaptic cleft using
a) reuptake into the presynaptic terminal
b) transport into astocytes
c) degradation by enzymes
d) all of the above

2007-1

1. Santiago Ramon Y Cajal
a) invented the Golgi stain
b) promoted the Neuron Doctrine
c) invented the Nissl stain
d) promoted the Reticular Theory
e) More than one of the above

2. An ion channel in the membrane of a dendritic spine
a) is a protein
b) is translated in the soma
c) is transported along microtubules from the soma to the spine
d) All of the above

3. An alpha motor neuron with many dendrites and a cell body in the ventral horn of the spinal cord and with an axon that synapses on muscle cells can be categorized in all of the following ways EXCEPT

a) Golgi Type II
b) Primary Motor
c) Multipolar

4. The first scientist to propose that neurons use “biological electricity” to carry information through the body was
a) Golgi
b) Galvani
c) Cajal
d) Volta

5. An important function of glial cells is insulation of axons with myelin. Which of the following statements about myelination is correct?
a) Oligodendroglia provide insulation to neurons in the peripheral nervous system
b) Astrocytes insulate neurons in both the central and peripheral nervous systems
c) a Schwann cell insulates a single axon
d) in the central nervous system, each glial cell insulates a single neuron

6. Which of the following statements about Alzheimer's disease is NOT correct:
a) a behavioral symptom is memory loss
b) tau protein is thought to be involved
c) it is diagnosed in part by post mortem examination revealing neurofibrillary tangles
d) it involves a breakdown of neurofilament structure

7. In axoplasmic transport:
a) there is a slow transport mechanism that moves proteins up the axon at a rate of about 10 meters per day
b) slow transport is both anterograde and retrograde
c) kinesin is used for fast anterograde transport
d) anterograde transport is utilized by the herpes simplex virus to reach the soma from the skin
e) the mitochondrial police check visas at all membrane borders

8. In neuronal membranes:
a) ion channels are always voltage sensitive
b) it is impossible for ions to cross the membrane if there is not a selective channel for it
c) if a channel for a particular ion is open, there will always be a net movement of those ions through the channel
d) the farther the equilibrium potential is from Vm, the higher the driving force on the ion

9. According to the Nernst equation, if the extracellular concentration of potassium ions is lowered:

a) E k will become more positive and the membrane permeability to potassium will be unaffected
b) E k will become more positive and the membrane permeability to potassium will increase
c) E k will become more positive and the membrane permeability to potassium will decrease
d) E k will become more negative and the membrane permeability to potassium will be unaffected
e) E k will become more negative and the membrane permeability to potassium will increase
f) E k will become more negative and the membrane permeability to potassium will decrease

10. Which of the following statements about the ionic basis of the resting membrane potential is NOT correct:
a) the intracellular and extracellular fluids are neutral
b) the negative resting membrane potential is based on a differential distribution of positive and negative ions right at the membrane
c) the resting potential is negative because there are many more negative ions inside the membrane than outside
d) the resting potential is negative because a large percentage of the available positive ions move outside the membrane

11. Suppose you are making your roommate a delicious sodium chloride smoothie one sunny afternoon and you want to show them how equilibrium potentials work. You take a glass off the shelf and divide it in half with a piece of membrane you picked up at Whole Foods. You dump all of the NaCl into side 1 of the glass and they you open sodium channels in the membrane. What happens next?

A: the driving force on Na+ decreases

B: the electrical force on Na+ ions equals the force of diffusion

C: Na+ ions move down their concentration gradient toward side 2

D: the electrical force on Na+ ions is smaller than the force of diffusion

Which of the following is a logical sequence (from left to right) for these events:

a) B - C – A - D
b) D – C – A - B
c) B – C – A – D
d) A – C – B - D

12. The cell organelle that builds proteins based on the nucleic acid code in mRNA is:
a) smooth endoplasmic reticulum
b) soma
c) mitochondria
d) ribosome
e) Golgi apparatus

13. Various diseases involve changes in the shape of action potentials. Which of the following abnormalities would NOT be associated with heightened neuron and brain excitability? In other words, which of these would NOT tend to make neurons more depolarized over time (rather than hyperpolarized)?
a) no action potential undershoot
b) slow Na+ channel inactivation
c) absence of voltage-gated K+ channels
d) voltage-gated Na+ channels that close after being open 10 msec
e) low numbers of voltage-gated Na+ channels

14. The phase of the action potential in which the neuronal membrane is most hyperpolarized is:
a) falling phase
b) rising phase
c) overshoot
d) undershoot
e) threshold

15. The phase of the action potential in which K+ conductance is highest is:
a) falling phase
b) rising phase
c) overshoot
d) undershoot
e) threshold

16. In the relative refractory period:
a) it is impossible to initiate a new action potential
b) more K+ than Na+ voltage-gated channels are open
c) V m is greater than the threshold for action potentials
d) the Nernst equation states that V m will approach the equilibrium potential for Na+
e) propagation of action potentials is abolished

17. In the de-inactivated state:
a) Na+ channels are open and Na+ ions will cross the membrane if there is a driving force
b) Na+ channels are closed but will open if the membrane is depolarized
c) Na+ channels are closed but will open if there is sufficient Ca++ entry
d) Na+ channels are closed but will open automatically after approximately 1 msec
e) Na+ channels are open, but Na+ ions will not cross the membrane because V m > E Na

18. A toxin commonly used to block K+ channels is:
a) TEA
b) lidocaine
c) TTX
d) STX
e) SEX

19. In the propagation of action potentials:
a) action potentials propagate faster in thinner axons because the intracellular resistance to ion flow is lower
b) in myelinated axons, action potentials propagate faster than in unmyelinated axons because the machinery for Na+ and K+ ion flow must only take place at nodes of Ranvier
c) the overall distance that action potentials can propagate along an unmyelinated axon is specified by the length constant
d) in myelinated axons, action potentials occur continuously along the axon but can only be observed experimentally at nodes of Ranvier

20. Which of the following statements about voltage-gated K+ channels is NOT correct:
a) once open, they remain open as long as the neuron is depolarized
b) they open automatically about 1 msec after the initiation of an action potential
c) the mechanism to open them involves a change in protein conformation
d) the length of their de-inactivated state determines the duration of the absolute refractory period

21. Which of the following is NOT a general stage of all chemical synaptic transmission:
a) signal termination
b) G-protein activation
c) release of neurotransmitter
d) synthesis of neurotransmitter
e) effect of neurotransmitter on the postsynaptic cell

22. Which of the following neurotransmitters is a catecholamine:
a) serotonin
b) acetylcholine
c) GABA
d) dopamine
e) glutamate

23. In the synthesis of catecholamines, feedback inhibition slows the activity of what rate-limiting enzyme:
a) GABA amino hydroxylase
b) dopa decarboxylase
c) tryptophan
d) tyrosine hydroxylase
e) nomakeacatecholaminase

24. Dale's Principle states that:
a) each neuron uses one neurotransmitter
b) the rate limiting enzyme determines the amount of transmitter synthesis
c) all neurotransmitters are synthesized in the soma except for peptides
d) a neuron only synthesizes as much neurotransmitter as is needed

25. Which of the following is NOT true of peptide neurotransmitters:
a) they are stored in dense core vesicles
b) they are synthesized in the terminal bouton
c) the Golgi apparatus snips them off from larger proteins
d) they are more likely than most other neurotransmitters to violate Dale's Principle

26. Which of the following statements about peptide neurotransmitter release is NOT correct:
a) it occurs at active zones
b) it occurs at higher action potential rates than the release of monoamines at synapses that use both transmitters
c) it is based on exocytosis of dense core vesicles
d) it occurs further from Ca++ than the release of non-peptide transmitters

27. The following are common elements of neurotransmitter release:
A. SNAREs change conformation, pulling a vesicle toward the terminal membrane

B. action potentials depolarize the terminal bouton membrane

C. voltage-gated Ca++ channels open

D. Ca++ enters the terminal bouton

E. vesicles fuse with the membrane and release neurotransmitter into the synaptic cleft

Which of the following is the correct sequence (from left to right) for these events:
a) B – A – C – D - E
b) B – D – C – A - E
c) B – C – D – A - E
d) B – A – D – C - E

28. Otto Loewi's experiments with frog hearts showed that:
a) heart rate is regulated by a G-protein transmitter system
b) heart rate is influenced by the binding of synaptotagmin and Ca++
c) communication between the vagus nerve and heart is chemical, not electrical
d) communication between the vagus nerve and heart uses a peptide transmitter
e) with a bit of mustard, they make a tasty midnight snack

29. Glutamate
a) is an amino acid
b) has more than one type of receptor
c) is an excitatory neurotransmitter in the brain
d) More than one is correct
e) All of the above are correct

30. Which of the following responses will be the fastest?
a) neurotransmitter binding to a ligand-gated ion channel
b) neurotransmitter binding to a G-protein coupled receptor with an ion channel as the effector protein.
c) neurotransmitter binding to a G-protein coupled receptor that activates the IP3/DAG pathway.
d) neurotransmitter binding to a G-protein coupled receptor that activates the cAMP pathway.

31. Which of the following results is the strongest evidence that a cell is using cAMP as a second messenger to get a particular response (rather than other second messenger systems)?
a) blocking G-proteins blocks the response.
b) preventing seven transmembrane spanning receptors from functioning blocks the response.
c) blocking adenylyl cyclase blocks the response.
d) blocking all protein kinases blocks the response.

32. All of the following are true of the IP3/DAG second messenger system EXCEPT
a) DAG diffuses to the smooth endoplasmic reticulum (ER) and triggers calcium release.
b) phospholipase C (PLC) activation leads to the production of two second messengers
c) protein kinase C is activated
d) GTP binds to the alpha subunit of a G-protein

33. Which of the following would cause a decrease in the strength of a synapse that uses acetylcholine (ACh) as the neurotransmitter?
a) increase in the level of choline acetyltransferase (ChAT) in the presynaptic terminal
b) increase in the level of acetylcholine transporters in membrane of synaptic vesicles.
c) increase in the levels of acetylcholinesterase (AChE)
d) increase in the levels of acetylcholine receptors.

34. Which of the following would cause an increase in the length constant of a dendrite?
a) more open potassium channels
b) more voltage-gated sodium channels
c) more open chloride channels
d) more voltage-gated potassium channels

35. Postsynaptic potentials
a) are all the same size
b) can demonstrate temporal summation
c) can be excitatory or inhibitory depending on the ion channels that are affected
d) More than one of the above
e) All of the above

36. Protein phosphatase
a) removes a phosphate group from a protein
b) adds a phosphate group to a protein
c) is a second messenger
d) More than one of the above

2007-3

1) All of the following are normal steps in protein synthesis EXCEPT
   a) Transcription occurs in the nucleus
   b) Translation occurs at a ribosome
   c) Ion channel proteins are manufactured on free ribosomes in the cytoplasm
   d) Proteins are assembled by joining together amino acids

2) Neurons that communicate via chemical synapses are consistent with the Neuron Doctrine proposed by _____ while neurons that have gap junctions are consistent with aspects of the Reticular Theory proposed by _____.
   a) Cajal; Golgi
   b) Cajal; Galvanni
   c) Golgi; Cajal
   d) Golgi; Galvanni
   e) Galvanni; Cajal
   f) Galvanni; Golgi

3) Destruction of _____ would be the most effective way to stop fast axonal transport.
   a) Neurofilaments
   b) Microtubules
   c) Microfilaments
   d) Dendritic spines

4) In a typical neuron at rest, the membrane potential is closest to the equilibrium potential for:
   a) Ca++
   b) K+
   c) Mg+
   d) Na+

5) Rabies and herpes simplex viruses both exploit what cellular process to invade the nervous system:
   a) axoplasmic transport
   b) synaptic transmission
   c) protein synthesis
   d) transcription

6) People with multiple sclerosis have difficulty walking because of:
   a) transection of the corticospinal tract
   b) the disruption of tau protein and microtubules
   c) demyelination of axons
   d) a failure of exocytosis at synapses

7) The absolute refractory period of the action potential is a consequence of voltage-gated Na+ channels being in which state:
   a) activated
   b) deinactivated
   c) inactivated
   d) Rhode Island

8) Lidocaine is an effective local anesthetic because it blocks which ion channel:
   a) Ca++
   b) K+
   c) Mg+
   d) Na+

9) The amount of ion flow (current) across a neuronal membrane is given by:
   a) gion (Vm – Eion)
   b) 2.3 (RT/zF) log ([ion] out / [ion] in)
   c) gion ([ion] out – [ion] in)
   d) 2.3 (RT/zF) log ([Vm] / [Eion])

10) The rate limiting enzyme in the synthesis of catecholamine neurotransmitters is:
   a) dopa decarboxylase
   b) protein kinase C
   c) acetylcholinesterase
   d) tyrosine hydroxylase

11) Peptide neurotransmitters are made in the:
   a) soma
   b) axon boutons
   c) mitochondria
   d) dendrites

12) What specialized proteins are responsible for fusion of synaptic vesicles with the presynaptic membrane:
   a) AMPAs
   b) SNAREs
   c) DAGs
   d) mGluRs

13) All the following statements about G-proteins are correct EXCEPT:
a) G-proteins float in the postsynaptic membrane in the absence of neurotransmitter
b) the subunits of the activated G-protein split apart
c) a channel in the activated G-protein opens to allow the flow of Na+
d) GTPase hydrolyzes GTP and converts it to GDP

14) All the following would decrease the postsynaptic effect of a neurotransmitter EXCEPT:
a) decrease the amount of transmitter released
b) increase transmitter degradation
c) decrease transmitter reuptake
d) decrease the number of transmitter receptors

15) All of the following statements about synaptic integration are correct EXCEPT:
a) there is both spatial and temporal summation of postsynaptic potentials
b) mini postsynaptic potentials are graded because different vesicles carry different amounts of neurotransmitter
c) if there is sufficient depolarization, spikes are initiated at the axon hillock
d) the probability of an action potential is increased if dendritic length constant increases

2009-1

1. All of the following statements about the Central Nervous System are true EXCEPT:
a) axons are myelinated by oligodendroglia
b) it is surrounded by bone
c) axons can regenerate and make functional connections when damaged
d) Broca's area is located within the CNS

2. The fact that chemical synapses exist between neurons in the nervous system is evidence that supports
a) Cajal's Neuron Doctrine
b) Golgi's Reticular Theory
c) Nissl's cytoarchitecture Theory
d) Descartes' Mind-Brain Problem

3. You are working in the lab late on Saturday evening when your roommate, Chuck, comes in and accidentally spills some "jungle juice" on the brain slices sitting on the lab bench. After admonishing Chuck for his breach of proper lab protocol you realize that the juice has potential as a Nissl stain because
a) it has labeled the axon connections between two distant brain areas
b) a small percentage of the neurons in the slice demonstrate full labeling of dendritic trees
c) neuron cell bodies are clearly labeled
d) presynaptic terminals are clearly labeled

4. Which of the following are proteins?
a) tyrosine hydroxylase
b) a voltage-gated sodium channel
c) glutamate
d) More than one of the above.
e) All of the above (a,b & c)

5. All of the following are true of glial cells EXCEPT:
Glial cells
a) myelinate axons.
b) synthesize neurotransmitter
c) outnumber neurons in the brain
d) regulate the content of the extracellular fluid bathing neurons

6. Which of the following is a scaffolding protein that is stabilized by tau protein?
a) microfilaments
b) microtubules
c) neurofilaments
d) neurotubules
7. One day a rabid postal worker wanders from Thayer Street into Salomon and bites a NEUR 0010 student peacefully sitting in the back row doing the NY Times crossword on her laptop. You witness the horror and announce to class that to stop the rabies virus from reaching the soma of neurons, you must block which type of axoplasmic transport?
a) anterograde transport using the motor protein dynein
b) anterograde transport using the motor protein kinesin
c) retrograde transport using the motor protein dynein
d) retrograde transport using the motor protein kinesin

8. The equilibrium potential for Na^+ is roughly
a) -80 millivolts
b) -65 millivolts
c) +62 millivolts
d) +123 millivolts

9. The driving force on K^+ at the neural membrane can be calculated as
a) diffusion force – electrical force
b) gk * Vm
c) Vm - Ek
d) gk * Vm

10. According to the Nernst equation, if a neuronal membrane is at rest and the extracellular concentration of Na^+ is suddenly raised by a factor of 10 from its normal concentration (by adding NaCl to the extracellular fluid)
a) the resting potential will not change because the membrane at rest is impermeable to Na^+
b) the equilibrium potential for E_{NA} will increase to a more positive value
c) the driving force on Na^+ decreases
d) the extracellular concentration of K^+ will decrease to compensate

11. Most proteins in neurons are synthesized in
a) soma
b) synaptic cleft
c) axons
d) dendrites

12. Which of the following ions has a larger intracellular concentration than extracellular concentration
a) Ca^{++}
b) Cl^-
c) K^+
d) Na^+

13. The equilibrium potential for an ion is defined as the membrane potential at which
a) the electrical force is zero
b) the diffusion force is zero
c) the electrical force equals and opposes the permeability
d) the electrical force equals and opposes the force of diffusion

14. During the course of an action potential, the membrane potential is lowest during the
a) undershoot
b) overshoot
c) falling phase
d) rising phase

15. Action potentials are generally initiated at the
a) axon hillock
b) terminal bouton
c) active zone
d) dendritic branch point

16. The absolute refractory period results most directly from the properties of which ion channel
a) Ca^{++}
b) Cl^-
c) K^+
d) Na^+

17. At the resting membrane potential, the driving force is highest for which ion
a) Ca^{++}
b) Cl^{-}
c) K^{+}
d) Na^{+}

18. When voltage-gated Na^{+} channels are in the inactivated state, they are
a) open and able to pass Na+
b) closed but able to open if depolarized
c) closed but able to open if hyperpolarized
d) closed and unable to open with depolarization or hyperpolarization

19. You are starting to sense that your roommate resents the fact that you have way more facebook friends than he does. He invites you to a homemade dinner of a strangely enticing stew made with puffer fish and dinoflagellates. With one sip your lips start to tingle, you jump from the table, and as you run from the room you shout "holy #$%*@!, that stuff will block all my Na^{+} channels because it contains"
a) tetramethylammonium and bungarotoxin
b) tetrodatoxin and tetramethylammonium
c) saxitoxin and bungarotoxin
d) saxitoxin and tetrodatoxin

20. Local anesthetics such as lidocaine work by stopping action potentials by blocking which ion channels
a) Ca^{++}
b) Cl^{-}
c) K^{+}
d) Na^{+}

21. All of the following would increase the speed at which action potentials are propagated EXCEPT:
a) make the axon fatter
b) myelinate the axon
c) make the axon longer
d) add more voltage-gated Na^{+} channels

22. Saltatory conduction
a) means action potentials propagate continuously down an axon but they can only be recorded at nodes of Ranvier
b) means action potentials skip down an axon, only occurring at nodes of Ranvier
c) occurs in both myelinated and unmyelinated axons
d) makes you thirstier than peppertory conduction

23. Dr. Evil is at it again…he has developed a toxin that causes an uncontrolled increase in the concentration of intracellular calcium in presynaptic terminals of neurons. An expected effect of this toxin would be
a) prevention of the release of neurotransmitter from synaptic vesicles
b) an increase in the concentration of neurotransmitter in synaptic vesicles
c) blocking of voltage-gated sodium channels
d) uncontrolled fusion of synaptic vesicles and release of neurotransmitter

24. All of the following are criteria for the classification of a substance as a neurotransmitter EXCEPT:
a) The neurotransmitter is synthesized and packaged
b) The signal must be terminated in affected cells
c) The neurotransmitter must either be an amino acid or an amine
d) The neurotransmitter must be released from the presynaptic neuron.
e) The neurotransmitter must have an effect on the postsynaptic cell.

25. Which would be the ***most effective*** way to ***slow down*** the synthesis of norepinephrine (NE)?
a) inhibit tyrosine hydroxylase
b) inhibit dopa decarboxylase
c) inhibit dopamine beta-hydroxylase
d) decrease levels of norepinephrine

26. Which of the following would cause a ***decrease*** in the amount of glutamate stored in synaptic vesicles of glutamatergic neurons?
a) Blocking glutamate transporters in the presynaptic membrane of glutamatergic neurons
b) Increasing levels of choline in presynaptic terminals of glutamatergic neurons
c) Increasing levels of ATP in the presynaptic terminals of glutamatergic neurons
d) Inhibiting action potentials in glutamatergic neurons.

27. V-snares and T-snares are
a) proteins that are responsible for the docking and fusion of vesicles with the presynaptic membrane.
b) toxins that block release of neurotransmitter
c) ion channels that cause depolarization of the presynaptic membrane
d) enzymes that break down serotonin once it is released into the synaptic cleft

28. A neurotransmitter binds to a receptor, permeability to an ion increases, and the postsynaptic membrane hyperpolarizes. Which of the following ion channels had its permeability increased
a) Cl^-
b) Ca^{++}
c) ACh^+
d) Na^+

29. Neurotransmitter receptors often have subtypes; AMPA, NMDA, and kainite receptors are subtypes for which neurotransmitter
a) acetylcholine
b) dopamine
c) glutamate
d) glycine

30. At a G-protein coupled receptor, an effector protein is generally
a) part of the receptor that binds to the transmitter
b) a subunit of the G-protein activated by the receptor
c) a byproduct of the GDP-GTP exchange reaction
d) a protein activated by binding to a G-protein subunit

31. Acetylcholine slows the heart rate in Otto Loewi's classic frog experiment because
a) The alpha subunit of the G-protein activates adenylyl cyclase
b) The beta-gamma subunits of the G-protein gate a K^+ channel
c) Activated IP_3 causes the release of Ca^{++}
d) ACh-gated Na^+ channels open, hyperpolarizing the cells

32. Kinases
a) add phosphate to proteins
b) remove phosphate from proteins
c) add calmodulin to proteins
d) remove calmodulin from proteins

33. Binding of norepinephrine to the NE beta receptor leads to the cAMP second messenger that activates
a) protein phosphatase
b) protein kinase A (PKA)
c) diacylglycerol (DAG)
d) phospholipase C (PLC)

34. In the phosphoinositide system, all of the following are second messengers EXCEPT
a) DAG
b) IP_3
c) PIP_2
d) Ca^{++}

2010-1

1. Which of the following is the strongest evidence that ***contradicts*** Cajal's Neuron Doctrine and ***supports*** Golgi's Reticular Theory?
a) Dale's Principle.
b) the presence of electrical synapses in the brain.
c) fact that peptides and non-peptide neurotransmitters are stored and released in slightly different ways.
d) reuptake of neurotransmitters into the presynaptic terminal.

2. You want to know if neurons in a specific brain region are spinous or aspinous. Which of the following procedures would allow you to shed light upon this question?
a) a Golgi Stain
b) a Nissl Stain
c) intracellular recording
d) a stain that only labels axons

3. In the peripheral nervous system, glial cells that insulate axons with myelin are:
a) astrocytes
b) oligodendroglia
c) Schwann cells
d) microglia

4. A disease in which the immune system attacks myelin is:
a) Alzheimer's disease
b) Multiple Sclerosis
c) Parkinson's disease
d) Rabies

5. The severity of mental retardation has been found to correlate with:
a) reduced branching of axons
b) the degree of glial scar formation
c) abnormalities in the spacing and shape of dendritic spines
d) lower axonal density of voltage-gated Na^+ channels

6. The herpes simplex virus responsible for cold sores enters the nervous system by:
a) anterograde transport that uses a kinesin motor protein
b) anterograde transport that uses a dynein motor protein
c) retrograde transport that uses a kinesin motor protein
d) retrograde transport that uses a dynein motor protein

7. In neurons, the ion with the highest intracellular concentration is:
a) Ca^{++}
b) Cl^-
c) K^+
d) Na^+

8. One evening you are crunching through a panini at the Gate when, to your amazement, you spot by the condiments a piece of plastic labeled "membrane permeable only to Na^+". Being astute neuroscience students, you and your roommate decide to conduct an experiment. You fill a drinking glass with water and put the membrane down the middle so there is water on both sides of it. You then take the salt shaker and dump a lot of NaCl only into the water on one side ("side 1") of the membrane. You sit around staring at the glass for awhile pondering the meaning of life and then you take from your backpack the equipment you always carry around to measure ion concentrations. The solution in the glass has reached equilibrium and you find:

a) there are equal concentrations of Na^+ on the two sides of the membrane and there is no potential difference between the two sides
b) there are equal concentrations of Na^+ on the two sides of the membrane and side 1 has a positive potential relative to side 2 (the side you didn't dump the salt into)
c) there is a much higher Na^+ concentration on side 1 and side 1 has a negative potential relative to side 2
d) there is a much higher Na^+ concentration on side 2 and side 1 has a posative potential relative to side 2

9. Later that night you get hungry again and you go into the Shark Sushi Hibachi restaurant on Thayer St. No end of surprises, they are just pulling a squid from the fish tank – thinking quickly you ask if you can do an experiment with the giant axon before they cook up the critter. You pull electrodes and electronics from your handbag and setup an impromptu physiology rig. You find that the intracellular K^+ concentration is 100 mM, the extracellular K^+ concentration is 5 mM and the membrane potential is -65 mV (more negative on the inside). Then you increase the extracellular potassium concentration to 100 mM. You find that the membrane potential is now closest to:

a) -100 mV
b) -65mV
c) 0
d) +65 mV

10. You are just about worn out from a long night of neuroscience when the most incredible thing of all happens – an alien teleports onto the main green right in front of you. With the beings consent you conduct experiments confirming that the resting membrane potential follows similar rules throughout the galaxy. Aliens are different from us (but of course) and instead of K^+ and Na^+, the membrane potential is largely determined by ions Y^+ and Z^+. The equilibrium potential for Y^+ is -100 mV, the equilibrium potential for Z^+ is +100 mV, and typical alien neurons are 100 times more permeable to Y^+ than Z^+. You find that the resting potential of the alien neurons is closest to:
a) -100 mV
b) 0 mV
c) +100 mV
d) who cares, blast the thing before it kills everyone on Earth

11. A neuron's spike initiation zone is also known as the:
a) axon hillock
b) terminal bouton
c) active zone
d) dendritic spine

12. The different concentrations of Na^+ and K^+ inside and outside of neurons are largely produced by:
a) ion transporters
b) ion pumps
c) the flow of ions during action potentials
d) voltage-gated ion channels

13. The driving force on an ion is:
a) the degree to which the membrane will allow the ion to flow
b) the net amount of ion movement across the membrane
c) the difference between ion permeability and ion conductance
d) the difference between the equilibrium potential for the ion and the membrane potential

14. If an axonal membrane is briefly depolarized above threshold, a single action potential is fired. If depolarization above threshold is continued longer than necessary to evoke a single action potential, the consequence will be:
a) more action potentials identical to the first
b) more action potentials with subsequent ones have larger voltage amplitude than the first
c) more action potentials with subsequent ones having shorter duration than the first
d) more action potentials with subsequent ones having a shorter length constant than the first

15. During the falling phase of the action potential:
a) voltage-gated Na^+ channels open and voltage-gated K^+ channels open
b) voltage-gated Na^+ channels close and voltage-gated K^+ channels open
c) voltage-gated Na^+ channels open and voltage-gated K^+ channels close
d) voltage-gated Na^+ channels close and voltage-gated K^+ channels close

16. The absolute refractory period occurs when most voltage-gated Na^+ channels are:
a) activated
b) inactivated
c) de-inactivated
d) fed up with being sort-of-kind-of refractory

17. Tetrodatoxin interferes with neuron function by blocking:
a) Ca^{++} channels
b) Cl^- channels
c) K^+ channels
d) Na^+ channels

18. Which disorder is most closely associated with a decrease in the rate of action potential propagation down axons:
a) Alzheimer's disease
b) Multiple Sclerosis
c) Parkinson's disease
d) Rabies

19. Lidocaine and cocaine are similar in that:
a) they are both local anesthetics
b) they both block K^+ channels
c) they both suppress action potentials
d) more than one of the above
e) all of the above

20. At electrical synapses:
a) ions can cross directly from the presynaptic to the postsynaptic neuron
b) the space between the presynaptic and postsynaptic membranes is significantly larger than at chemical synapses
c) there are only inhibitory effects of the presynaptic on the postsynaptic neuron
d) depolarization of the postsynaptic membrane results from Ca^{++} entry into the presynaptic terminal

21. The specialized synapses that nerves make on muscle are called:
a) gap junctions
b) active zones
c) neuromuscular junctions
d) secretory zones

22. Synaptic vesicles are:
a) found in both the presynaptic and postsynaptic elements at the synapse
b) used to hold monoamine neurotransmitters
c) filled with proteins by ribosomes
d) teeny tiny ships that sail the neural sea

23. Which of the following is NOT a catecholamine neurotransmitter:
a) acetylcholine
b) norepinephrine
c) epinephrine
d) dopamine

24. The critical enzyme involved in the synthesis of acetylcholine is:
a) Acetyl CoA
b) acetylcholinesterase
c) choline acetlytransferase
d) acetylcholine carboxylase

25. An example of end product inhibition is:
a) the suppression of mRNA translation by synthesized proteins
b) the inability of G-protein subunits to separate in the presence of an effector enzyme
c) neuronal death by transport of the rabies virus
d) the reduction of tyrosine hydroxylase activity by norepinephrine

26. Peptide neurotransmitters are:
a) synthesized in axon terminals
b) released at active zones
c) released with lower rates of action potentials then the rate needed to release amine neurotransmitters
d) stored in secretory granules

27. Four events leading up to the release of neurotransmitter are:

A: entry of Ca++ into the axon terminal
B: binding of V-SNARES with T-SNARES
C: binding of synaptotagmin with Ca^{++}
D: change in conformation of the V- and T-SNARES

Which of the following is the correct order of these events in time (left=first, right=last):
a) ABCD
b) BACD
c) ACDB
d) BCAD

28. AMPA, NMDA and Kainate all interact with specific types of glutamate receptors in the brain. They are best described as being _____ for glutamate receptors
a) agonists
b) neurotransmitters
c) antagonists
d) protagonists

29. When GTP binds to the alpha subunit of a G-protein the alpha subunit is said to be "activated" meaning that it will now bind to the
a) protein kinase.
b) G-protein coupled receptor.
c) effector protein.
d) second messenger.

30. Compared to ligand-gated ion channels, responses mediated by G-proteins
a) last longer.
b) undergo more amplification from neurotransmitter released to response triggered
c) are a bit slower to begin.
d) More than one of the above
e) All of the above

31. The ***most effective*** way to shut down the IP3/DAG second messenger system would be to stop
a) release of calcium from the endoplasmic reticulum.
b) the activity of adenylyl cyclase (AC)
c) the activity of calmodulin (CaM)
d) the activity of phopholipase C (PLC)

32. Increasing the length constant in the dendrites of a neuron would
a) decrease the likelihood that the cell will fire an action potential.
b) increase the effectiveness with which depolarization spreads down a dendrite.
c) increase the length of dendrites.
d) decrease the likelihood of spatial summation

33. One way to initiate an IPSP in a neuron would be to release neurotransmitter that
a) opens calcium channels in the membrane
b) opens potassium channels in the membrane
c) opens sodium channels in the membrane
d) closes chloride channels in the membrane

34. Kinases and Phosphatases are locked in an epic battle for control of protein function within a cell. Which of the following statements best describes the interaction between kinases and phosphatases?
a) kinases dephosphorylate proteins while phosphatases phosphorylate proteins
b) both kinases and phosphatases are second messengers but one is excitatory and one inhibitory
c) kinases add a phosphate group to proteins while phosphatases remove a phosphate group from a protein
d) Both can be activated by cAMP, but Kinases are in "cAMP Edward" while Phosphatases are in "cAMP Jacob."

35. All of the following are necessary steps required to turn off a neurotransmitter signaling pathway which uses cyclic AMP (cAMP) EXCEPT
a) dephosphorylate the G-protein coupled receptor
b) clear neurotransmitter from the synaptic cleft
c) break down cAMP into 5' AMP
d) remove GTP from the alpha subunit of the G-protein

2010-3

1. Cajal and Golgi waged their epic neuroscientific smackdown in the "corpus colleseum" a century ago and if they were alive today they would most likely still be arguing. Armed with modern neuroscientific data, Cajal would say, "Ah ha! The Neuron Doctrine is right! Look at these data demonstrating_____." Golgi would say, "Ah ha! The Reticular Theory is right! Look at these data demonstrating _____."
a) chemical synapses; electrical synapses
b) electrical synapses; chemical synapses
c) that chloride channels are inhibitory; that potassium channels are inhibitory
d) that potassium channels are inhibitory; that chloride channels are inhibitory
e) that my biceps are larger than yours; that my level of maturity is twice as great as yours

2. The _____ is the site of transcription and translation, the _____ contains the most neurotransmitter receptors and the _____ is where most neurotransmitters are stored.
a) axon terminal; soma; dendrite
b) soma; dendrite; axon terminal
c) dendrite; axon terminal; soma
d) soma; axon terminal; dendrite

3. A tiny little horse named Peter is in the middle of an axon half way between the cell body and the axon terminal and needs to find his way to the cell body of the neuron. Which of the following directions would be the best at getting Peter to the correct location in the cell?
a) "Follow the microtubules in the anterograde direction."
b) "Follow the microtubules in the retrograde direction."
c) "Follow that kinesin molecule."
d) "I have no idea. Go ask that London cab driver for directions."

4. To achieve your goal of becoming the most powerful person on the planet you focus your research on harnessing the power of the mighty neuron. Which organelle is most responsible for energy production in neurons:
a) endoplasmic reticulum
b) Golgi apparatus
c) mitochondria
d) nucleus

5. The protein kinesin is associated with which of the following critical cell functions:
a) axoplasmic transport
b) synaptic vesicle exocytosis
c) saltatory conduction of action potentials
d) neurotransmitter reuptake

6. If a typical neuron is at a membrane potential of +50mV, which ion experiences the smallest driving force:
a) Ca++
b) Cl-
c) K+
d) Na+

7. At the NeurOlympics you have the opportunity to win an amazing and provocative, 3D model of a Purkinje cell if you can answer one simple question: which of the following are essential for an ion to cross the cell membrane:
a) nonzero ionic driving force
b) nonzero ionic conductance
c) nonzero membrane potential
d) both a and b
e) all of the above

8. The phase of the action potential most associated with inactivation of voltage-gated sodium channels is:
a) rising phase
b) overshoot
c) falling phase
d) undershoot

9. At home over winter break you learn the hard way that your mother has moved her collection of 18th century iron anvils onto a high shelf in your bedroom. Sleeping one night, an anvil falls off the shelf and hits you causing a holiday red gash in your forehead. As you wait at the emergency room you look forward to the injection of lidocaine they will give your forehead because it will stop the pain for a while by blocking which channels:
a) substance P
b) sodium
c) epinephrine
d) potassium

10. Dopamine, norepinephrine and epinephrine are
a) synthesized in axon terminals.
b) stored in synaptic vessicles.
c) all synthesized from tyrosine.
d) All of the above.

11. Blocking calcium channels in the presynaptic terminal would
a) prevent the docking of vesicles at active zones
b) cause the presynaptic terminal membrane to depolarize.
c) block the release of neurotransmitter
d) All of the above

12. Which of the following signaling pathways allows for the fastest transmission of information across a synapse?
a) IP3 and DAG second messenger system
b) cyclic AMP second messenger system
c) G-protein-gated ion channel
d) ligand-gated ion channel receptors

13. All of the following would block a signal that is transmitted via the cAMP signaling pathway EXCEPT
a) blocking G-protein-coupled receptors
b) inhibiting protein kinase A (PKA)
c) blocking the release of calcium from the endoplasmic reticulum
d) preventing GTP from binding to G-proteins

14. Inhibitory post-synaptic potentials
a) can be generated by opening potassium channels
b) are always generated through the use of G-protein-coupled receptors
c) can summate via temporal and spatial summation
d) More than one of the above
e) All of the above

15. Which of the following molecules directly reverses the effects of protein kinase?
a) protein phosphatase
b) cAMP
c) calcium
d) transporter proteins

2011-1

1. Which of the following is the least common type of brain tumor?
a) astrocytoma
b) glioblastoma
c) meningioma
d) neuroma

2. Excessive brain levels of beta amyloid protein are associated with all the following EXCEPT:
a) dementia
b) disruption of tau protein binding
c) aggregation of neurofilaments
d) neuron death

3. Neurons use chemical (rather than electrical) transmission of information in:
a) axon
b) dendrite
c) soma
d) synapse

4. A disease involving neuron death resulting from retrograde axonal transport of an infectious agent is:
a) Alzheimer's disease
b) multiple sclerosis
c) rabies
d) herpes simplex

5. Astrocytes are thought to be involved in all the following processes EXCEPT:
a) guide neurons during development
b) relay action potentials between neurons
c) regulate ion concentrations in the extracellular space
d) protect neurons by taking up toxins

6. Limb weakness and blurry vision are frequent symptoms of axon demyelination in which disease:
a) Alzheimer's disease
b) multiple sclerosis
c) rabies
d) herpes simplex

7. Proteins are made by:
a) ribosomes in the cytoplasm
b) endoplasmic reticulum in the nucleus
c) mitochondria in the soma
d) transporter proteins at synapses

8. Mental retardation severity has been found to correlate with the:
a) number of brain synapses
b) total brain volume
c) length and shape of dendritic spines
d) amount of ATP in neurons

9. At Thanksgiving you want to prove to your family that you can control the universe at a molecular scale. After everyone is sated on pumpkin pie you fill a wine glass with water and you place an impermeable membrane to divide the water into left and right sides. Into the membrane you insert open sodium-selective channels. You then add a bunch of table salt (Na+Cl-) to the water on the left side. To the amazement of your parents you correctly predict that the equilibrium state of the solution is:
a) Na+ will be in equal concentrations on both sides of the glass; Cl- will only be on the left side
b) Na+ will be in equal concentrations on both sides of the glass; Cl- will be in equal concentrations on both sides of the glass,
c) Na+ will be on both sides but more concentrated on the left side; Cl- will only be on the left side
d) Na+ will be on both sides but more concentrated on the left side; Cl- will be on both sides but more concentrated on the left side

10. According to that precocious showoff Walther Nernst (Nobel Prize for work done at age 25), what will happen in typical neurons if you increase the extracellular potassium concentration from 5 mM to 500 mM (intracellular concentration stays at 100 mM)?
a) The equilibrium potential for K+ will increase and fewer action potentials will occur
b) The equilibrium potential for K+ will decrease and action potentials will stop
c) The equilibrium potential for K+ will increase and action potentials will stop
d) The equilibrium potential for K+ will decrease and more action potentials will occur

11. The ionic driving force is:
a) E_{ion}
b) $g_{ion} - E_{ion}$
c) $V_m - E_{ion}$
d) $g_{ion} * V_m$

12. In an action potential, V_m is closest to E_{Na} during which phase?
a) rising phase
b) overshoot
c) falling phase
d) undershoot

13. In an action potential the largest number of delayed rectifier potassium channels is open during which phase?
a) rising phase
b) overshoot
c) falling phase
d) undershoot

14. Sodium ions can pass through the pore of a voltage-gated sodium channel when the channel is in which state(s)? Choose the BEST answer from below.
a) activated
b) deinactivated
c) inactivated
d) activated and deinactivated

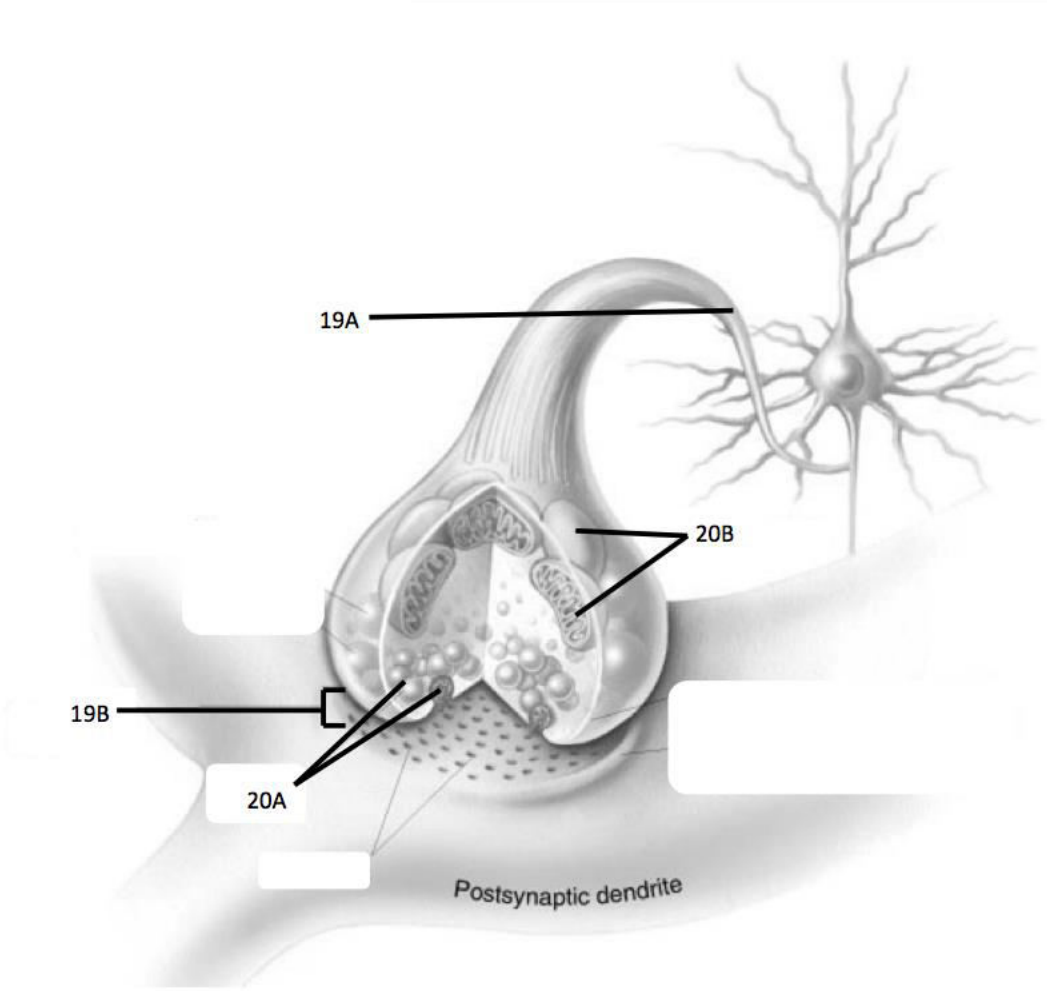
15. The absolute refractory period is most closely associated with voltage-gated sodium channels in which state?
a) activated
b) deinactivated
c) inactivated
d) Rhode Island

16. Lidocaine is an effective local anesthetic because it:
a) blocks sodium channels and small fibers are affected more than large fibers
b) blocks sodium channels and large fibers are affected more than small fibers
c) blocks potassium channels and small fibers are affected more than large fibers
d) blocks potassium channels and large fibers are affected more than small fibers

17. Which of the following moves fastest down an axon?
a) action potentials in an axon without myelination
b) salutatory conduction in a myelinated axon
c) passive electrical diffusion
d) axoplasmic transport

18. Connexons are channels in the cell membrane located at:
a) the axon hillock
b) electrical synapses
c) chemical synapses
d) nodes of Ranvier

19 - 20. On the answer sheet, clearly write the names of the structures pointed to.



21. Otto Loewi's experiment with frog hearts is important because it demonstrated that the nervous system uses:
a) peptide neurotransmitters
b) chemical neurotransmitters
c) electrical neurotransmitters
d) two frog hearts

22. Synthesis of the neurotransmitter epinephrine involves all the following EXCEPT:
a) dopamine
b) NE
c) 5-HT
d) tyrosine

23. Which of the following is a monoamine neurotransmitter?
a) ACh
b)GABA
c) NE
d)substance P

24. Peptide neurotransmitters are synthesized in the:
a) axon
b) axon terminal
c) dendrite
d) soma

25. Synaptic vesicles are anchored to the presynaptic terminal membrane by:
a) Calcium
b) SNAREs
c) synaptotagmin
d) transporters

26. At a ligand-gated ion channel receptor, neurotransmitters open ion channels. Which of the following combinations of neurotransmitters and channels would lead to a depolarization in the postsynaptic cell?
a) ACh and K^+
b) GABA and Cl^-
c) Glycine and Cl^-
d) Glutamate and Ca^{++}

27. Before a neurotransmitter binds to a G-protein coupled receptor, GDP is bound to which subunit of the G-protein:
a) alpha
b) beta
c) delta
d) gamma

28. Dale's principle states that:
a) a neurotransmitter uses ligand-gated channels or G-protein coupled receptors, but not both
b) a neuron synthesizes, stores, and releases only one neurotransmitter
c) amino acid neurotransmitters are all excitatory
d) a neuron makes chemical synapses or electrical synapses, but not both

29. Second messengers generated by the breakdown of PIP_2 are:
a) Ca^{++} and CaMK
b) PKC and PLC
c) DAG and IP_3
d) CaMK and PKC

30. When norepinephrine binds to beta receptors, adenylyl cyclase is activated producing the second messenger:
a) ATP
b) cAMP
c) GTP
d) PKA

31. The biological activity of important brain proteins is altered by adding phosphates. This is accomplished by which enzymes:
a) kinases
b) phosphatases
c) phosphoesterses
d) ATPases

32. After release from vesicles, neurotransmitter is pumped back into the presynaptic nerve terminal by:
a) kinases
b) SNAREs
c) synaptotagmin
d) transporters

33. When an action potential reaches a presynaptic nerve terminal, depolarization causes which critical step leading to neurotransmitter release:
a) entry of Ca^{++} into the nerve terminal
b) exit of Ca^{++} from the nerve terminal
c) entry of Na^{++} into the nerve terminal
d) exit of Na^{++} from the nerve terminal