**Midterm 1 Study Guide**

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Reading Summaries:

* Ch1 (Annie)
  + Phrenology - science of correlating structure of the head with personality traits
    - developed in 1809 by Joseph Gall who believed bumps on the surface of the skull reflected bumps on the surface of the brain
      * Gall and followers mapped 100s of people’s skulls, relating the differing shapes to personality traits
        + very inaccurate since the shape of the skull does not match the shape of the brain
    - was used for a lot of racist arguments
    - brought about idea that different sections of the brain were related to different cognitive functions
    - introduced idea of behaviors being determined by the brain rather than by the heart
  + Paul Broca- surgeon in 1800s who became convinced that different parts of the cerebrum controlled different functions
    - Broca had a patient (patient “TAN”) who could understand language but could himself only pronounce the word “tan”
      * Broca performed an autopsy on TAN in 1861 and found a lesion in the left frontal lobe of TAN’s brain
        + based on this and several other cases, Broca concluded that this part of the cerebrum was responsible for speech
    - Broca’s aphasia- damage in the frontal region of the brain that results in patients who can understand language but cannot speak or write

VS

* + - * Wernicke’s aphasia- damage to temporal lobe that results in patients who can speak but cannot understand the language
  + Phineas Gage- dynamite worker in 1848 who had an iron bar that entered his head under his left eye, passed through his frontal lobe, and exited through the top of his skull
    - was mobile even while the iron bar was in his brain
    - survived for 12 more years after bar was removed from his brain
      * lost vision in left eye
      * had seizures
      * had emotional outbreaks and his personality changed as a result of the damage done to the cerebral cortex in both hemispheres of brain, especially the frontal lobes
* Ch2 (Gillian)
  + two types of cells in nervous system = neurons and glia
  + Golgi stain = silver solution (reveals more than the Nissl stain)
    - Nissl stain: German neurologist found that a class of basic dyes would stain the nuclei of neurons and clumps surrounding the nuclei (called nissl bodies). The stain distinguishes neurons and glia from one another and lets histologists (histology = microscopic study of tissue) look at the cytoarchitecture, or arrangement, of neurons in different parts of the brain. (led to understanding that different parts of brain have different functions)
  + neurites = either axons or dendrites
  + Camillo Golgi = reticular theory (neurons fused at the ends, incorrect)
  + Santiago Ramon y Cajal developed neuron doctrine: neurons are not fused together (correct)
  + dendritic spines
    - more sensitive to certain types of activity
    - related to learning - people with cognitive impairments have underdeveloped spines. mice with enriched environments have thicker dendritic spines.
  + classifying neurons
    - by number of neurites (unipolar, bipolar, multipolar)
    - by shape of dendritic tree (stellate, pyrimidal) or spinous/aspinous
    - by connections (primary sensory, motor, and interneurons)
    - by axon length (Golgi I, Golgi II)
    - by neurotransmitter (cholinergic, glutamatergic etc)
  + types of glial cells
    - Astrocytes (most numerous glia in brain, regulating chemical content, blood brain barrier)
    - Ogliodendrocytes (myelinate CNS neurons, one oglio myelinates multiple axons)
    - Schwann cells (myelinate PNS, multiple schwann cells on one PNS axon - spaces between called nodes of Ranvier)
    - Ependymal cells (line ventricles in brain)
    - Microglia (phagocytes - immune system of nervous system)
* Ch3 (Schuyler)
  + Channel proteins- R group and diameter determine the ion selectivity
  + Ions diffuse down the concentration gradient
  + Ion pumps are enzymes that use the energy released by the breakdown of ATP to transport certain ions across the membrane
  + Diffusion only occurs if there are channels permeable to the ions and if there is a concentration gradient
  + How current flows is determined by electrical potential and conductance
  + Potential reflects the difference in charge between the anode and cathode
  + Conductance is ability of electrical charge to migrate from one point to another
  + Current is represented by Ohm’s law, which is Current=conductance x voltage (I=gV)
  + Membrane potential is the voltage across the neuronal membrane at any moment
    - Microelectrode (glass tube) measures membrane potential
  + The electrical potential difference that exactly balances an ionic concentration gradient is an ionic equilibrium potential
    - Large changes in membrane potential are caused by miniscule changes in ionic concentration
    - Net difference in electrical charge occurs on the inside and outside surfaces of the membrane
      * Because bilayer is so thin
      * Membrane is said to have capacitance
    - Ions are driven across the membrane at a rate proportional to the difference between the membrane potential and the equilibrium potential
      * The difference between the real membrane potential and the equilibrium potential (Vm-E(ion)) is the ionic driving force
    - If the concentration difference across the membrane is known for an ion, an equilibrium potential can be calculated for that ion
  + The Nernst equation can be use to calculate the exact value of an equilibrium potential for a particular ion
  + The sodium-potassium pump is an enzyme that breaks down ATP in the presence of internal Na+
    - Ensures that K+ is concentrated inside the neuron and that Na+ is concentrated outside
      * Estimated that it expends as much as 70% of the total amount of ATP used by the brain
  + Calcium pump is an enzyme that actively transports Ca++ out of the cytosol across the cell membrane
  + An equilibrium potential for an ion is the membrane potential that results if a membrane is selectively permeable to that ion alone
    - Goldman equation is a mathematical formula that takes into consideration the relative permeability of the membrane to different ions
  + Most potassium channels have four subunits that are arranged like the staves of a barrel to form a pore
    - Pore loop contributes to the selectivity filter that makes the channel permeable mostly to K+ ions
  + Because the neuronal membrane at rest is mostly permeable to K+, the membrane potential is close to EK+
    - Membrane potential is sensitive to concentration of extracellular K+
  + A change in membrane potential from the normal resting value to a less negative value is called a depolarization of the membrane
  + Blood brain barrier is a specialization of the walls of brain capillaries that limits the movement of potassium (and other bloodborne substances) into the extracellular fluid of the brain
  + Glia (specifically astrocytes) have membrane potassium pumps that concentrate K+ in their cytosol, and they also have potassium channels
    - K+ depolarizes the astrocyte membrane and the K+is dissipated over a large area by the extensive network of astrocytic processes
      * Called potassium spatial buffering
* Ch4 (Pier)
  + Big Picture of Action Potential(AP): frequency and pattern of AP constitute code used by neurons to transfer info from one location to the other
  + At rest, membrane is at -65mV (close to potassium equilibrium)
  + 1st part of AP = rising phase(trying to be positive)
    - rapid depolarization of the membrane: continues until about 40 mV
    - too much of a positive shot in AP is called the overshoot
  + falling phase is rapid re-polarization, or hyperpolarization of cell (trying to be negative again to reach resting potential)
    - causes undershoot if too many negative ions flow in
  + process lasts about 2 milliseconds
  + critical level that must be crossed to reach AP is called the Threshold (about -40mV)
    - *AP is caused by depolarization of the membrane beyond threshold*
  + Depolarization is caused by the influx of Na+ ions across the membrane
  + Hyperpolarization is caused by the efflux of k+
  + After one AP, it is impossible to initiate another for about 1millisec = **absolute refractory period (because sodium channels deinactived (?))**
  + **Relative refractory period**: it can be relatively difficult to initiate another AP for several milliseconds after absolute refractory period, amount of time to depolarize a neuron to AP threshold is elevated above normal
  + Equilibrium K+ = -80mV
  + if membrane is at -142mV, Na+ will flow in in a direction towards Equilib of Na+
  + voltage gated sodium channels open == highly selective to Na+
  + when sodium channels are blocked with toxins, effect could be fatal ex) Puffer Fish (puffer fish neurotoxin called Tetrodotoxin or TTX)
  + APs only conduct in one direction - does not turn back on itself →→ not → then ← === orthodromic conduction
  + > Axonal diameter = faster AP conduction velocity EX) Giant Squid axons were needed to improve squids response to stimuli
  + A spine on a dendrite is mature when it is a fat clump, bigger
    - immature = long, thin
  + Myelin facilitates current flow down axon, increases AP velocity
  + Saltatory conduction = AP skipping from node to node in myelinated axons
  + axon hillock is spike initiation zone
* Ch5 (Vania)
  + Types of Synapses
    - Electrical
      * proven in 1959 by Furshplan and Potter (how?)
      * Gap junctions - direct (TWO WAY!) channels between neurons
      * very fast but weak
      * used for synchronization of tasks
      * When one neuron activated, other gets jump too
    - Chemical
      * Proven in 1800s by Otto Loewi
        + Frog Heart Experiment - transferred fluids surrounding activated neuron to another heart, same effect happened
      * Synaptic cleft - 20-50nm.
        + Pre Synaptic - source cell
        + Post Synaptic - receiving cell (with receptors)
      * usually axon to dendrite (axodendritic), but can also be axon to cell body (axosomatic) and axon to axon (axoaxonic)
  + Neurotransmitters
    - Four Criteria to be a NT:
      * made in neuron
      * when neuron activated, must be released
      * if we take chemical soup and bathe another neuron, must get same response
      * cleanup crew must exist – so no eternal clogging
    - Synthesis and Storage
      * Source cell synthesises NT - Ribosomally or in Golgi Apparatus
      * stores it in granules (vesicles)
      * uses transporters to send to terminal (proteins “walk” them down)
      * vesicles wait at synaptic membrane, ready to fuse
    - Release
      * When cell depolarizes, voltage gated Calcium channels open
      * Very small amount of Calcium comes in, triggers fusion of vesicle to membrane
      * NT released into synapse
      * Empty vesicle recycled for later use
    - Receptors and Effectors
      * ionotropic – direct gating, fast and weak
        + NT binds, channel opens and lets ions through
      * metabotropic
        + NT binds, G protein activated, can start cascade “second messenger” and make structural changes
        + NT acts outside cell, G Protein acts inside (intracellular).
      * Note - some receptors also on presynaptic cell, which trigger regeneration of NT after release
    - Recovery and Degradation
      * Diffusion
      * Reuptake by transporters
      * Destruction - ex ACh is cut in half
      * glial cell extraction and recycling
  + Synaptic Integration
    - EPSP
      * (excitatory post synaptic potential)
      * Every time NT released, some ions can enter post synaptic cell and raise membrane potential. (positive contribution)
      * If enough of these happen close together, threshold can be reached
      * Always one nerve, but either three signals at different points at same time (parallel) or three signals at same point one after another (in sequence)
    - IPSP
      * (inhibitory post synaptic potential)
      * Analogous to above, NT can open channels that cause cell membrane potential to drop, thus inhibiting the other signals (negative contribution)
    - Dendrites
      * Leaky, so need to refresh signal often - thus proximity matters
      * Have spines (see other sections)
* Ch6 (Meron)
  + Amino Acids: glutamate(Glu), glycine(Gly), gamma-aminobutyric acid(GABA). Synthesized in axon terminal
  + Glutamate is the most abundant excitatory neurotransmitter in nervous system.
  + GABA: major inhibitory neurotransmitters in brain.
  + Glycine inhibitory NT as well but not as abundant as GABA.
  + Glutamate Gated Ion Channels: AMPA, NMDA, Kainate
    - AMPA, NMDA gated channels mediate the bulk of fast excitatory synaptic transmission in brain.
    - Kainate gated receptors function is not completely understood.
    - AMPA gated channels:
      * permeable to both Potassium and Sodium. Only a few are permeable to Calcium.
      * Net effect of activating them at normal, negative membrane potentials is to admit Na ions into cell, causing rapid and large depolarization.
    - NMDA gated channels:
      * permeable to Ca. Na and Ca influx enter cell when channel opens.
      * When Glutamate binds to NMDA receptor, at normal negative resting membrane potentials, the channel gets clogged by Mg ions which prevents other ion flow through channel.
      * Mg falls off receptor only when membrane becomes depolarized due to influx of Na from AMPA channels at same and neighboring synapses.
      * NMDA differ from AMPA receptors in two ways:
        + 1) NMDA channel permeable to Ca
        + 2) NMDA channel is voltage dependent
  + GABA-gated and Glycine-gated channels (inhibitory channels):
    - Mediate most of synaptic inhibition in CNS
    - Both Channels gate a chloride channel.
    - Regulates membrane to ensure that membrane does not get overly excited.
    - Synaptic inhibition:
      * Too much: loss of consciousness and coma
      * Too little: can lead to seizure
  + G-Proteins: step by step process
    - 1) Each G-protein consists of 3 subunits: Alpha, Beta, Gamma ( the subunits are almost always represented by their Greek letter). In resting state, GDP molecule bound to Alpha subunit.
    - 2) GDP-bound G-protein bumps into proper receptor. G-protein releases GDP and exchanges it for a GTP. GTP is abundant in cytosol.
    - 3) GTP-bound G-protein splits into two parts: Alpha subunit with attached GTP go one way and Beta, Gamma subunits another.
    - 4) Alpha subunit eventually breaks down GTP into GDP, consequently terminating its own activity.
    - 5) Alpha and Gamma, Beta subunits rejoin allowing possibility of new a new cycle.
  + G-Protein Second Messenger:
    - 1) GTP bound alpha subunit binds adenylyl cyclase and activates it.
    - 2) Active adenylyl cyclase catalyzes the conversion of ATP to cAMP
    - 3) cAMP activates other molecules, such as Protein Kinase A (PKA), which open ion channels.
    - **Second Messengers occur in between steps 3 and 4 in the G-Protein step by step process listed above.**

Ch7 (Carol)

I. Central Nervous System

A.The Brain

1. The Cerebrum- The most rostral (front) section of the brain

* + - * + divided into different lobes that specialize in function

1. Parietal Lobe- touch, pain

2. Temporal Lobe- memory

3. Frontal Lobe- thought, movement, speech

4. Occipital lobe- vision

* Structure
  + frontal and parietal lobe is divided by the central sulcus
  + parietal and frontal lobe is divided from the temporal lobe by the Sylvian fissure (lateral fissure in picture)
  + if viewed from the top, the left and right sections of the brain are divided by a sagittal fissure that divides brain into left and right hemispheres (left hemisphere controls right side of body and right controls left. )

2. The Brain Stem- stalk that sprouts the cerebellum and cerebrum

* -a nexus of fibers that relay info to and from the brain
* -also regulates vital body functions like breathing, body temperature, and consciousness
* -most vital part of brain, one can survive damage to cerebrum and cerebellum but usually not the brain stem

3. The Cerebellum- “little brain”

* - located underneath the cerebrum
* - called little brain but has as many neurons as the cerebrum
* - its is the movement control center but in this case, left side of cerebellum controls left side of body and right side control right side

B. The Spinal Cord

* -attached to brain stem
* - connects and communicates to body through spinal nerves in the peripheral nervous system
* -2 sections of spinal cord
  + -dorsal root- relays info into brain (afferent)
  + -ventral root- relays info outside of brain (efferent)

II. Peripheral Nervous System

A. Somatic Peripheral Nervous System

* - In charge of voluntary functions
* - Innervate the skin, joints and muscles
* - Somatic motor axons are attached to cell bodies that are in the CNS
* - Somatic sensory axons are attached to cell bodies that clustered outside of the spinal cord. These clusters are called dorsal root ganglia
* - Each spinal nerve has a dorsal root ganglia

B. Autonomic or Visceral Peripheral Nervous System

* - controls involuntary functions of the body
* - Innervate organs, blood vessels and glands

III. The Meninges- protects the CNS ( brain and brain stem) from outside

* 3 layers
  + a. Dura Mater “hard mother”- outer most
  + b. Arachnoid layer
    - -layer looks spidery and filled with cavities of cerebrospinal fluid (produced in the ventricular system)
* c. Pia Mater “Soft mother”- inner most
  + -soft thin layers
  + - invisible to eye

IV. The Ventricular System

* brain is hollow on the inside with caverns that form the ventricular system
* produces the cerebrospinal fluid that helps protect the brain in the arachnoid layer.

V. The Cerebral Cortex

* -the cerebral cortex is sheets of cortical neurons, parallel to the surface of the brain
* -three types: Hippocampus, olfactory cortex and neocortex
* -neocortex is only found in mammals and therefore is the one that we generally are referring to when we say cerebral cortex
* -neocortex has changed through the evolution of mammals
* -bigger the mammal= more area of cerebral cortex
* -bumps(Sulci) and grooves (gyri) on the cerebrum are caused by the cerebral cortex

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***By Topic:***

*Note: Draft, needs fleshing out.*

Glial Cells:

* 10 times more abundant than neurons.
* oligodendrocytes - coat axons (myelin sheath) in CNS
* ependymal - make cerebral fluid, blood brain barrier
* schwann cells - PNS, myelin sheaths
* microglia - immune system,
* astrocytes- blood brain barrier, regulate environment,

Neurons:

* spiny - have little bumps on dendrites. Tips are synapses, body is for inhibitors
* different forms – pyramid, spindle, granules
* Golgi I - long axons, usually pyramid
* Golgi 2 - short, processes local stuff, usually granule shape
* Excitatory Post-Synaptic Potentials
  + raises membrane potential, approaches threshold
* Positive membrane – “dePolarized”
* Negative membrane – HyperPolarized
* Myelin sheath and nodes of ranvier, axon thickness related to speed
  + sheath so no ion leakage
  + nodes of ranvier - gap in shield, optimally located to renew action potential
    - Node to node communication = saltatory coduction
  + axon thickness: thicker = faster.

Brain and Lobes:

* frontal (problem solving and planning)
* parietal (top middle, spatial stuff, reading )
* occipital (in back, vision)
* temporal (by ear, does memory and emotion, word comprehension, hearing)
* Special: Sylvian Fissure - separates temporal lobe

Neurotransmission:

* sodium and potassium (61.54 and -80 mV at rest)
* electrical and diffusional forces cancel each other out
* potassium concentrated inside. As it leaves makes inside negative, which pulls it back in.
* Calcium – low concentrations, causes NT release, pulls up (mV = 123)
* Chloride – inhibitor, pulls down (mV= -65)
* Synaptic channels – depolarizer, pulls up, brings up past action potential.
* equations
* **Action Potential**
  + Once hit threshold, sodium rushes in (Rising phase) (-55mv)
  + at peak, sodium inactivated, potassium channels open finally so it can rush out (falling phase, ultimate refractory for sodium)
  + Once we pass potassium's equilibrium, potassium reverses and sodium deinactivated, but resting channels pull it down into the undershoot (relative refractory)
  + Neuron restores equilibrium
  + frequency of APs reflects the intensity of the stimulus
* electrical and chemical synapses
  + electrical – directly connected through a gap junction
  + chemical – uses NT
    - frog heart experiment
* NT made in cell, loaded into vesicles, sent to front. Calcium comes in, causes fusion and release
* receptors
  + ionotropic – direct gating, fast and weak
    - NT binds, channel opens
  + metabotropic
    - G proteins, can start cascade and structural changes
  + **FOUR CRITERIA**
    - made in neuron
    - when neuron activated, must be released
    - if we take chemical soup and bathe another neuron, must get same response
    - cleanup crew must exist – so no eternal clogging
  + Glutamate – Excitatory in CNS (amino acid)
  + GABA – Inhibitory in CNS (amino acid)
  + Glycine – Inhibitory in PNS (amino acid)
  + Dopamine, Histamine, Acetylcholione – excitatory in PNS (amines)
  + NMDA receptors – glutamate receptors, detect coincidences – deploraziation and NT at same time. also permeable to Ca 2+ so more cell processes are triggered. (kainate and AMPA only permeable to Na+ and K+)
  + **HOW THIS WORKS**
    - Signal comes in and either G proteins start or channels open, which causes change in polarization

**Ion equilibrium potentials:**

K+ = -80 mV

Na+ = 62 mV

Ca2+ = 123 mV

Cl - = -65 mV

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**Sample Questions:**

1. Describe what Na and K are doing at -100mv, +100mv, and 0mv.
2. Name the four lobes of the brain and their main functions.
3. Explain the core differences between chemical and electrical synapses.
4. Explain the purpose and structure of the myelin sheath.
5. Define “hyperpolarization” and “depolarization”.
6. Patient TAN and Phineas Gage both experienced brain damage. Which parts of their brains were damaged and what effect did this damage have?
7. Define PNS and CNS, and explain how they differ.
8. Explain “white matter” and “gray matter”, and how it differs in the spine vs brain.
9. What is the EPSP? How is it different than the IPSP?
10. What is the ratio of Neurons to Glia?
11. Name 3 glial cells and define their function.
12. Define phrenology.
13. What are four ways of deactivating a neurotransmitter after work is done?
14. Who created the neuron doctrine and reticular theory?
15. (Bad question)
16. How is Broca’s aphasia different from Wernicke’s aphasia?
17. What is the difference between Golgi I and Golgi II neurons?
18. Describe endocytosis and exocytosis.
19. Draw a graph of an action
20. potential and label all significant areas. For each, explain what Na+ and K+ are doing.
21. Why is the resting membrane potential about -65 mv?
22. What are the four criteria for something to be defined a neurotransmitter?
23. What fluid runs through the ventricles of the brain and the arachnoid space?
24. What did Otto Loewi do and why is it important?
25. How many meninges do we have and what are they called?
26. How do you distinguish between mature and immature dendritic spines?
27. What is the difference between metabotropic and ionotropic receptors?
28. What are the nodes of Ranvier and what is their effect on the action potential?
29. What are two ways of speeding up the propagation of an impulse down an axon?
30. How is Action Potential activated?

**Answer Key:**

1. Describe what Na and K are doing at -100mv, +100mv, and 0mv.
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5. Define “hyperpolarization” and “depolarization”.

-hyperpolarization is more negative, depolarization is more positive

1. Patient TAN and Phineas Gage both experienced brain damage. Which parts of their brains were damaged and what effect did this damage have?
2. Define PNS and CNS, and explain how they differ.
3. Explain “white matter” and “gray matter”, and how it differs in spine and brain?
4. What is the EPSP? How is it different than the IPSP?

-excitatory = flow of Na+ in (mv shoots up) and inhibitory = flow of Cl- in (mV dips down)

1. What is the ratio of Neurons to Glia?

-1:10 (100 billion:1 trillion)

1. Name 3 glial cells and define their function.
2. Define phrenology.
3. What are four ways of deactivating a neurotransmitter after work is done?

-degradation by enzymes, reuptake by presynaptic neuron, diffusion away from the cleft, taken up by neighboring glial cells

1. Who created the neuron doctrine and reticular theory?
2. What is the difference between muscarinic and nicotinic ACh receptors?
3. How is Broca’s aphasia different from Wernicke’s aphasia?
4. What is the difference between Golgi I and Golgi II neurons?

-axon length. golgi I is longer II is shorter

1. Describe endocytosis and exocytosis.

-exo = releasing neurotransmitter. endo = reuptake

1. Draw a graph of an action potential and label all significant areas. For each, explain what Na+ and K+ are doing.
2. Why is the resting membrane potential about -65 mv?
3. What are the four criteria for something to be defined a neurotransmitter?

-produced inside the neuron naturally, needs to produce a response on a particular target, needs to produce same response when applied experimentally, needs to be naturally

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5. What is the difference between metabotropic and ionotropic receptors?

-metabotropic = uses g protein to propagate

1. What are the nodes of Ranvier and what is their effect on the action potential?
2. What are two ways of speeding up the propagation of an impulse down an axon?
3. How is Action Potential activated?