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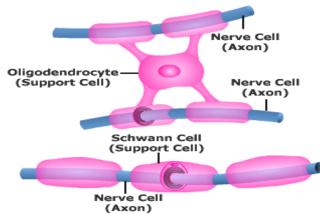
*It is very important to take detailed notes, to augment this outline.*

Remember that we will not have time to cover all concepts in the textbook. So, if you have questions about material not covered during class, please make sure to ask (you can ask during class or send an email to the class account).

## I. Cells of the brain

- Rules of Thumb of biological psychology:
  - Named via shape, function, location and/or discoverer
    - dendrite, soma, nodes of Ranvier, hypothalamus
  - Named more than once
    - Glia, glial cells, neural glia
    - Medulla, medulla oblongata
    - Serotonin, 5-HT
  - Different shape = different function

oligodendrocytes vs. Schwann cells



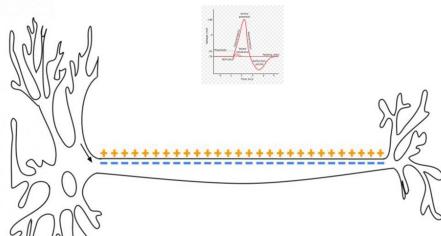
- Neuron anatomy & physiology
  - receives, processes and transmits information
  - dendrites & dendritic spines
  - soma
    - e.g., organelles like mitochondria
    - nucleus
      - genetic material
  - Axon
    - Some: myelin sheath & Nodes of Ranvier and/or elongated unmyelinated areas
    - Some: axonal varicosities
  - Terminal buttons
- Glia (the “glue” of the brain, but has many functions)
  - oligodendrocytes (CNS) & Schwann cells (PNS)
    - oligodendrocytes: one cell can create several segments of myelin sheath & cover more than one axon

- Schwann cells: one cell creates only one segment of myelin sheath for only one axon
- astrocytes
  - Synchronizes communication between neurons, nurtures cells, and removes waste products
- microglia
  - Functions as part of immune system, removes waste products & invaders such as bacteria & viruses
- radial glia
  - Guides migration & growth of immature neurons

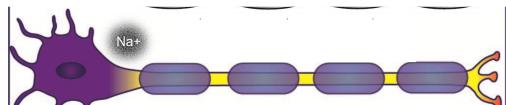
## II. Types of neural signals (don't get thrown off by the complicated names)

- Synapses
  - Axo-dendritic
  - Axo-somatic
  - Axo-axonic
  - Glia = private "conversations"
- Action potential

- I. Cells of the Brain  
II. Types of neural signals
- Action potential
    - Electrical & chemical signal in axon
    - Unmyelinated



- I. Cells of the Brain  
II. Types of neural signals
- Action potential
    - Electrical & chemical signal in axon
    - Myelin sheath



- this is a type of neural signal which is electrical AND chemical
- it occurs in the axons of neurons (for neurons which have an axon)

- myelin sheath covers some neuronal axons and it makes the action potential travel down the axon much more quickly
- Special properties of the action potential (that is, the action potential is a signal with certain characteristics)
  - “all or none”
  - threshold of excitation
  - absolute refractory period
  - relative refractory period
- EPSPs & IPSPs
  - Electrical AND chemical signals
  - Cable properties: no threshold of excitation, strength varies, degrades over time and distance
  - EPSPs & IPSPs summated/integrated
    - If EPSPs > IPSPs (threshold of excitation) then action potential in the 2<sup>nd</sup> neuron
    - IF IPSPs > EPSPs OR if EPSP > IPSPs (but does not reach threshold of excitation), then NO action potential in the postsynaptic neuron
  - NOTE: a neuron is not silent when it is at rest. it spontaneously fires action potentials at a basal rate. when it is stimulated by other neurons (so lots of EPSPs), it can increase the rate at which it fires action potentials. if a neuron is inhibited by other neurons (so lots of IPSPs), it can decrease its usual rate of firing action potentials.
- Neurotransmitters
  - at the terminal buttons, there are vesicles full of chemicals called neurotransmitter (but not all neurotransmitter is encased in a vesicle)
  - when the action potential reaches the terminal buttons, **exocytosis** is triggered to occur (where the neurotransmitter is released from the vesicle)
  - the neurotransmitter diffuses across the synapse, which is filled with fluid (b/c all cells are bathed in a mildly, salty solution)
  - the neuron which releases the neurotransmitter (that is, sends the info) is called the presynaptic neuron
  - the neuron which receives the neurotransmitter is called the postsynaptic neuron
  - neurotransmitter must find receptors which it matches
  - when it matches a receptor, it binds to a place on the receptor (called the “binding site”)
  - this binding causes either an excitatory postsynaptic potential or an inhibitory postsynaptic potential

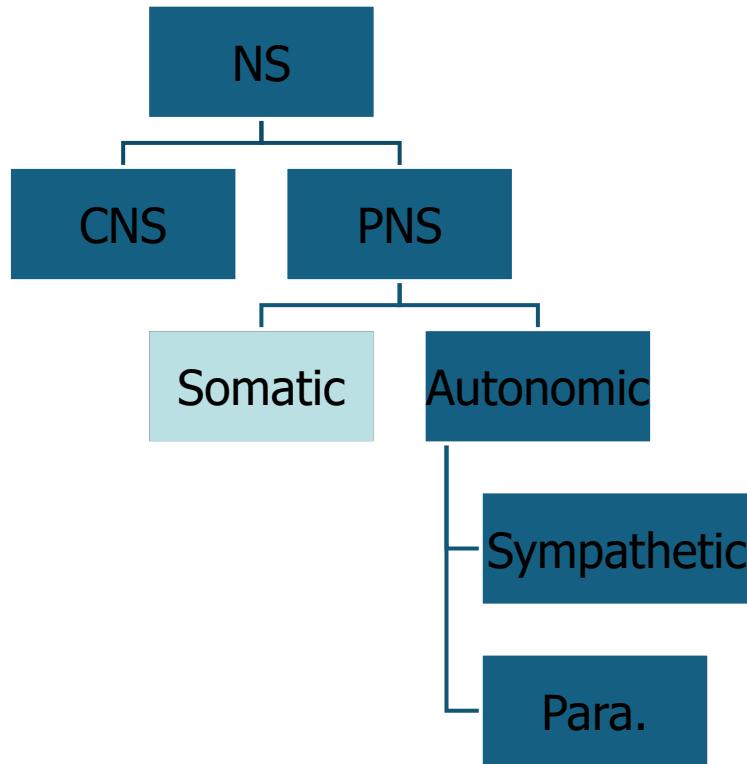
- neurotransmitter then unbinds from the receptor and either reuptake and/or enzymatic degradation occurs (a little bit may also diffuse away)

### III. Common neurotransmitters (and larger brain chemicals called neuropeptides)

- General information (additional details below)
  - Neurotransmitter names come from molecular structure
  - There are usually multiple ways to refer to neurotransmitters
  - There are multiple effects a neurotransmitter may have, depending on the type(s) of receptors it binds with.
  - Neurotransmitters come from food and neurotransmitters can be derived from another neurotransmitter.
  - Exogenous chemicals can increase or decrease neurotransmitter activity (agonist vs. antagonist)
  - Large chemicals may be neuropeptides or even proteins
- GABA vs. glutamate
- Acetylcholine
  - Different names
    - aka Ach
    - aka Acetylcholinergic
    - aka Cholinergic
  - Common functions
    - *This is a good place to point out that any particular neuron has many different effects, depending on WHICH type of receptor it binds with. It is true that neurotransmitters have to find receptors that it matches with, but generally, each neurotransmitter has several different types of receptors that it can bind with.*
    - PNS: muscle contractions
    - CNS: arousal, attention, learning, better memory
      - botulinum toxin
        - cholinergic antagonist (in that it blocks activity)
        - Botox is diluted form of botulinum toxin
      - curare
        - cholinergic antagonist
      - atropa belladonna
        - cholinergic antagonist
      - black widow spider venom
        - cholinergic agonist
      - nicotine
        - cholinergic agonist
- Monoamine neurotransmitters
  - *catecholamines* (one subtype of monoamine neurotransmitters)

- dopamine
    - aka DA
    - aka Dopaminergic
    - CNS: movement, addictions, mood
  - norepinephrine
    - aka NE
    - aka Noradrenergic
    - (don't confuse with cholinergic!)
    - CNS: mood, arousal
  - epinephrine (not in your textbook, but it is also a monoamine)
    - aka Epi (ever hear of the "Epi" shot? it is a shot of epinephrine!)
    - aka Adrenergic
    - PNS: cardiac contraction, CNS: mood
  - DA, NE, Epi are a sub-category of monoamines called catecholamines
    - box jelly fish
      - possibly cholinergic antagonist but also ADRENERGIC agonist (it increases activity)
    - *indolamine* (another subtype of monoamine neurotransmitters)
      - Serotonin
        - aka 5-HT
        - aka Serotonergic
        - CNS: sleep/arousal, mood, eating, aggression, impulsivity
  - Endorphins
    - aka type of neuropeptide (larger brain chemical)
    - larger neurotransmitter molecule
    - modulates/decreases pain
  - Neurotransmitters ultimately come from food
    - e.g. the catecholamines (i.e. DA, NE, Epi) come from the amino acid phenylalanine
      - phenylalanine > tyrosine > L-Dopa > **Dopamine** > **Norepinephrine** > **Epinephrine**
    - e.g. 5-HT comes from eating tryptophan
      - **tryptophan** > **serotonin** > can also be converted into **melatonin** (which makes you sleepy!)

### III. Organization of the Nervous system (be sure to know the functions)



- spinal cord injuries
  - permanent
  - functions from the level of the spinal injury and downward
- Afferent vs. Efferent
  - Afferent: “approaching” the brain
  - Efferent: “exiting” the brain

#### IV. Methods to study the brain

- Brain damage
  - What can brain-damaged people tell you?
- Lesioning (controlled damage)
  - via knife cut, electrolytic lesion, aspiration
  - sham studies – what are they for?
- Stimulation
  - via electrical stimulation, transcranial magnetic stimulation (TMS) or repetitive TMS (rTMS), chemical stimulation
- Brain Imaging
  - Tools which give structural information
    - CT scan: multiple X-rays
    - MRI: greatest resolution, large magnet, no radiation
  - Tool which gives functional information
    - PET scan: radioactive synthetic glucose, measuring blood flow
  - Tool which gives you both structural & functional information

- fMRI: measuring blood flow & oxygen, not as good structural resolution as MRI
- fMRI has even been used to differentiate between coma vs. unresponsive wakefulness syndrome vs. minimally conscious state

#### *V. Development of the Nervous system - Class*

- *Fertilization*
- *Development of the (tiny) neural tube (~24 days)*
  - *When abnormal development occurs:*
    - *neural tube defect*
      - *spina bifida*
      - *anencephaly*
- *Neural tube continues to swell & grow*
  - *first: 3 swellings: forebrain, midbrain, hindbrain with hollow center*
  - *later: 5 swellings: telencephalon, diencephalon, mesencephalon (midbrain), metencephalon, myelencephalon (medulla)*
  - *last: the telencephalon grows so much, it covers the rest of the brain*
- *Ventricles & CSF*
  - *hollow area remains in the brain*
  - *filled with fluid called cerebral spinal fluid*
  - *cushions the brain inside & out (it covers the brain, too)*
  - *CSF is created within the ventricles and circulates around the brain, is then absorbed into the circulatory system (blood system).*
  - *If there is blockage of the CSF circulation = hydrocephalous (literally, water on the brain)*

#### *VI. Brain: Physiology & Anatomy*

Guiding principles to understanding the brain:

- More medial and lower in the brain = primitive/vital functions (e.g. it is likely that these areas are evolutionarily old)
- Higher and more outer areas of the brain = highest level of brain functions
- Though the names give a clue as to what the area does, they may not be that helpful as they are greek and/or latin root words. You'll need to spend time memorizing the functions of various brain areas.
- Hindbrain (very base of the brain)
  - medulla
  - pons
  - cerebellum
  - reticular formation (from the very bottom of the medulla to the very tip of the midbrain)
    - ascending fibers: wakefulness/sleep
    - descending fibers: motor movement

- aka reticular activating system
- Midbrain
  - visual information: superior colliculi
  - auditory information: inferior colliculi
  - DA-producing neurons: substantia nigra
  - periaqueductal gray: this area of the brain is involved with modulation of pain perception. For example, opioids can be released in this area and this leads to decreased perception of pain.
  - reticular formation
- Forebrain
  - cerebral hemispheres
    - What happens when you cut through the corpus callosum?  
What is split-brain surgery and what are the consequences?
  - cerebrum = right and left hemispheres
  - corpus callosum
    - split-brain research
      - last resort for uncontrollable epilepsy
      - cut corpus callosum
      - results in evidence of lateralization (different functions of the different hemispheres) when tested carefully
    - main, not only, connection between hemispheres
- thalamus
  - “sensory relay station” b/c all sensory info goes here before going to their primary cortices
  - one exception: olfactory system does not send info here before going to its primary cortex
  - not a unitary structure, composed of different clusters of neurons
  - critical for consciousness
    - It connects the lower brain areas with the brain areas involved with higher mental functioning. If you damage this area, thereby disconnecting the lower from the higher areas of the brain, you will likely not be fully conscious.
- hypothalamus
  - 4 Fs (motivated behaviors)
  - not a unitary structure, composed of different clusters of neurons
  - controls the pituitary
- limbic system
  - network of different brain structures: thalamus, hypothalamus, hippocampus, amygdala, & some other nearby structures
  - processes emotional information
- cerebral cortex (“bark”)
  - where higher mental functions are done

- aka gray matter (b/c it looks gray) vs. white matter, which is beneath the gray matter (and looks white b/c of the myelin sheath of axons)
- 4 lobes
  - occipital lobe: houses the primary visual cortex
  - temporal lobe: houses the primary auditory cortex
  - parietal lobe: houses the primary somatosensory cortex
  - frontal lobe: houses the primary motor cortex + mirror neurons + prefrontal lobe
    - prefrontal lobe: executive functions (e.g. organizes & directs thought processes - planning, supports working memory, inhibits impulsive behaviors). Does not seem to fully mature until possibly ~ 25 yrs. of age
- primary cortex vs. association area
- sulcus (or sulci is plural): a groove
- gyri (a bump or ridge of the brain)
- fissure: a very deep groove in the brain
- Plasticity
  - musicians have larger somatosensory areas
  - man with amputated toe
  - neurogenesis: new neurons are created in SOME areas (i.e., hippocampus & olfactory bulb) (vs. synaptogenesis)

## VII. Cerebral specialization

- Left hemisphere?
  - language
  - Broca's area (speech production), Wernicke's area (speech comprehension)
- Right hemisphere?
- Connectivity between the hemispheres
- Split-brain research
  - Why would anyone do this surgery?
  - What are the results?
  - If you flashed a picture in the left visual field, would a person with split-brain be able to *say* what they saw?

## VIII. Endocrine System

- Hypothalamus
- Pituitary
  - Oxytocin
- The nervous system and the endocrine system work together...

## IX. Hereditary studies (If we do not get a chance to discuss this during class, and you are having trouble understanding this, please be sure to ask us about it, as always...)

- Is who we are due to our genes or our environment? Both.
  - Vulnerability/pre-disposition vs. destiny
  - e.g. short from of 5-HTT, growth mindset
- How much is a characteristic due to our genes? To answer this, you need to come up with a heritability estimate.
- Three ways to estimate heritability:
  - Family studies
    - method: see if the rates (how many have this) is higher in the affected family as compared with the non-affected family
    - if the rate is higher, the assumption is that the target behavior may be largely inherited
    - flaw: families do not share just genes, but also environment (can you give an example which illustrates this?). Thus, this design cannot tease apart the effects of genes vs. environment.
  - Twin studies
    - method: compare concordance rate (rate of agreement) between the monozygotic (MZ) and dizygotic (DZ) twins. Remember that MZ (aka identical) twins share 100% of their genes while DZ twins share 50% of their genes, like other siblings. The implication is that the higher concordance rate in monozygotic twins is b/c the target behavior is largely influenced by genes.
    - concordance rate example: 50% of MZ twins are the same on level of aggression (say that if one twin was high on aggression, the other twin is also high on aggression) while 10% of DZ twins had the same level of aggression, we would say that the concordance rate of MZ twins is greater than that of DZ twins
    - flaw: the assumption that MZ and DZ twins only differ in terms of genes may be invalid; it's possible that they experience different environments as well (e.g., if a pair of MZ was very attractive, they are likely to evoke a positive social environment; but if one pair of a DZ twin was very attractive and the other pair was very unattractive, they would likely evoke different social environments; thus, if the MZ twins seem more similar to each other than the DZ twins in this case, it wouldn't just be due to genes, it would also be because of environment).
  - Adoption studies
    - non-twin adoption study method: compare rates of the disorder among the biological vs. adoptive relatives. The assumption is that a higher rate of the disorder among the biological relatives indicates stronger genetic influence
    - twin adoption study method: gather MZ & DZ twins who have been reared apart. Compare concordance rate (of the target behavior) between the MZ & DZ twins. The assumption is that if the concordance rate is higher between the MZ twins as compared with the concordance rate between the DZ twins, it must be due to

- genetic influence since they did not share the same physical environment (presumably, though evoked social environment may still be a problem)
- o flaw of the adoption method: sample sizes tend to be too small (esp. with the twin adoption study method) b/c there are only a small number of people who manifest the target behavior AND have been adopted
  - small sample sizes can be misleading (imagine if you had aliens had chosen only Michael Jackson to research what a “man” was like; clearly, they may get a better idea of what a “man” is like if they picked up, say, 100 men, even if it one of those men were Michael Jackson)
- o another flaw: separating the twins does not ensure that they experience dissimilar environments (e.g., again, if they look alike, they may evoke the same social environment)
- What is genetic mapping?
  - o Genome-wide association studies
  - o polygenic
- What is epigenetics?
  - o What does your author suggest that efforts to determine how much genes vs. environment play a role in a certain characteristic is ultimately artificial?
  - o Epigenetic marks can be passed down generations

#### X. The Evolutionary Bases of Behavior

- Darwin: traits which provide either a) survival advantage or b) reproductive advantage are much more likely to be “selected” over time (via natural selection).
  - o Notice that “fitness” isn’t so much about survival unless it’s survival for the purpose of being able to reproduce. (It is very difficult to reproduce when one is dead.)
- Behavioral traits are subject to natural selection as well
- Population vs. individual organisms
- Though it can take awhile for species to “evolve,” many changes are also due to spontaneous mutations/variation and these can result in rather quick changes.
- The author suggests two implications of Darwin’s theory, one of which suggests that life’s diversity is not due to divine creation. *Is an alternative opinion possible? Could it be that divine creation created natural selection itself as an efficient method to create adaptive diversity? Are religions and the theory of evolution mutually exclusive?*
- Note: your author suggests that our preference for fat is a problem as it may lead to diseases such as obesity, heart disease, etc. However, please note that we still need a certain amount of fat in our diet to be healthy. Additionally, one could argue that sugar is the bigger problem these days. In fact, research

suggests that fat (with other dietary tips) can actually help to reduce insulin problems (which make people overweight/obese).

- Finally: aren't black-tipped hangingfly females HILARIOUS?!