

Neurons and neurotransmitters

PSY 200
Greg Francis
Lecture 05

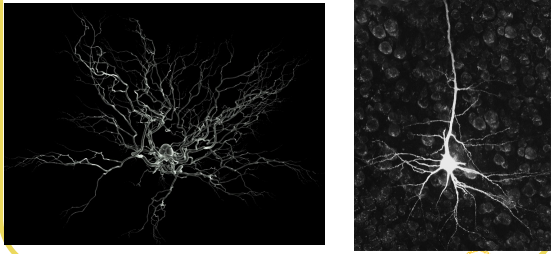
Why does (nearly) everyone love Prozac?

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Neurons

- The brain cells that are responsible for cognition are neurons

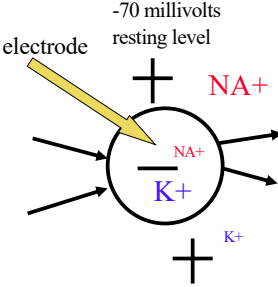


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Input / output

- Electrical signal
 - Established by the relative amount of charged ions inside versus outside the cell membrane
- Inputs change the resting potential of the cell
- Output identifies when the cell potential has increased a lot

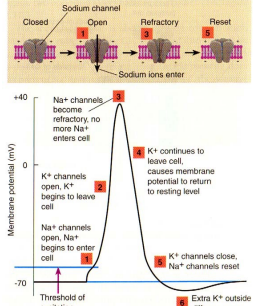


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Input at dendrites

- Changes the cell membrane potential
 - which causes further changes in the cell's chemistry
 - which causes further changes in the membrane potential
- Strong enough input crosses a **threshold** and the cell fires
 - action potential



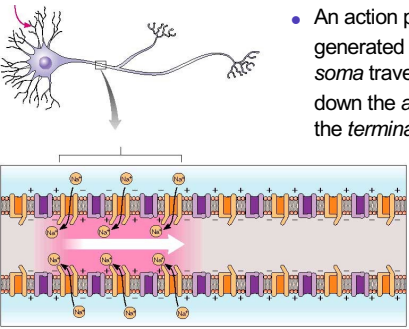
https://mind.ilstu.edu/curriculum/neurons_intro/flash_action_potential.html

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A neuron

- An action potential generated at the **soma** travels down the **axon** to the **terminals**

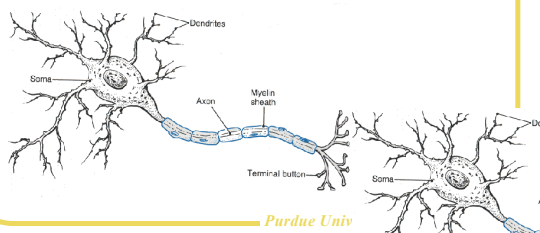


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A neuron

- The action potential then affects the membranes of other cells' dendrites



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Output

- Myelin is like insulation for the cell's axon
 - it insures that the signal generated by the action potential is strong
 - Jumps electrically rather than the normal chemical exchanges
- In multiple sclerosis the body's immune system attacks myelin
 - physical problems (paralysis)
 - cognitive problems (memory, reasoning, judgement)
 - cause unknown (300,000 people)

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Output

- The output of a neuron is either *excitatory* or *inhibitory* on the other neuron it reaches
- Excitatory:** when our neuron sends an output, the receiving neuron is *more* likely to produce an action potential
- Inhibitory:** when our neuron sends an output, the receiving neuron is *less* likely to produce an action potential

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Networks

- Cognitive behavior is related to groups of neurons working together
- Include excitation and inhibition
 - more later

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Epilepsy

- Disease of central nervous system
 - causes mostly unknown
- Seizures
 - bursts of electrical activity travelling through networks in the brain
 - brain activity is out of control
 - epileptic fits
- Isolated* seizures also occur due to high fever, lack of oxygen, or head injury

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Epilepsy

- EEG recordings are often used to diagnose epilepsy
- Many different types of epilepsy, with different EEG patterns

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11

Epilepsy

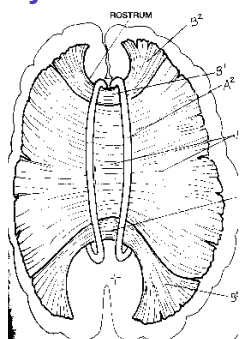
- One theory (but not yet proven) is that epilepsy patients' *inhibitory cells* are not working properly
- Excitatory cells activate everything until they "exhaust" themselves

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Epilepsy

- Treatment generally involves
 - ♦ drugs, diet, avoiding stress, keeping regular schedule
- In extreme cases surgery prevents seizures from spreading throughout the brain



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A balanced brain

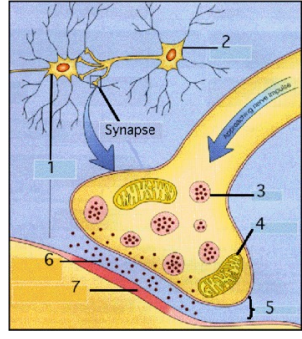
- The brain is a dynamic system
 - ♦ at multiple levels
- Neurons
 - ♦ balance between "forces" inside and outside of cell membrane allows for action potentials
- Networks
 - ♦ balance between excitation and inhibition
- Without these balances you do not think
- Contrast with ideas about using "more" of your brain

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Neural connections

- Axon --> dendrites



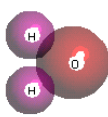
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15

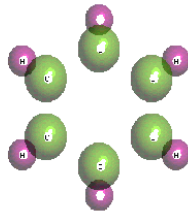
Molecular structure

- Molecules have a particular three-dimensional **shape**

water



benzene



C6H6

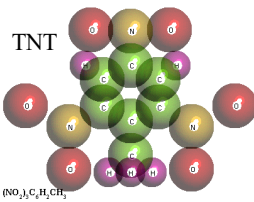
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16

Molecular structure

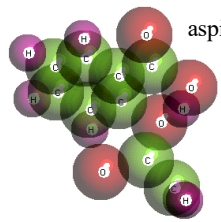
- Different molecules have different shapes

TNT



(NO2)3C6H5

aspirin



C9H8O4

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Molecular structure

- Neurotransmitters are just *molecules*
- At least 50 different neurotransmitters
 - ♦ dopamine, norepinephrine, serotonin, acetylcholine, glutamate, gamma-aminobutyric acid (GABA)
- All with different *shapes!*

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Receptor

- **Very large** molecules called *proteins*
- Similar to a filter
 - ♦ accepts some neurotransmitters
 - ♦ rejects others

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Receptor

- When it accepts a neurotransmitter, it starts a chain reaction of events
 - ♦ physical, chemical, electrical
 - ♦ locally changes the cell membrane
 - » depolarization (excitation)
 - » hyperpolarization (inhibition)

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Neurotransmitters

- Different neurotransmitters are associated with different properties
 - ♦ actually neurotransmitter and receptor pairs
- neural
- cognitive
- behavioral

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Tourette's syndrome

- Inherited (~200,000 in US)
- Behavior
 - ♦ Swearing
 - ♦ Tics
 - » Simple: eye blinking, facial grimacing, sniffing
 - » Complex: coordinated patterns, sniffing objects, jumping, twisting
- Too much dopamine
- Treated with Haldol (among others)
 - ♦ blocks dopamine

<https://www.youtube.com/watch?v=NIFpkruXrCI>
(6:15 in)

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Parkinson's

- Lack of dopamine
 - ♦ Many different causes
 - ♦ In extreme cases, patients are "frozen"
- Give patients large doses of L-DOPA
 - ♦ a precursor of dopamine
 - ♦ sometimes solves the problem
 - ♦ lots of side effects
- *Awakenings*, by Oliver Sacks

<https://www.youtube.com/watch?v=koL0PWCJ4lo>

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Drugs

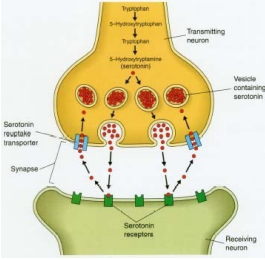
- Interact with neurotransmitters in lots of ways, for example
 - ♦ Replace: accepted by receptor and with similar effect
 - ♦ Production: increase or decrease
 - ♦ Reuptake: knock out enzymes that remove neurotransmitter from receptor, neurotransmitter has a bigger effect
 - ♦ Blocking: enter receptor but does not trigger reaction, partly closes receptor protein so neurotransmitter cannot enter


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Prozac

- Some forms of depression seem to be related to limits in the use of the neurotransmitter *serotonin*
- Prozac is a selective serotonin reuptake inhibitor (SSRI)
 - it keeps serotonin bound to a receptor for longer than usual, thereby increasing its effect
- Prozac is one of the most widely prescribed drugs in the world!




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Other drugs


- Amphetamines: release of norepinephrin or dopamine
- LSD: resembles serotonin
- Phenothiazine drugs: block dopamine
- Curare: blocks acetylcholine
- Cocaine: prolongs effects of dopamine
- Morphine: resembles a small set of neurotransmitters called endorphin peptides (modulate pain perception)
- Tetrahydrocannabinol (active ingredient in marijuana): binds to some neuroreceptors, but it's not clear what it does

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Conclusions

- Neural action potentials
- Shape of proteins
- Specific use of neurotransmitters for certain behaviors
- Current work on identification of role of neurotransmitters
- Lots of money to be made
- Lots more complicated than what we've seen here


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Next time

- Neural sensitivity
- Neural codes
- Receptive fields
- CogLab on Blind spot due!

- *How do you recognize your grandmother?*

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28