

BOOKLET #2

THE SYNAPSE

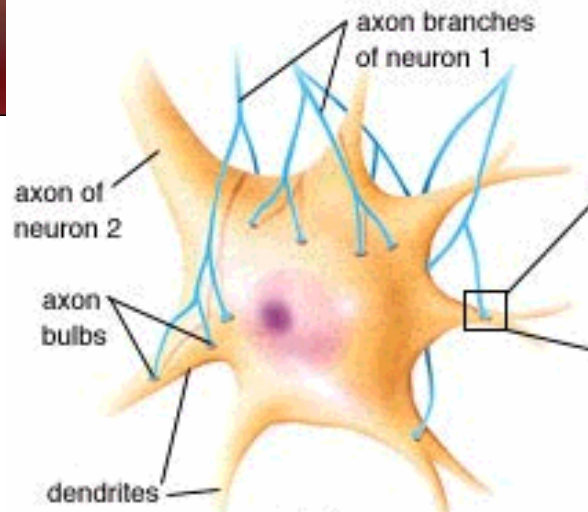
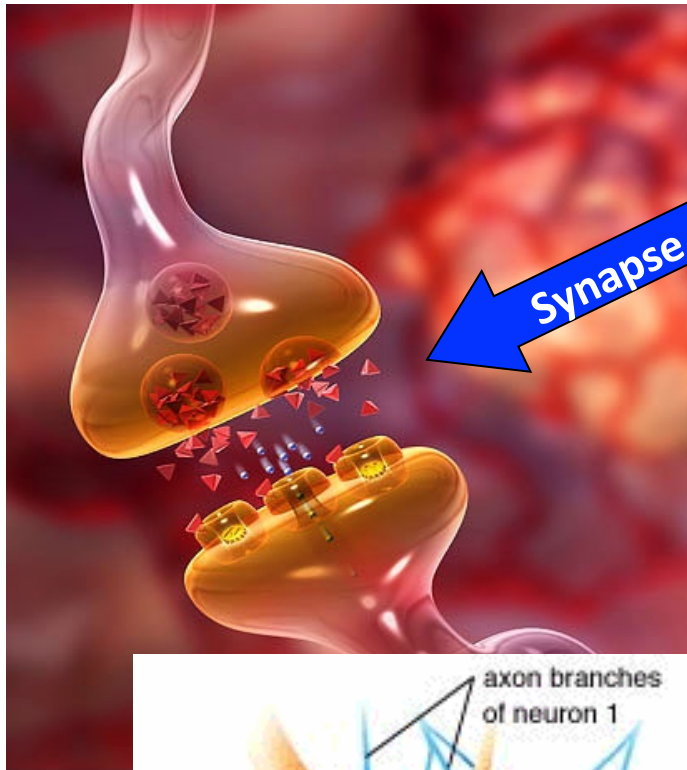


Terms you need to know...

- Post synaptic
- Pre-synaptic
- Neurotransmitter
- Synaptic Vesicles
- Synaptic Cleft
- Cholinesterase
- Acetylcholine
- Norepinephrine
- Endorphines
- Neuromuscular Junction
- Excitatory
- FASD

Synaptic Activities

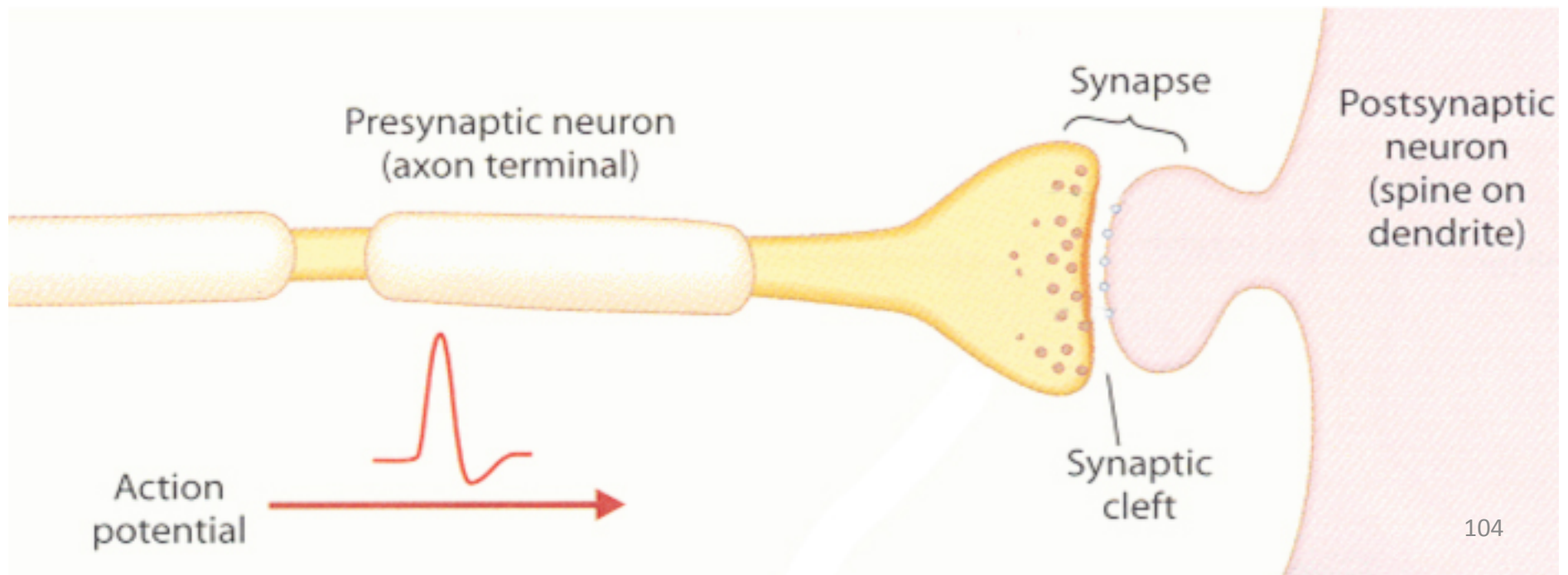
How does info get from one neuron to another?



- Neurons don't actually touch
- Info needs to jump from one neuron to the next across the **synapse or synaptic cleft**
- **Synapse:** space between neurons ~ 20nm
- Transmission across a synapse is slow
- There are many synapses

Pre- and Postsynaptic neurons

- An impulse moves ...
FROM the **presynaptic** neuron
TO THE to the **postsynaptic** neuron.
- The nerve endings of the presynaptic neuron are filled with **synaptic vesicles** which contain **neurotransmitters**.



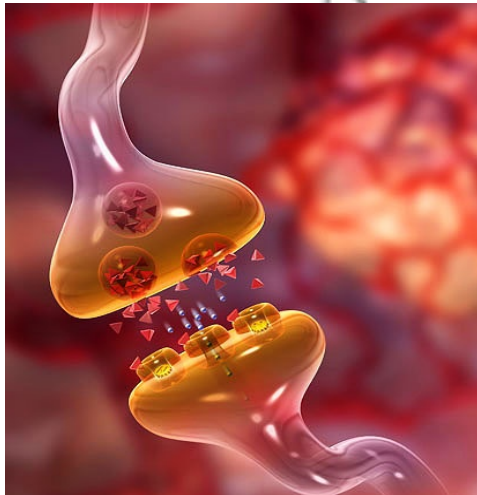
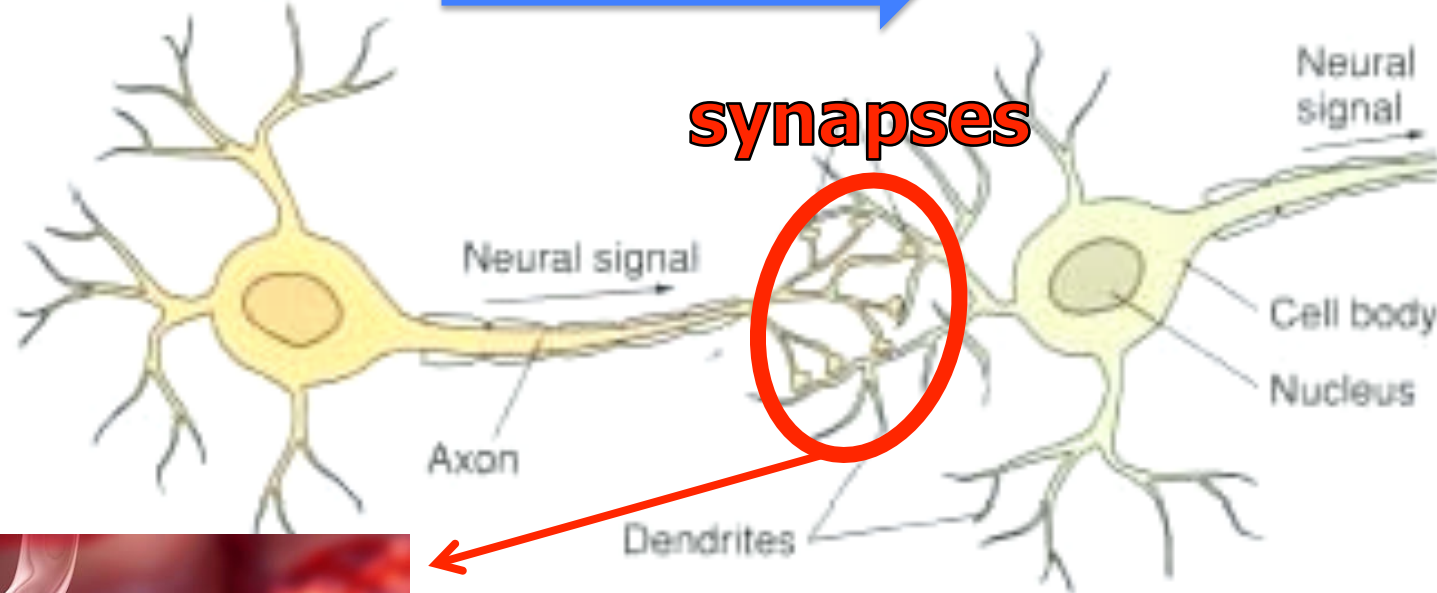
Pre and Post-synaptic Neurons

**Pre-synaptic
Neuron**

**Post-synaptic
Neuron**

AXON TERMINALS

DENDRITES

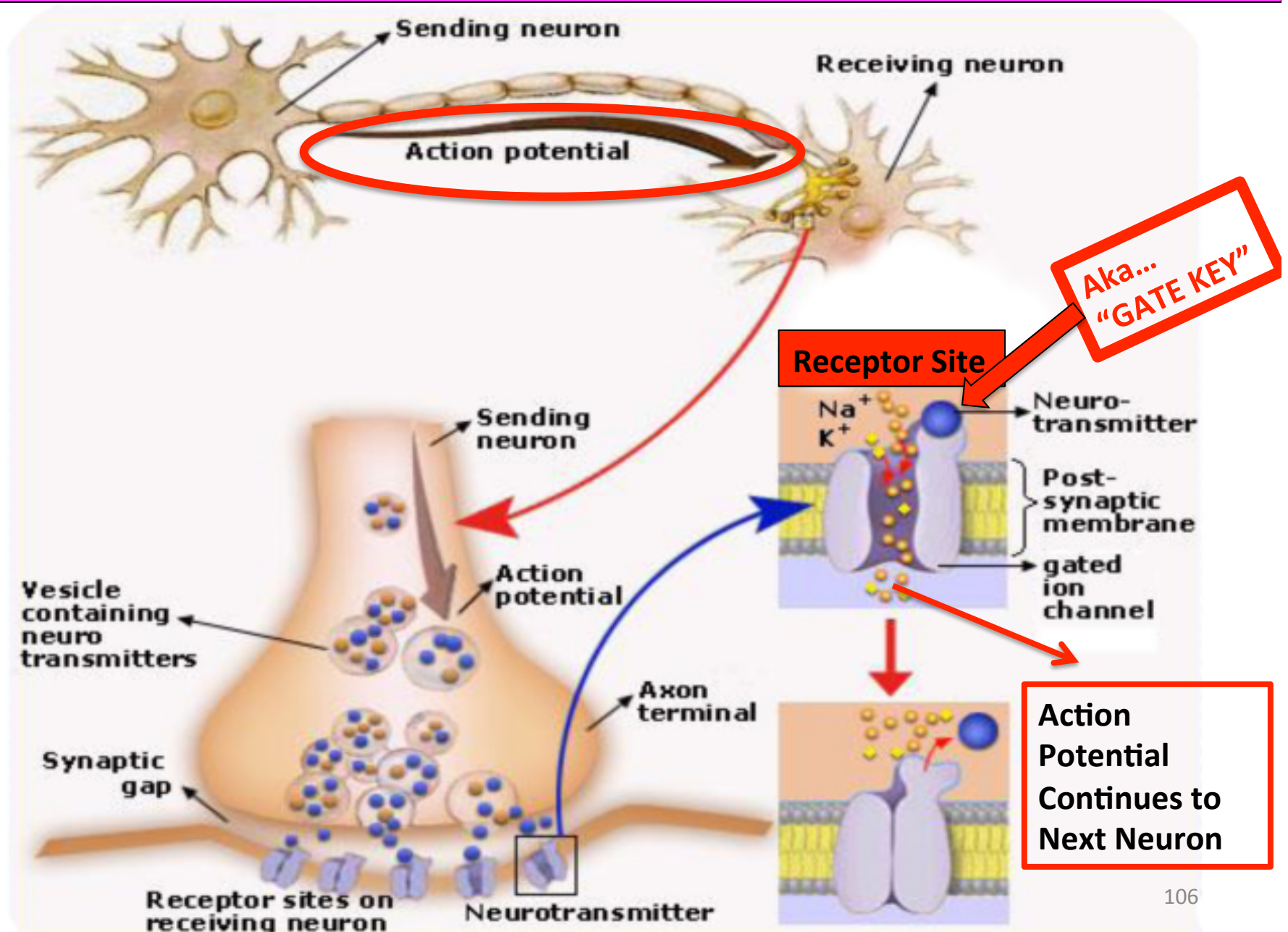


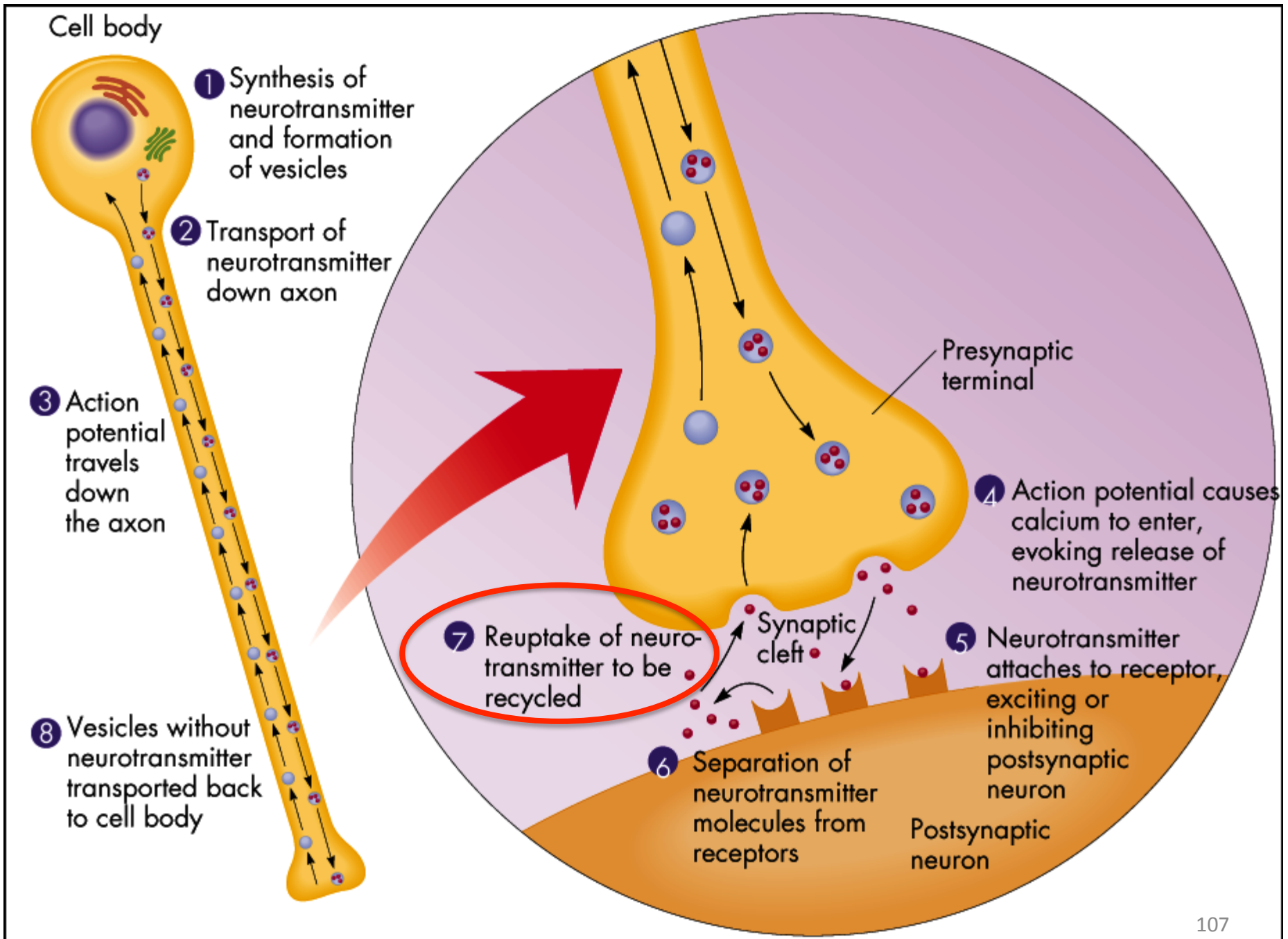
[CLICK ME: Synaptic Transmission I](#)

[CLICK ME: Synaptic Transmission II](#)

[extra: SynapseAnimation](#)

Synaptic Transmission

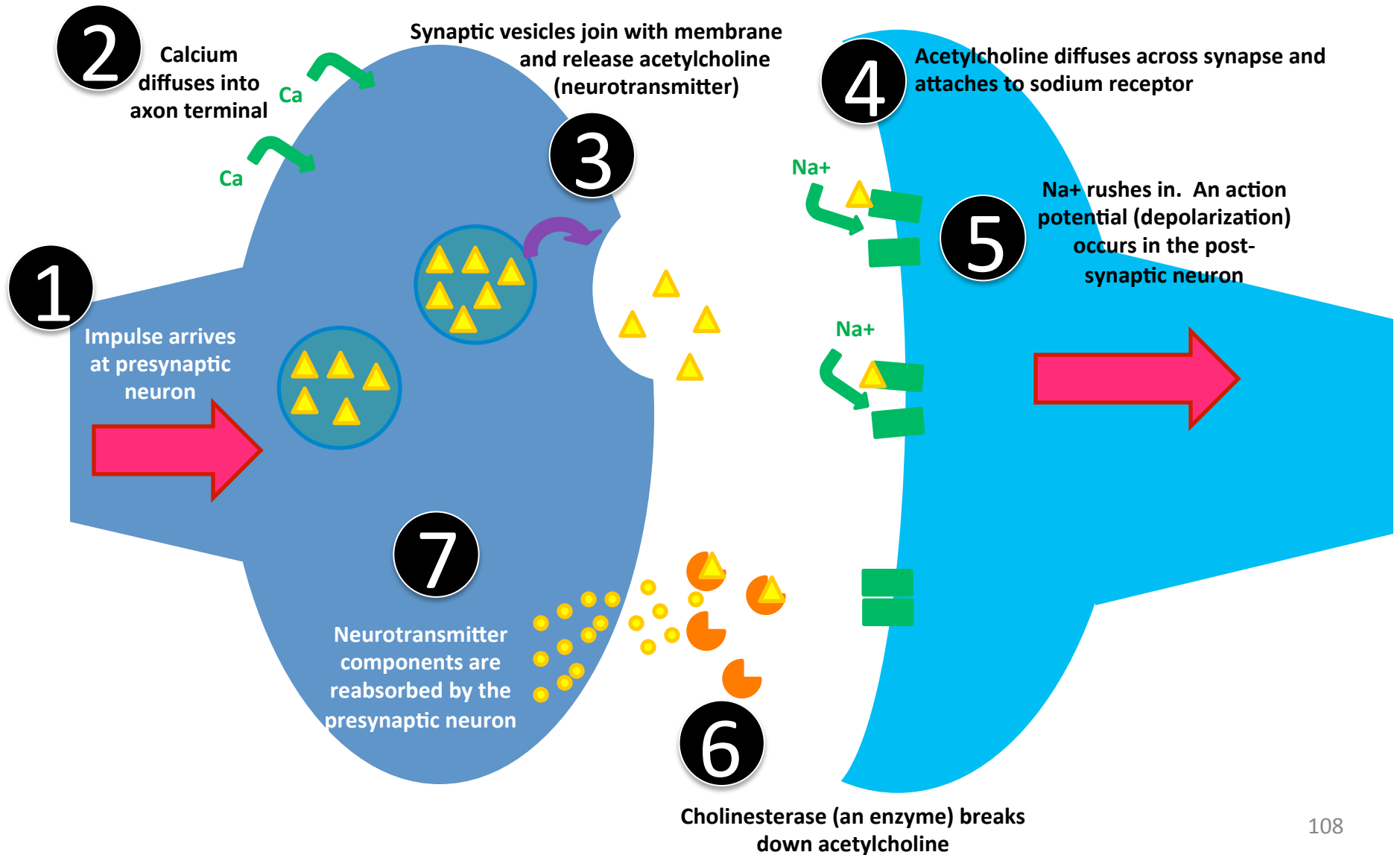




Synaptic Activity

Pre-synaptic Neuron (axon terminal)

Post-synaptic Neuron (dendrite)



Synaptic Activities

1. The nerve impulse arrives at the **presynaptic** membrane.
2. Ca^{2+} ions rush into the presynaptic membrane.
3. Synaptic vesicles merge with the membrane and release acetylcholine (neurotransmitter) into the synaptic cleft by **exocytosis. (requires ATP)**
4. Acetylcholine diffuses across the synapse and attaches to **receptors** on the postsynaptic membrane.
5. Na^+ channels open, Na^+ enters the cell and causes **depolarization** in the postsynaptic neuron = action potential.

Synaptic Activities

6. **Cholinesterase (enzyme)** from the postsynaptic neuron breaks down acetylcholine into **acetic acid and choline**. **This stops the postsynaptic neuron from being stimulated.**
7. **Neurotransmitter** components are reabsorbed by the **presynaptic neuron**.

REVIEW:

[Transmission across Synapse:](#)

[Synapses: Crash Course](#)

Did you know?

Insecticides block the action of cholinesterase
-The hearts of insects are completely under nervous control, so the heart will contract and never relax, finally causing death!



=



Review

Put the steps in order:

1. Na^+ channels open, Na^+ enters the cell and causes depolarization in the postsynaptic neuron = action potential.
2. Synaptic vesicles merge with the membrane and release acetylcholine (neurotransmitter) into the synaptic cleft by exocytosis. (requires ATP)
3. Cholinesterase (enzyme) from the postsynaptic neuron breaks down acetylcholine into acetic acid and choline. This stops the postsynaptic neuron from being stimulated.
4. Ca^{2+} ions rush into the presynaptic membrane.

Answer: **4213**

MORE Review

Put the steps in order:

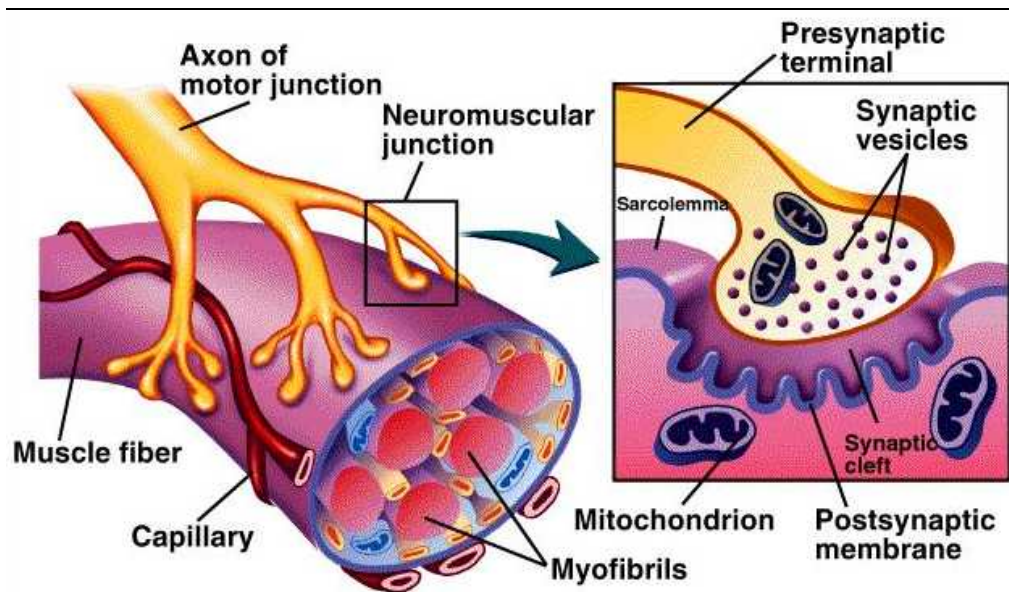
1. Neurotransmitter components are reabsorbed by the presynaptic neuron.
2. The nerve impulse arrives at the presynaptic membrane.
3. Acetylcholine diffuses across the synapse and attaches to receptors on the postsynaptic membrane.
4. Acetylcholine enters synapse

Answer: **2431**

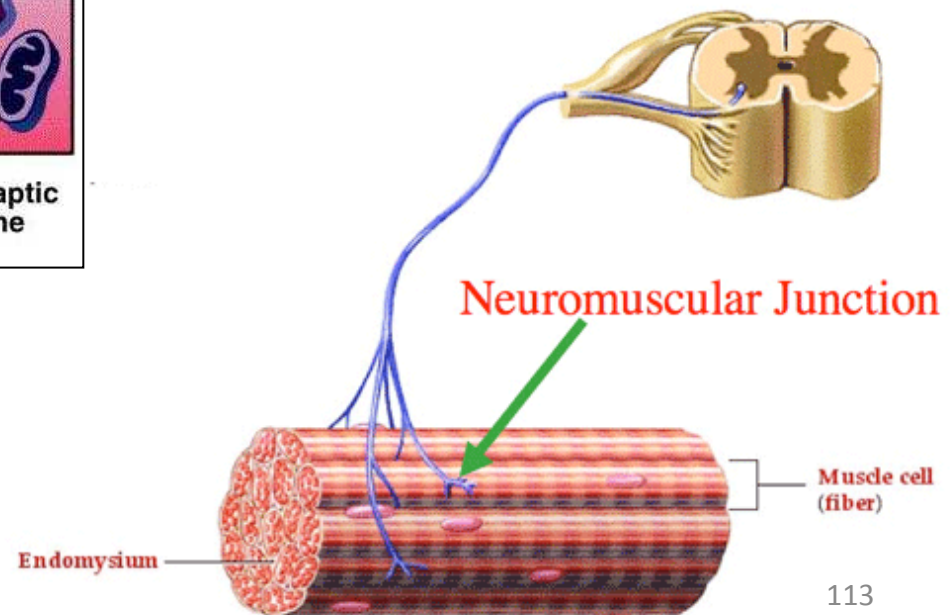
Neuromuscular Junctions

Neuromuscular junction is the synapse (connection) of a motor neuron with a muscle fibre

- causes the muscle to contract



Neuromuscular Junction



Types of Synapses

Excitatory

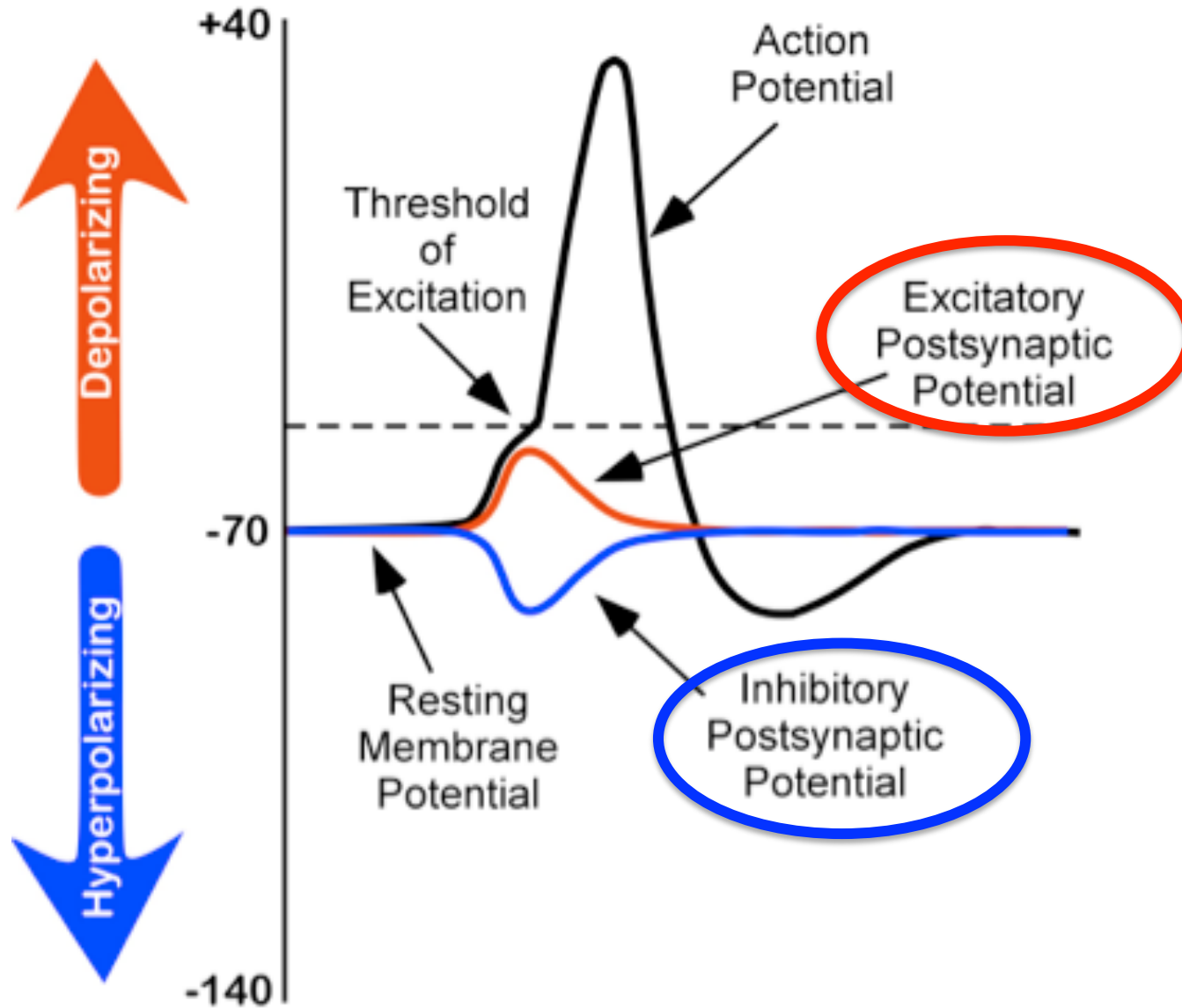
- Causes **depolarization** of the post synaptic neuron = action potential
- **Na⁺ channels on post synaptic neuron open** (= Na⁺ in causing AP to continue)

(CONTINUES THE TRANSMISSION)

Inhibitory

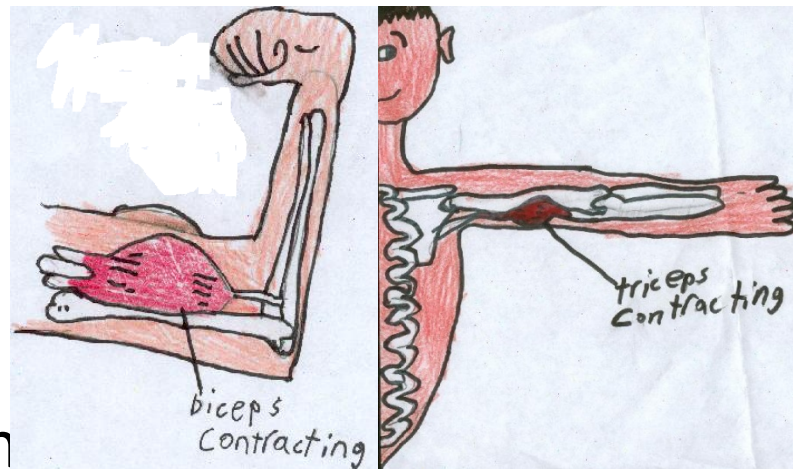
- Causes **hyperpolarization** of the post synaptic neuron (axon becomes more negative)
- This **inhibits depolarization**
- **(Takes more stimulus to cause action potential)**

Inhibitory vs Excitatory



Why do we need inhibitory synapses?

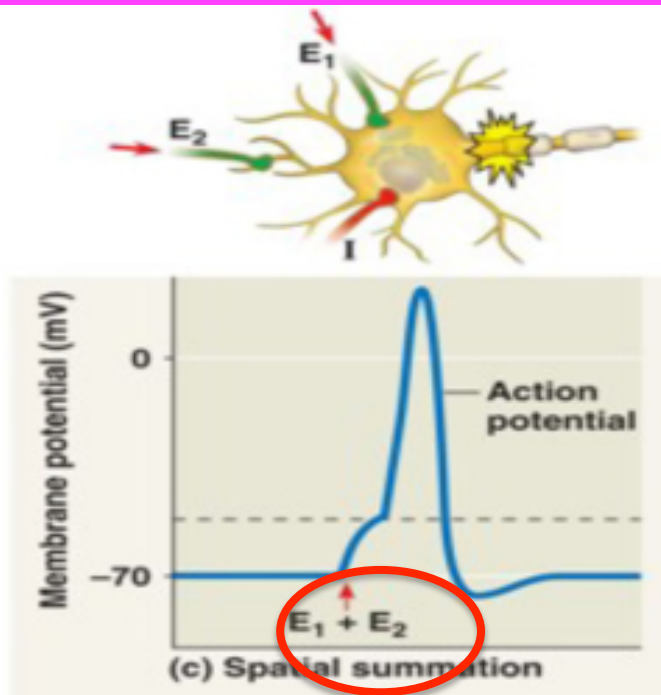
- To **prioritize sensory info**
 - What is more important? Remembering that you are wearing clothes or listening to me talk?
- To **coordinate movement** (biceps and triceps)



- Pain killers in sensory neurons (e.g. Tylenol)



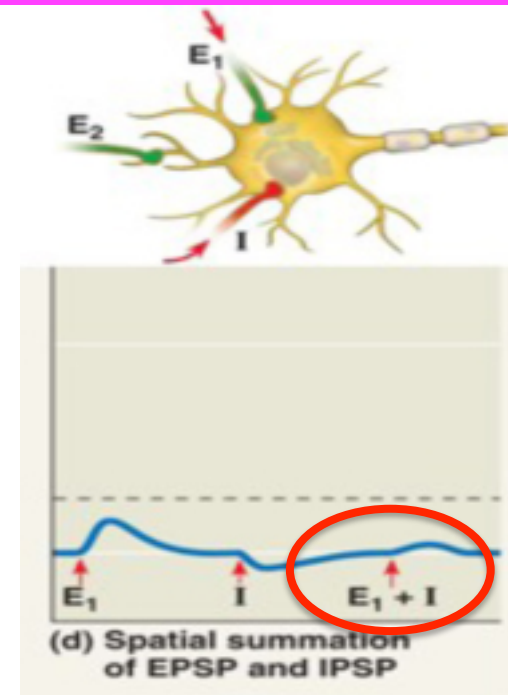
Summation (adding up or total)



Two neurons release excitatory neurotransmitters at the same time to cause an action potential

Neurons "E1" and "E2" must work together to cause an action potential

- Alone, they cannot reach threshold



One neuron is inhibitory while the other is excitatory

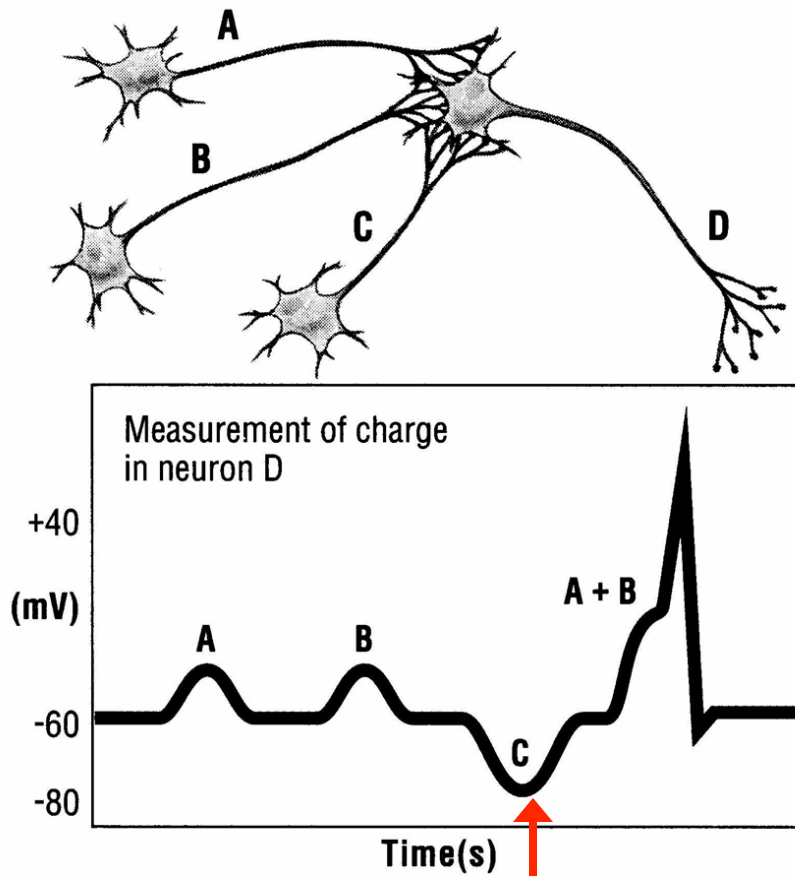
Neurons "E1" and "I" together do not create an action potential but essentially cancel each other

- they do not reach threshold

Summation

Two or more neurons release neurotransmitters at the same time to cause an action potential

- Neurons A and B must **work together** to cause an action potential in neuron D
- Alone, they **cannot reach threshold**



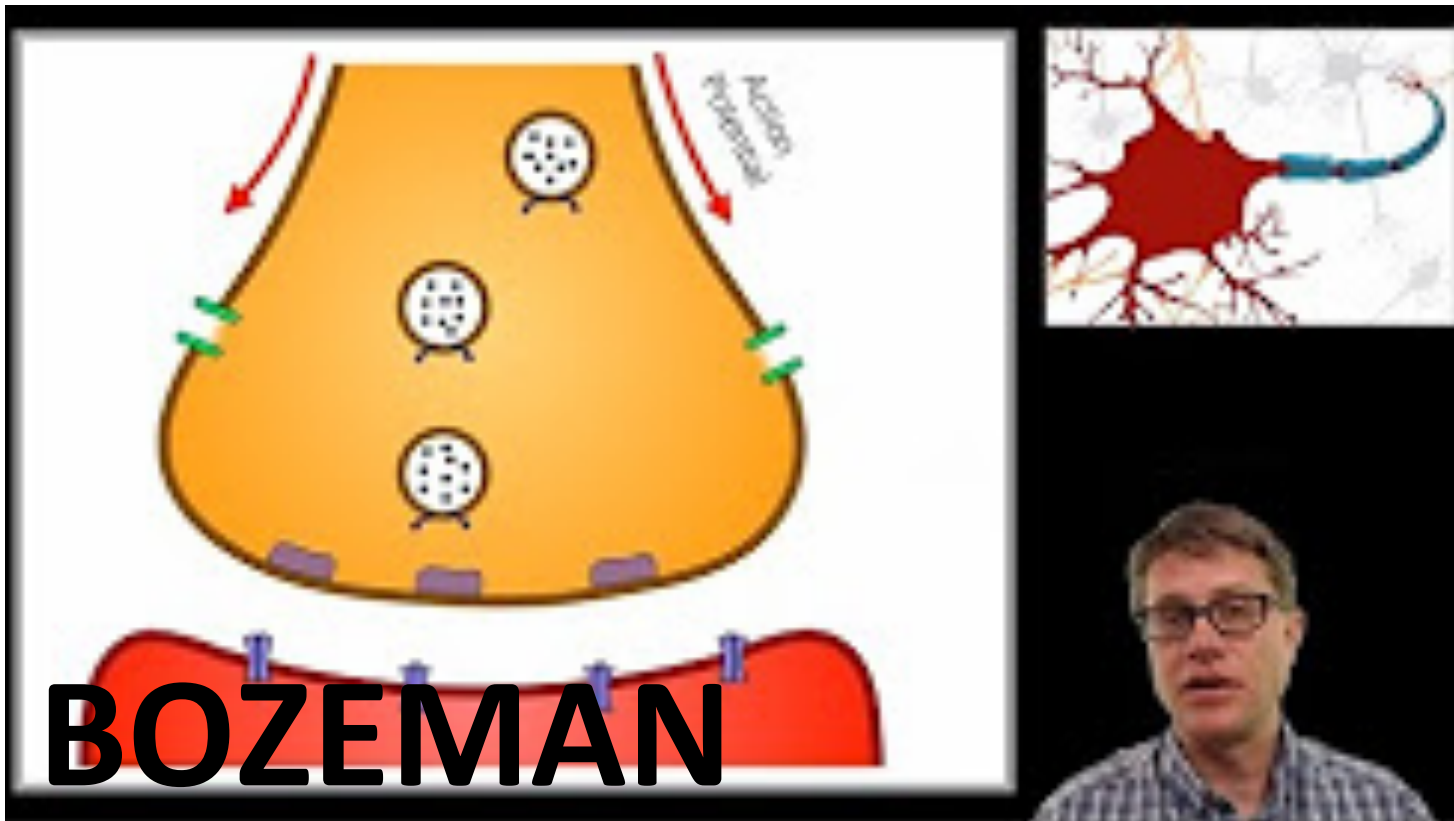
Neuron C is inhibitory

Think about it...

In pairs or partners, determine what would happen to **nerve transmission in the post-synaptic neuron** in the following cases:

- a) A drug is taken that **inhibits** the activity of cholinesterase
The post-synaptic neuron would be continuously stimulated.
- b) A student drinks alcohol, which opens **potassium** channels in the post-synaptic neuron
Hyperpolarization of the post-synaptic membrane.
- c) A drug (ex: amphetamine) is taken which **blocks the reuptake** of neurotransmitter
The post-synaptic neuron would depolarize more often (more dopamine in cleft means more stimulation of post-synaptic neuron)
- d) A drug is taken which prevents vesicles from releasing neurotransmitter
The post-synaptic neuron would NOT be stimulated. (stay polarized)
- e) A drug is taken which activates the same receptors as the neurotransmitter (opens more **sodium** channels in the post-synaptic neuron)
The post-synaptic neuron would be depolarized.

Let's Review...



ANOTHER REVIEW:

[Transmission across Synapse Animation](#)

A Great Nerve Impulse Review Video

(reflex arc, action potential, summation)

Autonomic Motor Pathways

	Sympathetic	Parasympathetic
Type of control	Involuntary	Involuntary
Function	Fight or flight	Rest and digest
Neurotransmitters	Norepinephrine	Acetylcholine

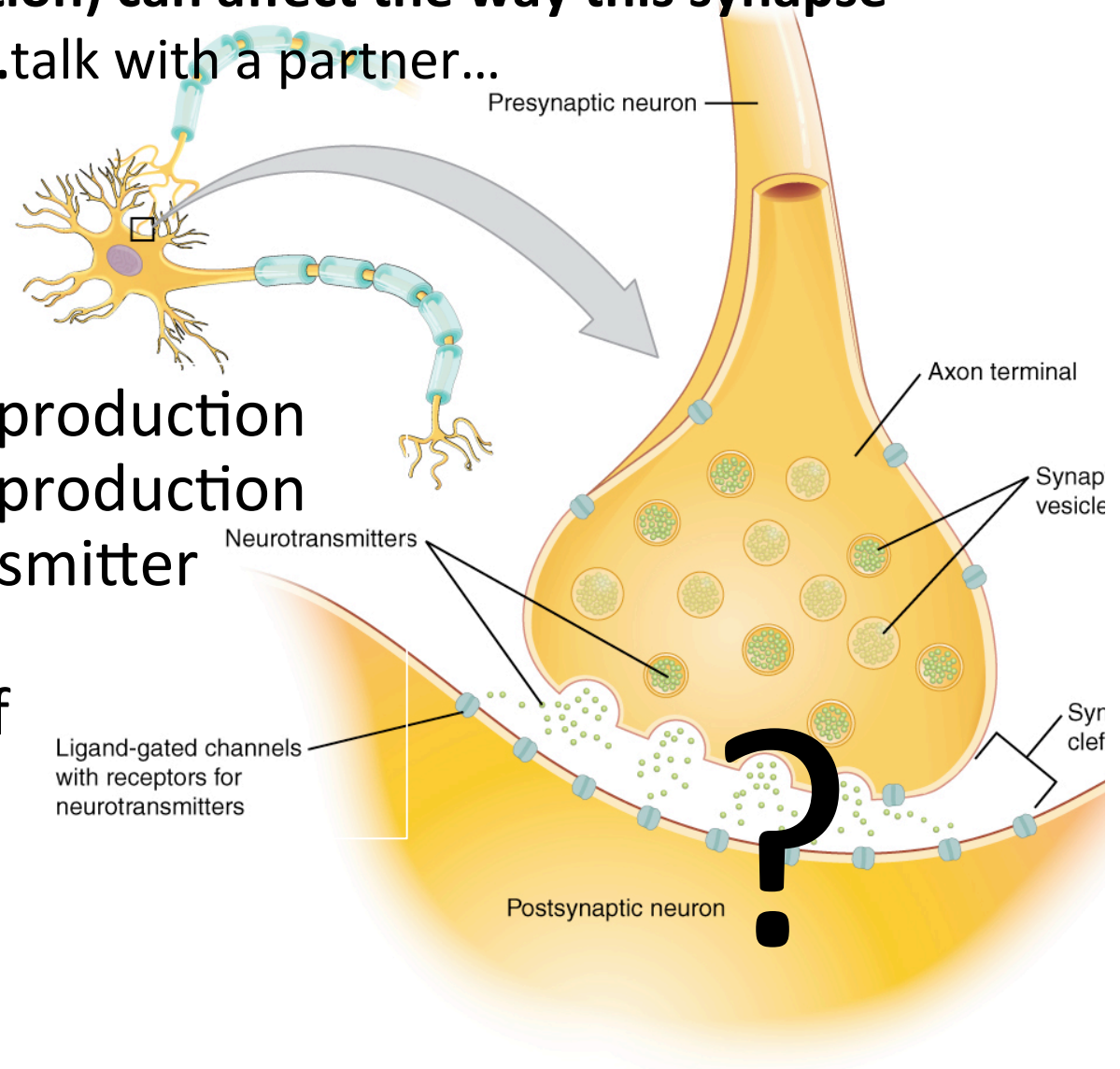
Nerve transmission in a myelinated neuron and neurotransmitters. Narrated by David Suzuki.

http://www.youtube.com/watch?v=haNoq8UbSyc&safety_mode=true

Think about it...what are some different ways a foreign chemical (drug or medication) can affect the way this synapse operates (sends signals)....talk with a partner...

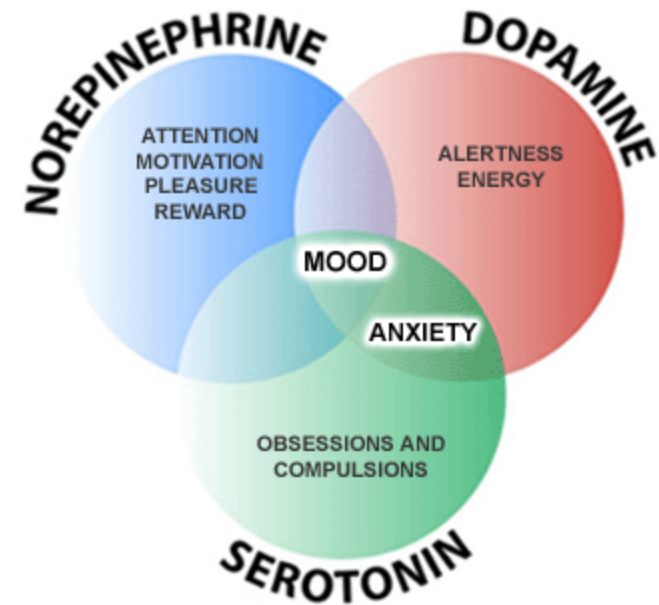
5 ways...

1. ↓ Neurotransmitter production
2. ↑ Neurotransmitter production
3. mimic the Neurotransmitter
4. Block receptor sites
5. Block reabsorption of Neurotransmitter



Neurotransmitters, drugs and you!

- There are several NT important to nervous system functioning, such as
 - Serotonin
 - Acetylcholine
 - Norepinephrine
 - Dopamine and
 - GABA (gamma aminobutyric acid)
 - endorphins
- Drugs contain chemicals that
 - ↓ Neurotransmitter production
 - ↑ Neurotransmitter production
 - mimic the Neurotransmitter
 - Block receptor sites
 - Block reabsorption of Neurotransmitter



The Effects of Drugs and disease on synaptic transmission. Animations

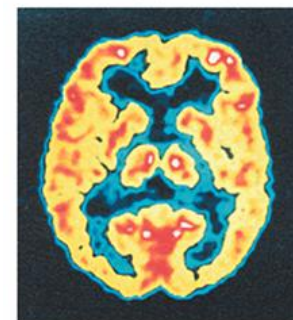
<http://outreach.mcb.harvard.edu/animations/synapse.swf>

Acetylcholine - **know this one**

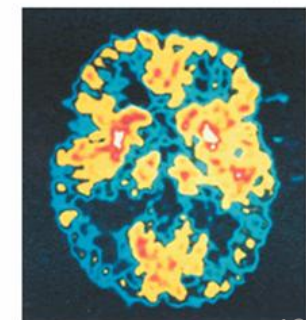
- Usually **excitatory**, but can be inhibitory
- Important in **thinking and memory**
- Low levels of acetylcholine is a symptom of **Alzheimer's disease**
 - Memory loss and decreased mental capabilities



BRAIN SCANS HELP IDENTIFY ALZHEIMER'S



NORMAL



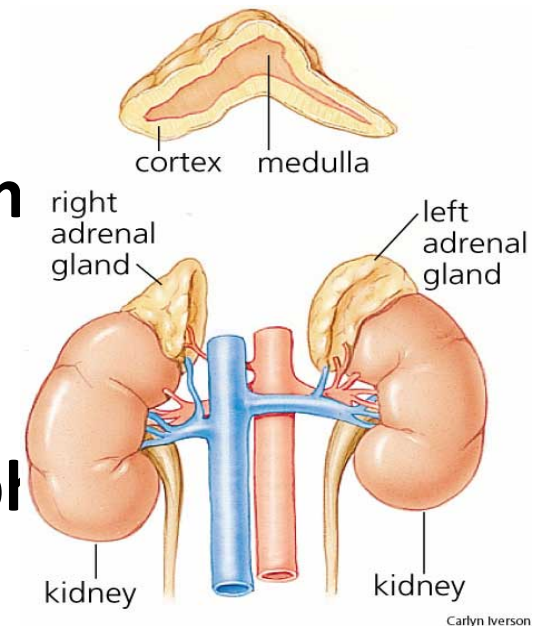
ALZHEIMER'S

125

Brain scans done with Positron Emission Tomography (PET) show how Alzheimer's affects brain activity. The left image shows a normal brain, while the right is from a

Norepinephrine-**know this one**

- Produced in the **adrenal gland**
- Can be excitatory or inhibitory
- Involved in **fight-or-flight response** (sym nervous system)
- Creates feelings of euphoria
 - Low amounts related to depression
- **Cocaine** blocks the reuptake of **norepinephrine** and **serotonin**
- Do you know where **coca cola** got its name?
 - Up to 1904, coke contained small amounts of cocaine
 - Today, coke still contains coca leaf extracts
 - but these leaves are de-cocainized



Parkinson's Disease



Dopamine

- Excitatory or inhibitory
- commonly associated with the *pleasure system of the brain*,
 - feelings of enjoyment and reinforcement to **motivate**
- Dopamine is released by naturally rewarding experiences such as
 - Food
 - Sex
- Involved in muscle activity
- Low levels are involved in **Parkinson's disease**
 - Involuntary muscle contractions and tremors
- Michael J. Fox

For these next ones you don't need to memorize the chemicals specifically, but, you do need to know how changes to a neurotransmitter affects an individual...

(ie) What if a chemical blocks a receptor site...what happens?

Action potential prevented from occurring in post-synaptic membrane because gates are not allowed to open

(ie) What if a chemical causes more of a neurotransmitter to be released?

More gates opened on post-synaptic membrane causing more action potentials

(ie) What if a chemical blocks a neurotransmitter from being reabsorbed?

The neurotransmitter builds up in cleft thus stimulating post-synaptic membrane gates to open more causing more action potentials

(ie) What if a chemical looks like (mimics) a neurotransmitter?

Will cause more gates on post-synaptic membrane to open which caused more action potentials

(ie) What if cholinesterase is prevented from doing its job?

Neurotransmitter builds up and causes post synaptic membrane to depolarize more often

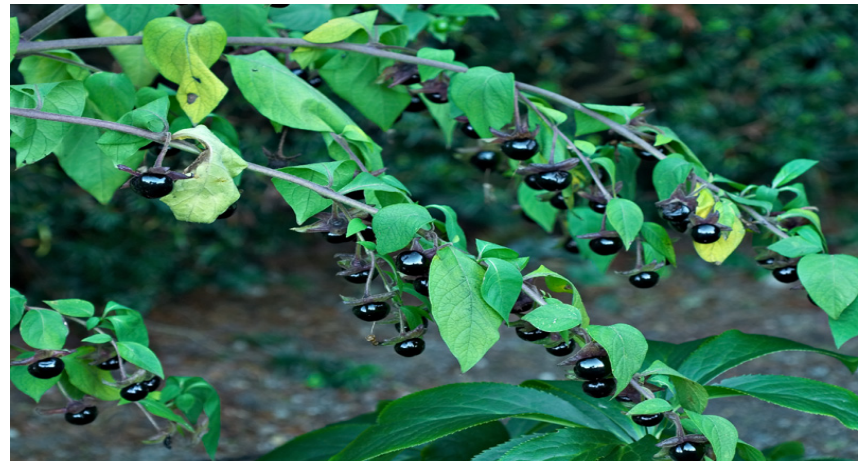
Hallucinogens

- Blocks acetylcholine receptors on the postsynaptic neuron
- **Scopolamine** – found in Gravol, to treat motion sickness



Ex. *Atropa belladonna*

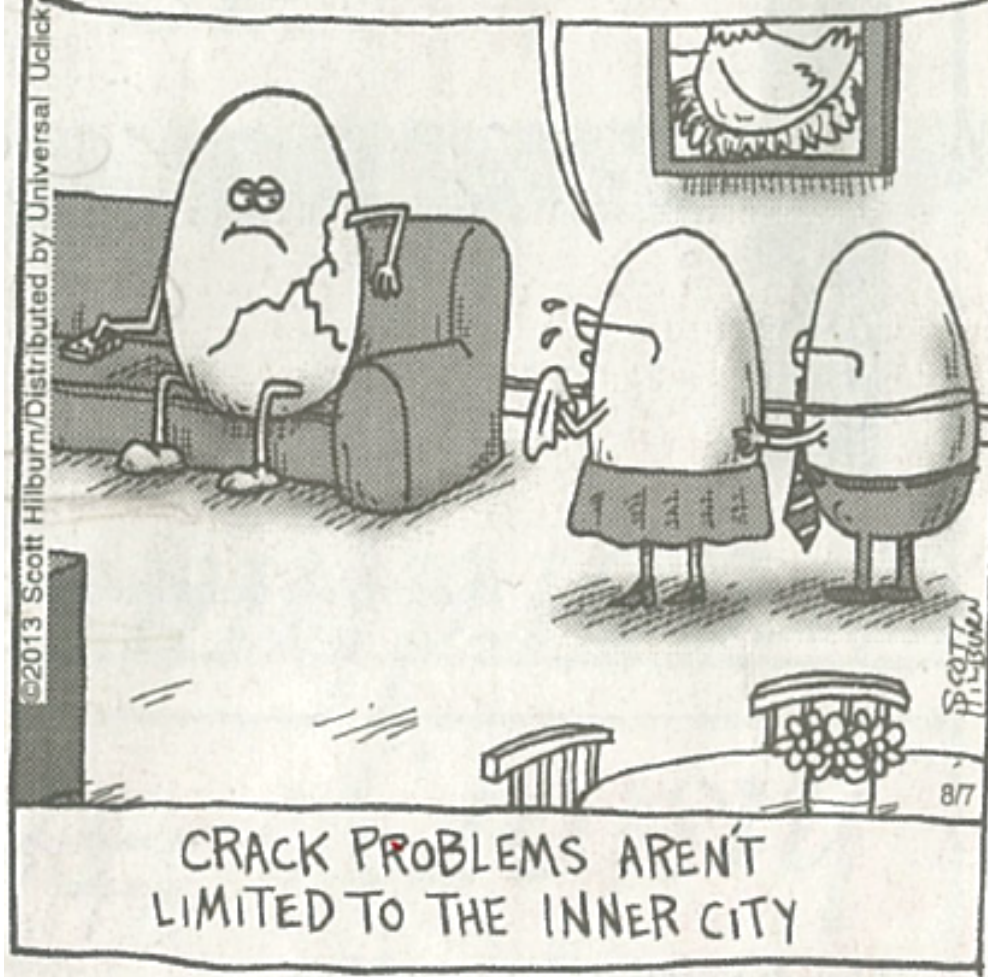
- In ancient Rome and Egypt, it was squirted into the eyes of women to make their pupils dilate, which was considered attractive



ARGYLE SWEATER

THIS IS HOW IT STARTS, HUMPTY. NEXT THING YOU KNOW, YOUR FATHER AND I WILL FIND YOU SUNNY SIDE DOWN IN A DUMPSTER BEHIND DENNY'S.

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CRACK PROBLEMS AREN'T LIMITED TO THE INNER CITY

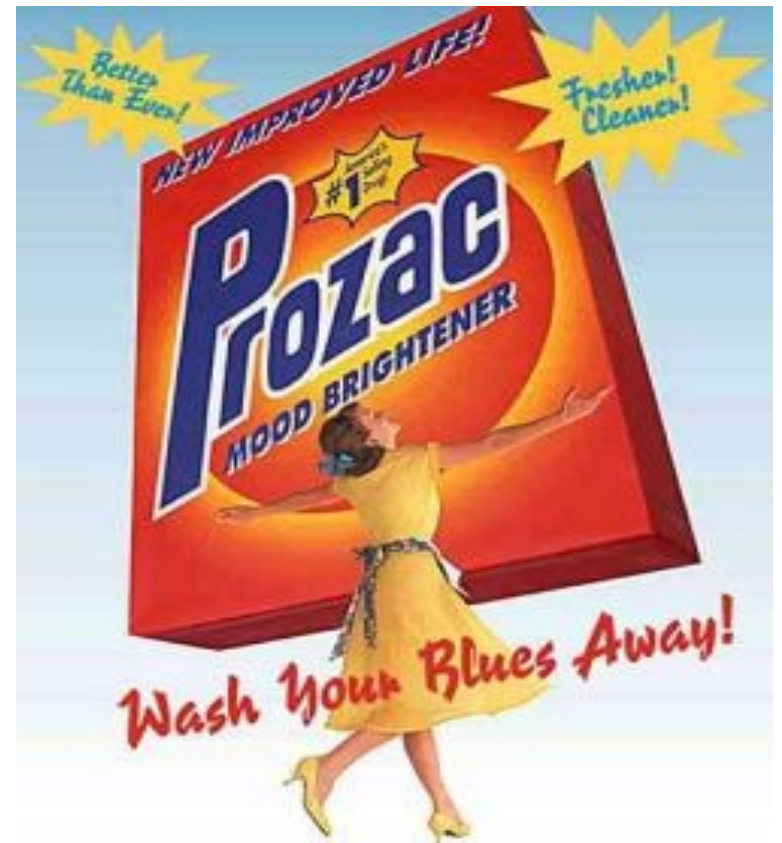
Methamphetamine (Crystal meth)

- Psychostimulant drug
- Causes the increased release of **norepinephrine**
- stimulates the heart and respiration, constricts blood vessels and induces sleeplessness
- Originally used to treat ADHD and obesity
- disturbs sleep patterns, loss of REM dreaming sleep, hyperactivity, nausea, delusion of power, increased aggressiveness and irritability



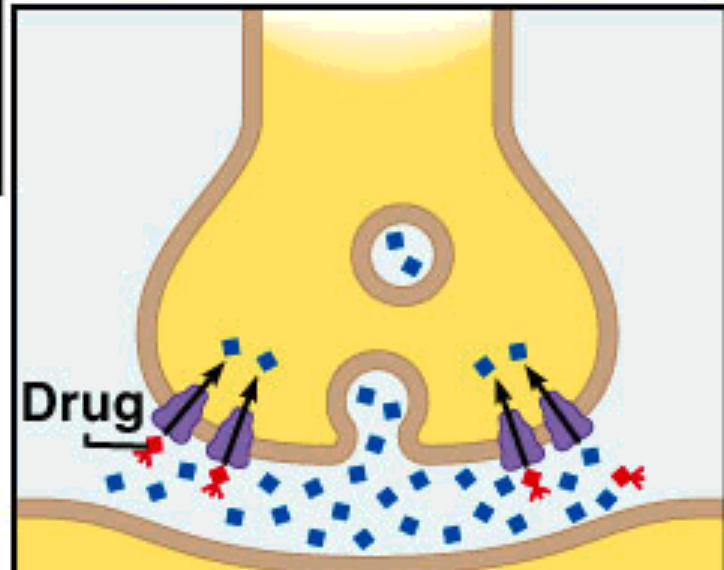
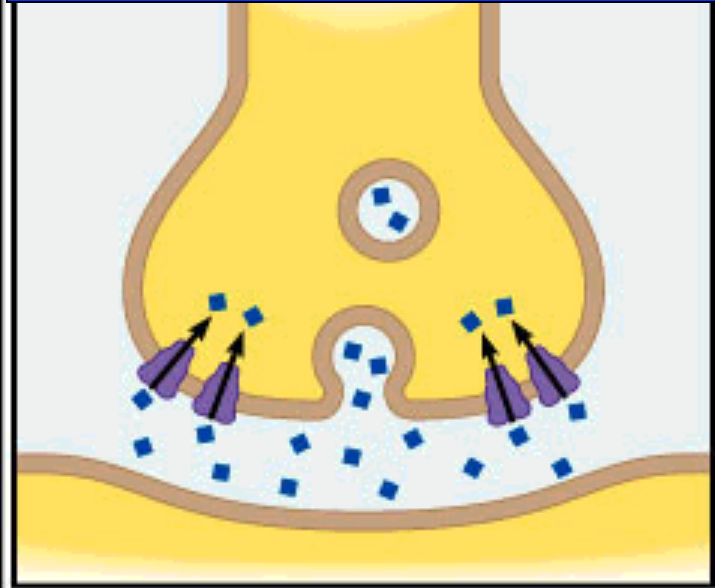
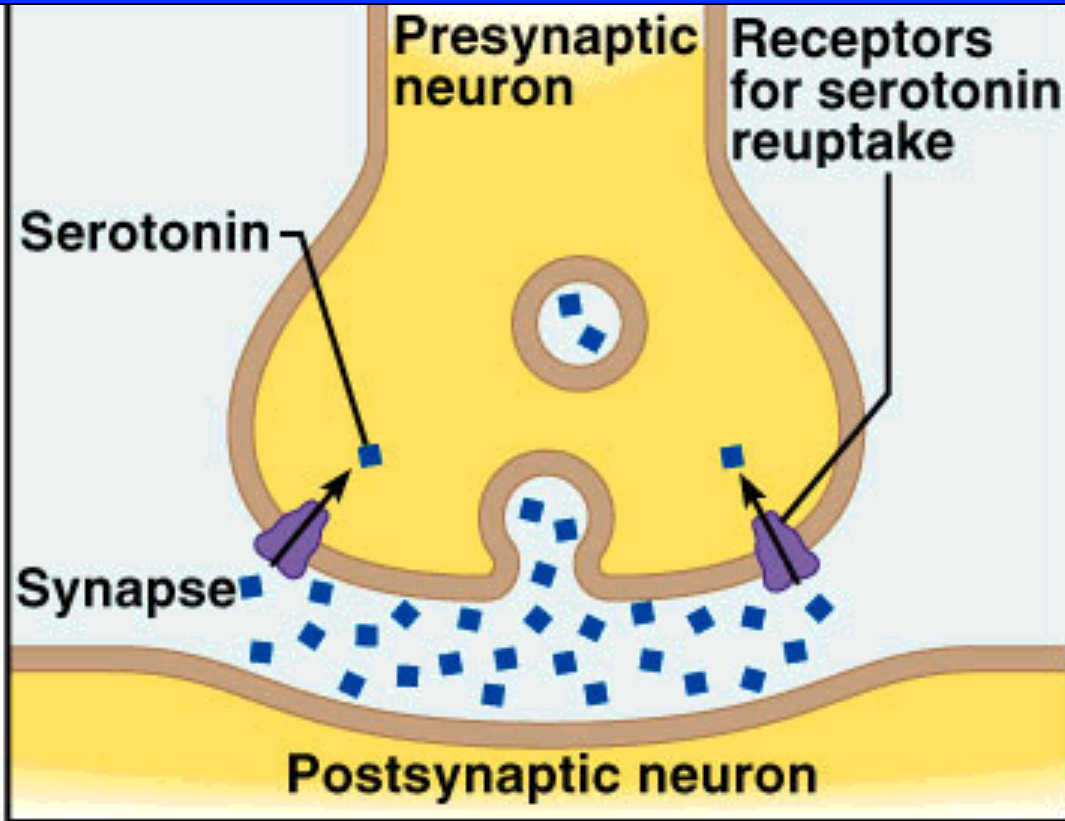
Serotonin

- Generally inhibitory
- High levels causes sleepiness
- Low levels are associated with **depression**
 - Serotonin is reabsorbed too quickly by the pre SN
- Drug like **Prozac (Zoloft)** prevent the reuptake of serotonin or stimulate serotonin receptors
- These are called **SSRI's (Selective Serotonin Reuptake Inhibitors)**



Non-depressed individuals

Depressed individuals

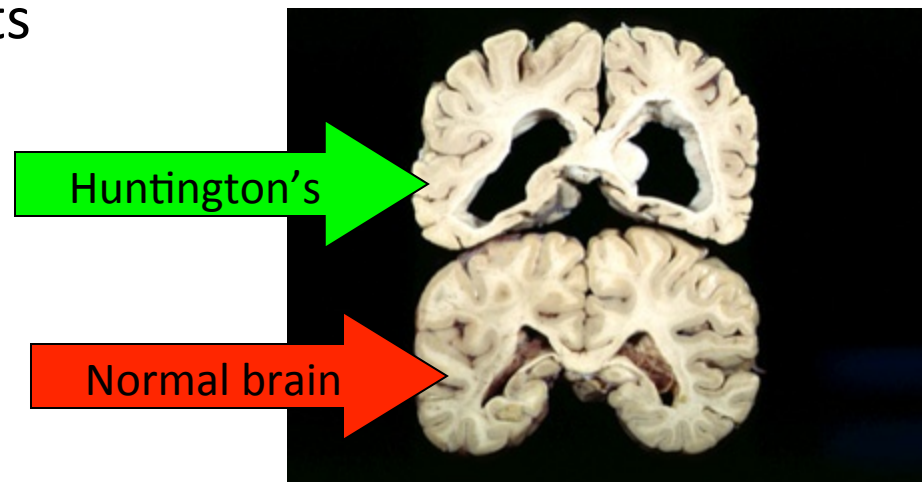


Anatomy of an anti-depressant

Depressed individuals treated with SSRI

GABA

- **Gamma aminobutyric acid**
- Inhibitory transmitter ([Reduces neurons excitability](#))
- Controls complex movements
- Low levels linked to **Huntington's disease**
 - Involuntary movements



Rohypnol

- You might know it as **“roofies”**
- Depresses the CNS
- Increases the binding ability of **GABA** to its receptor
[\(makes GABA do more\)](#)
- **Date rape drug**



Rape Drugs are out there.

Anyone who seems drunk after drinking little or no alcohol may have been drugged.

Alcohol
G.H.B.
Rohypnol
Roffies
Special K
Liquid X

TRUST YOUR INSTINCTS!

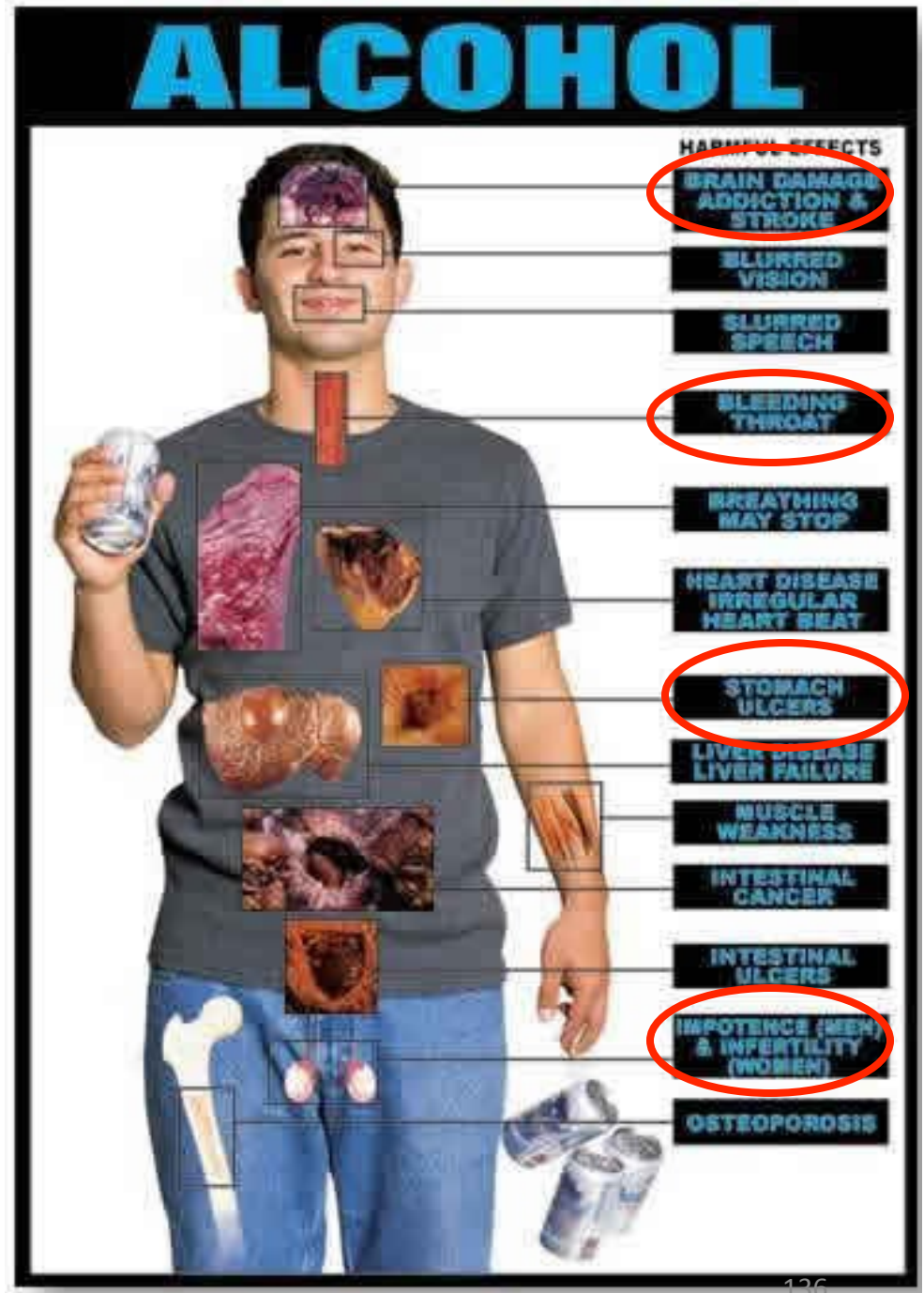
Are they in here?

For help 24 hours, call 911 or (805) 656-1111.
Transportation to a safe place may be provided.

Orange Police Department
Thank you Yellow Cab
Michael D. Bradbury
Ventura County District Attorney
Victim Services (805) 654-3622

Alcohol

- “Water of life”
- Alcohol abuse: ↑ GABA production
- Thus increasing inhibition
- Results in memory loss, mood swings, slower breathing
- **Reduces brain size**
- The fall of the Roman Empire has been blamed on **alcohol**



Alcohol

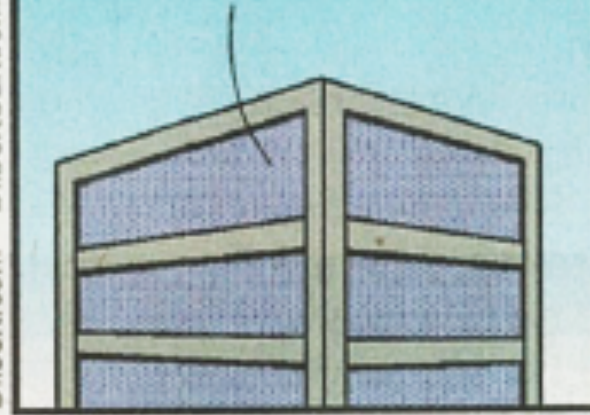
DILBERT

OUR OFFICERS
CAME UP WITH A NEW
COMPANY SLOGAN
AFTER TWO WEEKS
AT A RETREAT.



Dilbert.com DilbertCartoonist@gmail.com

THE NEW SLOGAN IS
"SHTOP SPITTING AHN
ME WHEN YOU TALK!"



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WE BELIEVE
ALCOHOL WAS
INVOLVED.




Endorphins

- Generally inhibitory
- They are produced by the pituitary gland and the hypothalamus during **strenuous exercise**, excitement, pain, death and orgasm and they resemble the opiates in their abilities to produce analgesia and a sense of **well-being**.
- Endorphins work as "**natural pain relievers**", whose effects may be enhanced by other medications.
- Effects mimicked by **morphine, heroin** and **methadone**
- Besides pain killing effects, prolonged morphine use can also lead to constipation!



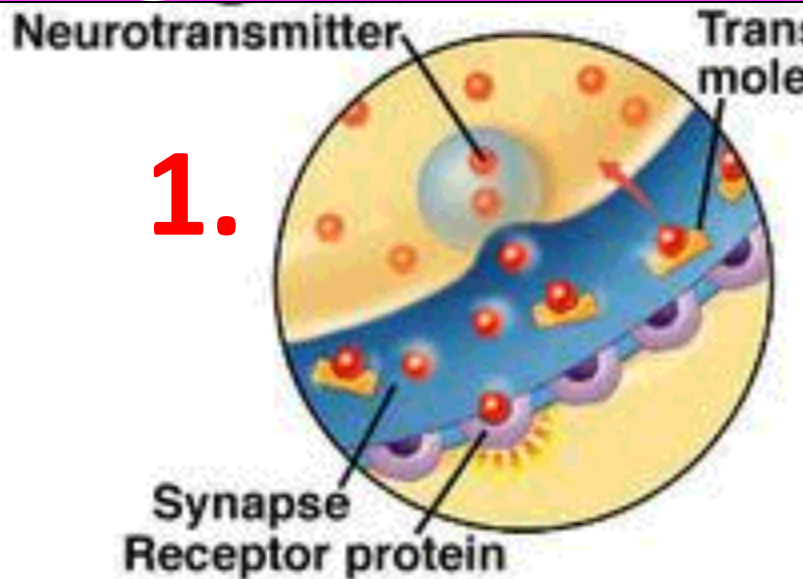


What causes addictions?

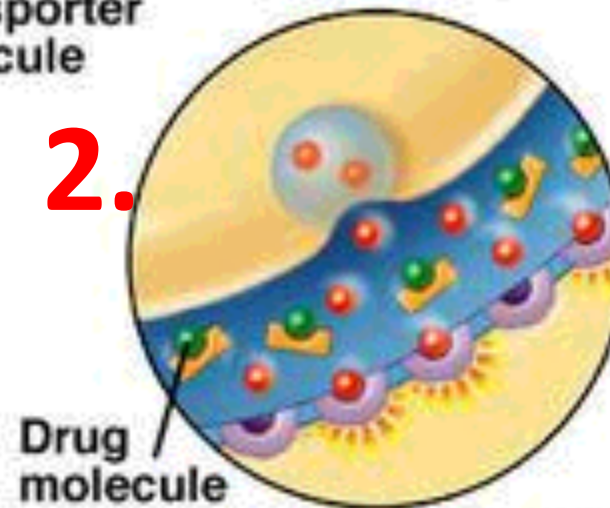
- **A drug that causes increased** production of **dopamine** creates feelings of reward
- This activates reinforcement systems, that are naturally activated by reinforcers such as food, water, sex, etc.
- **This reduces receptor numbers** on the post synaptic neuron
 - thus need more drugs to produce the same effect
 - The individual develops  **tolerance**



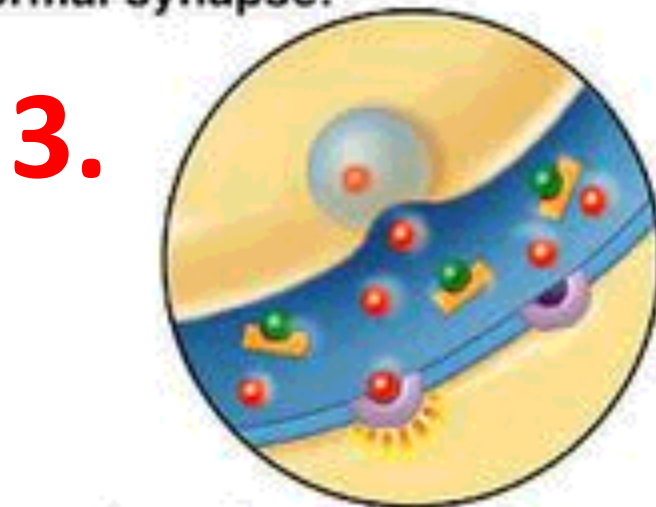
Drug Addiction and the Synapse



Neurotransmitter is reabsorbed at a normal synapse.



Drug molecules prevent reabsorption and cause overstimulation of postsynaptic membrane.



The number of receptors decreases.



The synapse is less sensitive when the drug is removed.



- Check out The “[Mouse Party](http://learn.genetics.utah.edu/content/addiction/mouse/)” game to learn more about how drugs interact in your brain



Mouse Party URL

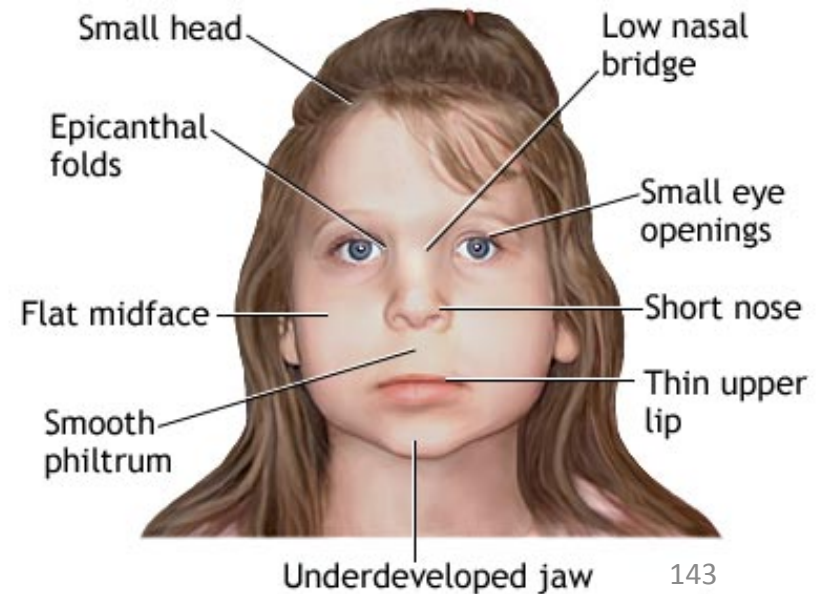
[http://learn.genetics.utah.edu/
content/addiction/mouse/](http://learn.genetics.utah.edu/content/addiction/mouse/)

Nervous System Disorders



Fetal Alcohol Spectrum Disorder

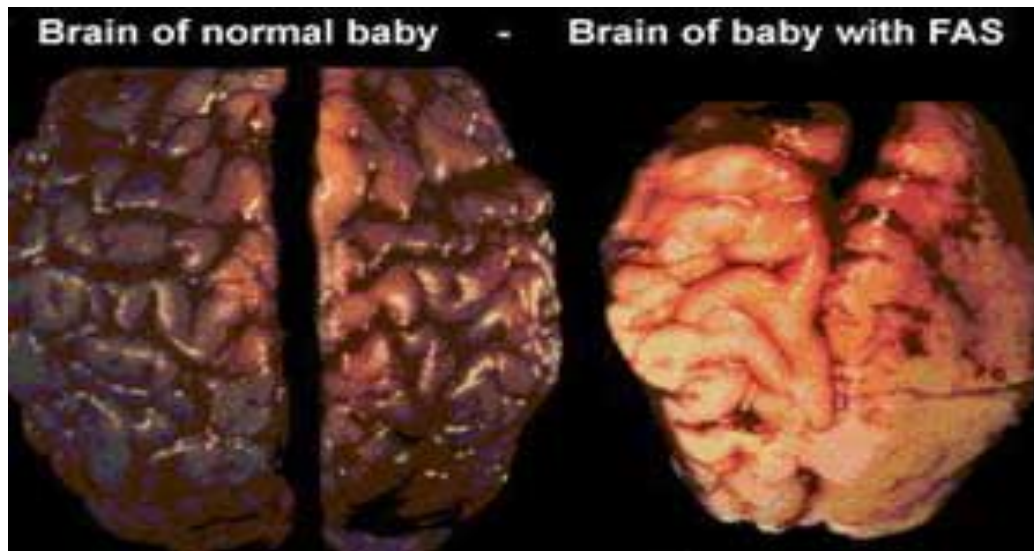
- Fetal Alcohol Spectrum (FAS) is used to describe a broad range of effects associated with alcohol use during pregnancy
- The spectrum can include **physical effects** as well as **effects on the brain** that may result in problems with **learning, emotions and behavior.**



Sometimes you can tell, sometimes you can't!

Fetal Alcohol Spectrum Disorder

- When a pregnant woman drinks, so does her baby
- The baby's growth can be altered and slowed
- The baby may suffer lifelong damage



Smaller brain with less developed convolutions (which increase brain surface area)

There's no cure for fetal alcohol syndrome.

ADHD

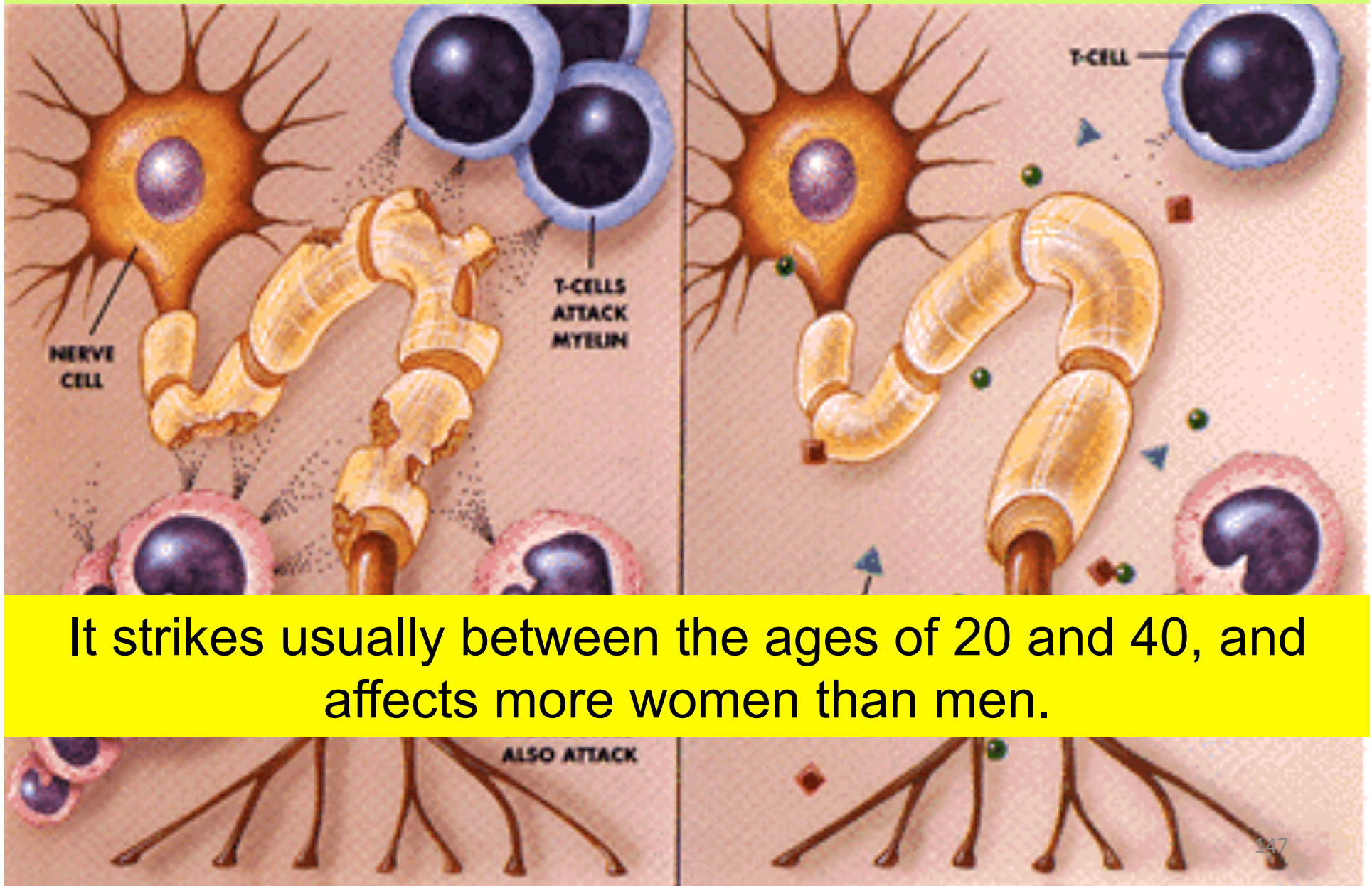
- Attention deficit/hyperactivity disorder
- Dopamine thought to be reabsorbed too quickly
- It does not spend enough time in the synapse
- Ritalin : increases dopamine & norepinephrine
- Ritalin also known as methylphenidate
- Long term effects unknown!



Multiple Sclerosis

- Multiple sclerosis is an autoimmune disease that affects the central nervous system (the brain and spinal cord).
- An acquired inflammatory, **demyelinating** disease - cells of the immune system invade the CNS and destroy myelin
- Both genetic and environmental factors have been implicated in the disease.

Multiple Sclerosis



It strikes usually between the ages of 20 and 40, and affects more women than men.

Multiple Sclerosis

- The inflammation **causes nerve impulses to slow down or become blocked**, leading to the symptoms of MS
- Many symptoms (differ based on what lobe is affected)
 - MS affects occipital lobe – **painful vision loss**
 - Hazy vision / bright lights
 - MS affects cerebellum – **difficulty walking**
 - These “episodes” can last for months

Multiple Sclerosis

- **Treatments:** medications (pain killers + promote myelination), wheel chairs, physical therapy to promote muscle growth, aqua therapy, leg braces/splint, occupational therapy, gene therapy

These would be considered technologies!!!



Parkinson's Disease

- Progressive degeneration of midbrain
- Midbrain loses it's ability to produce dopamine
- Dopamine is an opiate-like neurotransmitter
- Dopamine produces feelings of well-being
- Results in muscular tremors, partial facial paralysis and general weakness
- L-dopa given to slow dopamine breakdown

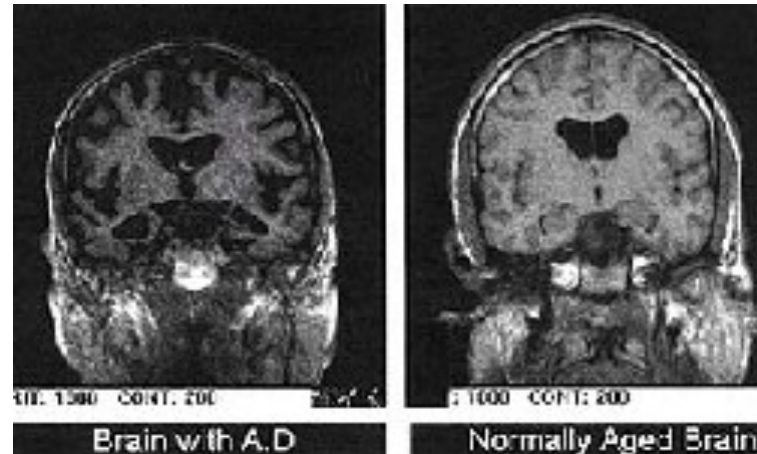


[Did Hitler Have Parkinson's? Video](#)

Alzheimer's Disease

- a progressive, degenerative disease of the brain, which causes thinking and memory to become seriously impaired.
- At this time, we do not yet know what causes Alzheimer's disease or how to stop its progression.
- **Amyloid protein deposits or plaques form in cerebral cortex**
- Memory affected
- Temporal lobe of cerebrum affected
- Scientists working to find ways to prevent plaque build up

More info on Alzheimer's disease:
<http://www.alzheimer.ca/english/disease/whatisit-intro.htm>



Alzheimer's Disease

Researchers have discovered that Alzheimer's disease:

- is not a part of normal aging
- affects both men and women
- is more common in people as they age -- most people with the disease are over 65
- is not caused by hardening of the arteries
- is not caused by stress

Alzheimer's Disease

- Scientists are looking at three areas:
- **Family history**
For a few families, there is a definite connection between family history and Alzheimer's disease. While for others, a family history of Alzheimer's disease puts them at greater risk than someone with no family history. Though knowledge in this area is growing, the connection to heredity is not fully understood.
- **The external environment**
The cause of Alzheimer's disease may be in our environment -- perhaps something in the water, soil or air.
- **The internal environment**
Alzheimer's disease may be caused by something within the body. It could be a slow virus, an imbalance of chemicals or a problem with the immune system.

Alzheimer's Disease Treatments

- **Cholinesterase inhibitors** help with the cognitive symptoms of Alzheimer's. They work by preventing the breakdown of a chemical messenger in the [brain](#) called acetylcholine, which is important for learning, memory, and attention.
- **Sensory therapies.** There is some evidence that sensory therapies such as music therapy and art therapy can improve Alzheimer's patients' mood, behavior, and day-to-day function. By stimulating the senses, these therapies may help trigger memory recall and enable Alzheimer's patients to reconnect with the world around them.

Alzheimer's Disease

Forgot to study?
Don't worry...drink
BE SMART!



Spinal Cord Injuries

- Spinal cord may be damaged by **disease or injury**
- If spinal neurons in cervical area damaged: result is complete **paralysis**
- This is known as quadraplegia
- If spinal neurons in lower back (lumbar area) are damaged: paraplegia
- Treatment: **wheelchair, stem cell transplants**

