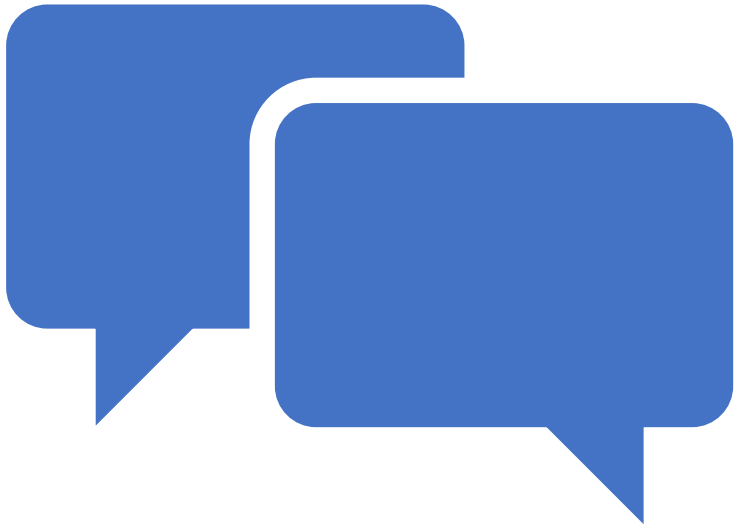
Think Again

Fall Term 2021

Class 4

Email and Website



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http://olli-think-again.weebly.com


We have to relieve the pressure on his skull. So I'm going to go in and take out about two dozen passwords.
Loose Parts books now at LoosePartsComic.com!
Blazek

On Tap for Today

- Review
- Neurotransmitters
- Brain Waves

Review

- There is no truth meter in the brain.
- It receives input through our senses and acts in ways learned to be most effective.
- Rational part of thinking rarely directs conclusions, mostly rationalizes those reached based on past experiences.
- Think about cognitive dissonance.

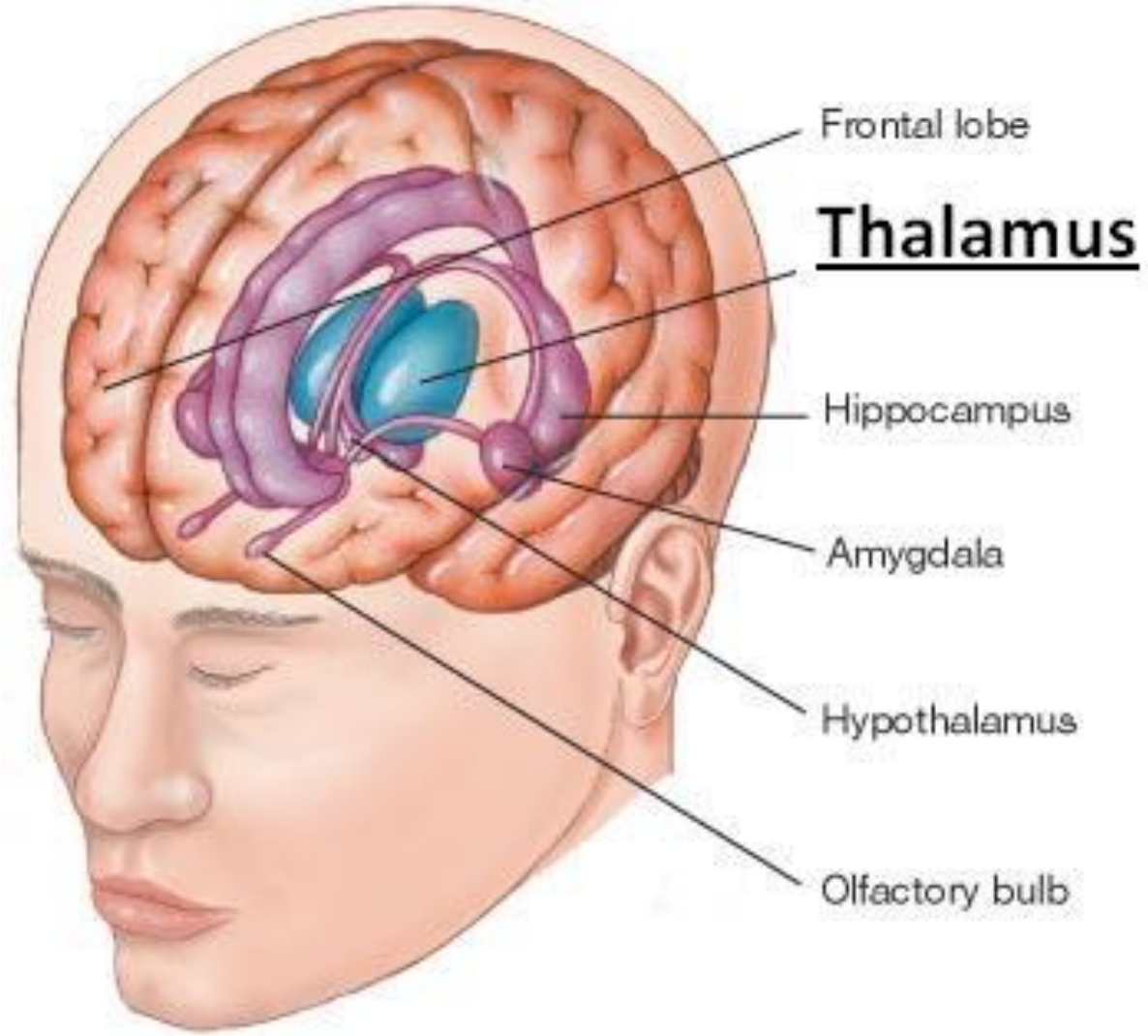
Optical Illusions

- The Internet has an almost infinite number of optical illusions.
- I chose a few that I felt would be helpful to get a better understanding of how the brain processes information.
- We have other illusions that our brains manage to paper over.
- There are no receptors at the back of the retina where the optic nerve attaches. We really see a small hole if we cover one eye but are virtually never aware of it.
- Peripheral vision inputs a blurry image, but it does not look blurry.
- The brain just fills in the hole and the peripheral vision details.

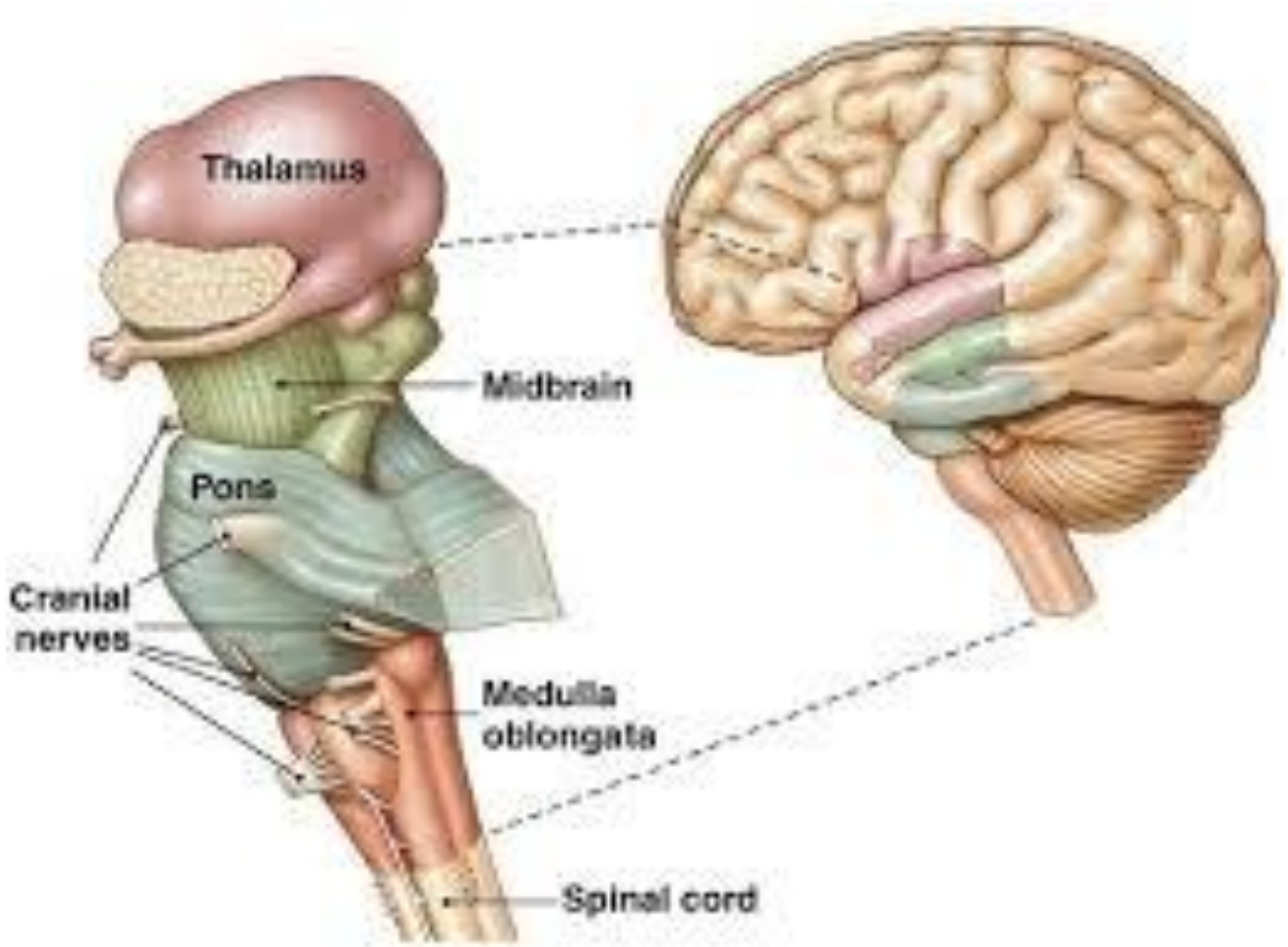
Emotions Are Real, But Not True

- We all feel emotions, sometimes quite strongly.
- Just like color is the way we have learned to perceive and describe photon wave lengths, emotions are labels we attach.
- But to what?
- To the combination and balance of neurotransmitters active in our brains as modulated by our brain waves.
- We can learn to adjust our neurotransmitters (a little), our brainwaves (a lot), and how we react (a whole lot).
- When it comes to emotions, trust but verify.

Thalamus


Frontal lobe
Thalamus
Hippocampus
Amygdala
Hypothalamus
Olfactory bulb

The Brain's Air Traffic Control



Thalamus

- Thalamus serves as relay station between sensory organs and in both directions with much more information going from cortex to thalamus.
- Regulates arousal, awareness, sleep, wakefulness
- Also connects to the hippocampus (memory)
- Sends signal simultaneously to the amygdala for potential bypass. If the amygdala perceives a threat, it sends chemicals to the cortex limiting its conscious activity.

Cortex to Thalamus to Cortex (1)
(theory based on evidence but not proven)

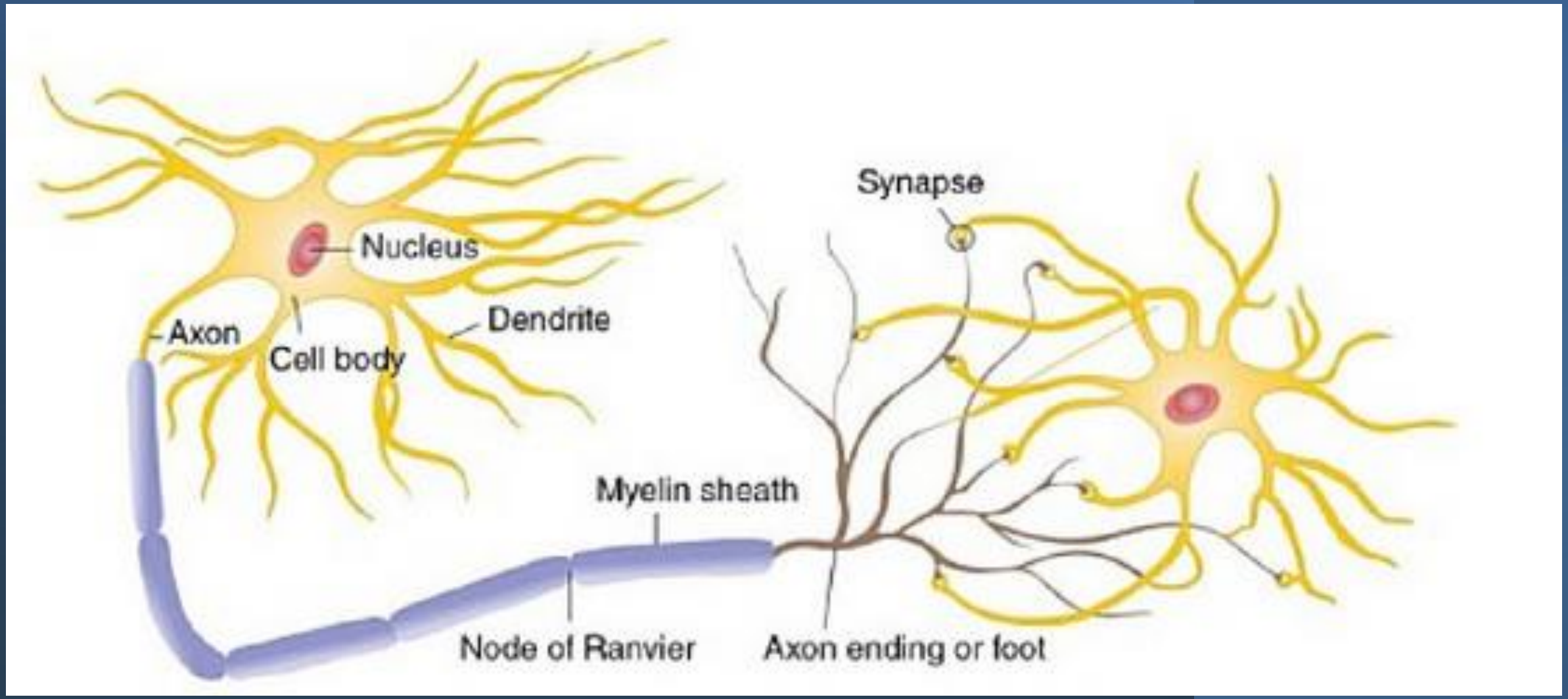
- Cortex makes predictions based on past experience and tells Thalamus what to expect
- Sensory input (other than olfaction which interacts with thalamus differently) enters Thalamus
- If Thalamus experiences what it expects, goes no further
- If inconsistent (which rarely occurs), goes to cortex for new prediction and to amygdala in case of emergency

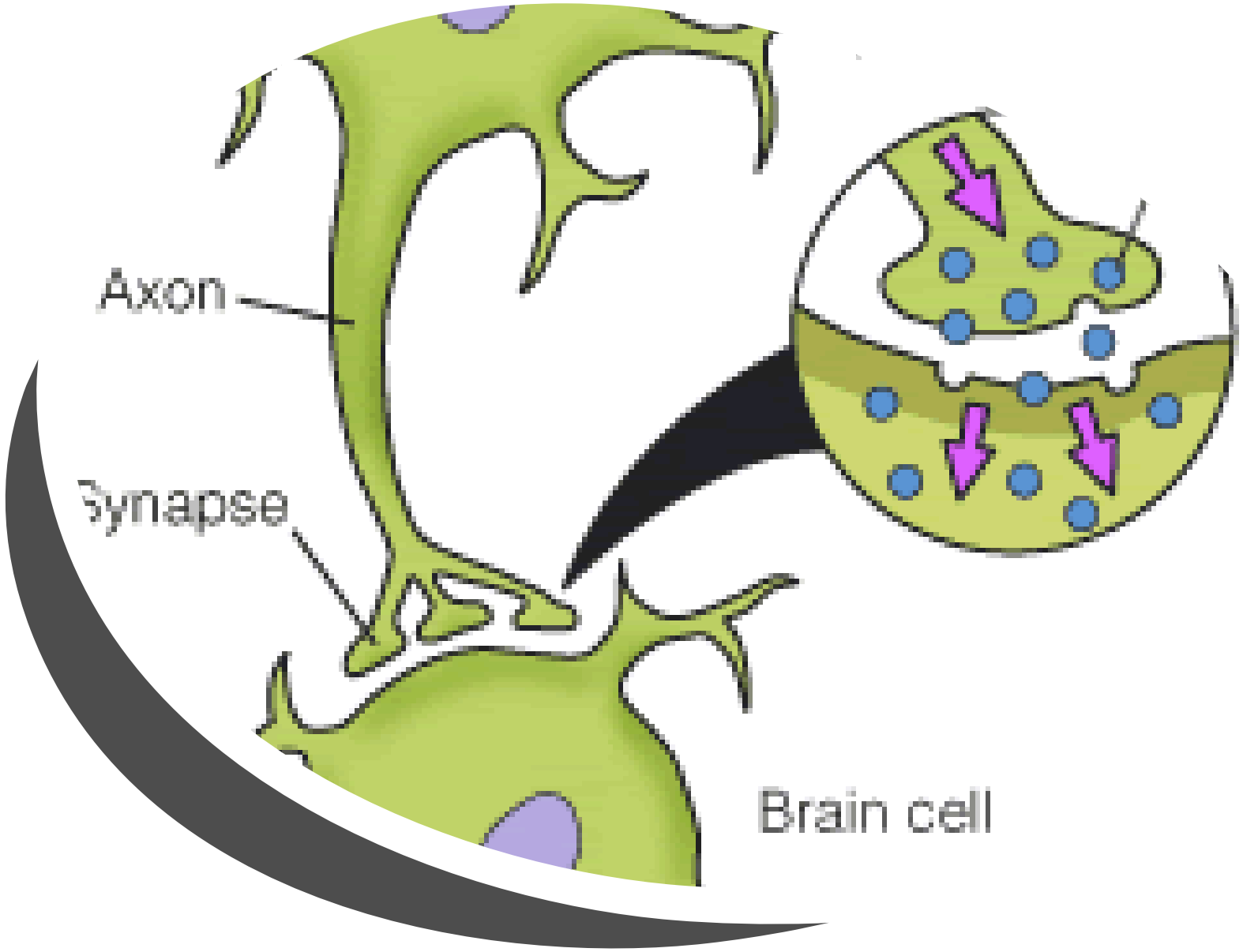
Cortex to Thalamus to Cortex (2)

- Continuous loops at higher cortical layers until Thalamus decides prediction works
- Conscious awareness of surroundings occurs only when sensory input violates expectations since cortex not notified if consistent
- Smells go directly to the Olfactory Nerve for unknown reasons, possibly because it was the first of the senses developed or possibly because of increased connection with danger.

Electrochemical Transmission

- Electrical charge creates ions, atoms or molecules with unbalanced charges.
- Extra electrons pass down the axon and at the end release sacs called vesicles that in turn release chemicals (neurotransmitters) that cross the synapse and bind to receptors on dendrites of other neurons.
- Same process continues from neuron to neuron.
- Myelin sheath acts as insulator to improve efficiency and speed.
- MS is caused by deterioration in the myelin sheath.


Synapse
Nucleus
Dendrite
Axon
Cell body
Myelin sheath
Node of Ranvier
Axon ending or foot


Axon
Synapse
Brain cell

Neurotransmitters

- Hundreds known and many more yet to be identified
- Characterized by molecular structure such as acetylcholine, biogenic amines, and amino acids
- Only work if we have receptors so must be naturally occurring or chemically designed to fool receptors
- One theory of placebo effect is that expectation causes release of natural chemical that must exist for artificial chemical to be effective

How They Work

- Chemical messengers that transmit signals from nerve cells to target cells. (when produced outside of the brain, referred to as hormones)
- Target cells may be in other nerves, glands, or muscles.
- Once the message is received, the neurotransmitters are either broken down (degradation), taken back by the neuron that released it (reuptake), or drift away (diffusion).
- Billions of neurotransmitters are working at any given time.

Influence of Neurotransmitters

- Excitatory transmitters promote the generation of electrical signals called action potentials in the receiving neurons.
- Inhibitory transmitters prevent action potentials.
- Some neurotransmitters are excitatory or inhibitory while others can be either depending on the receptor.
- Neuromodulators affect large numbers of neurons at once, may have different influences, and operate more slowly.
- They all serve many functions and no characterization of those functions will be entirely accurate.

Neurotransmitters Work Under the Radar

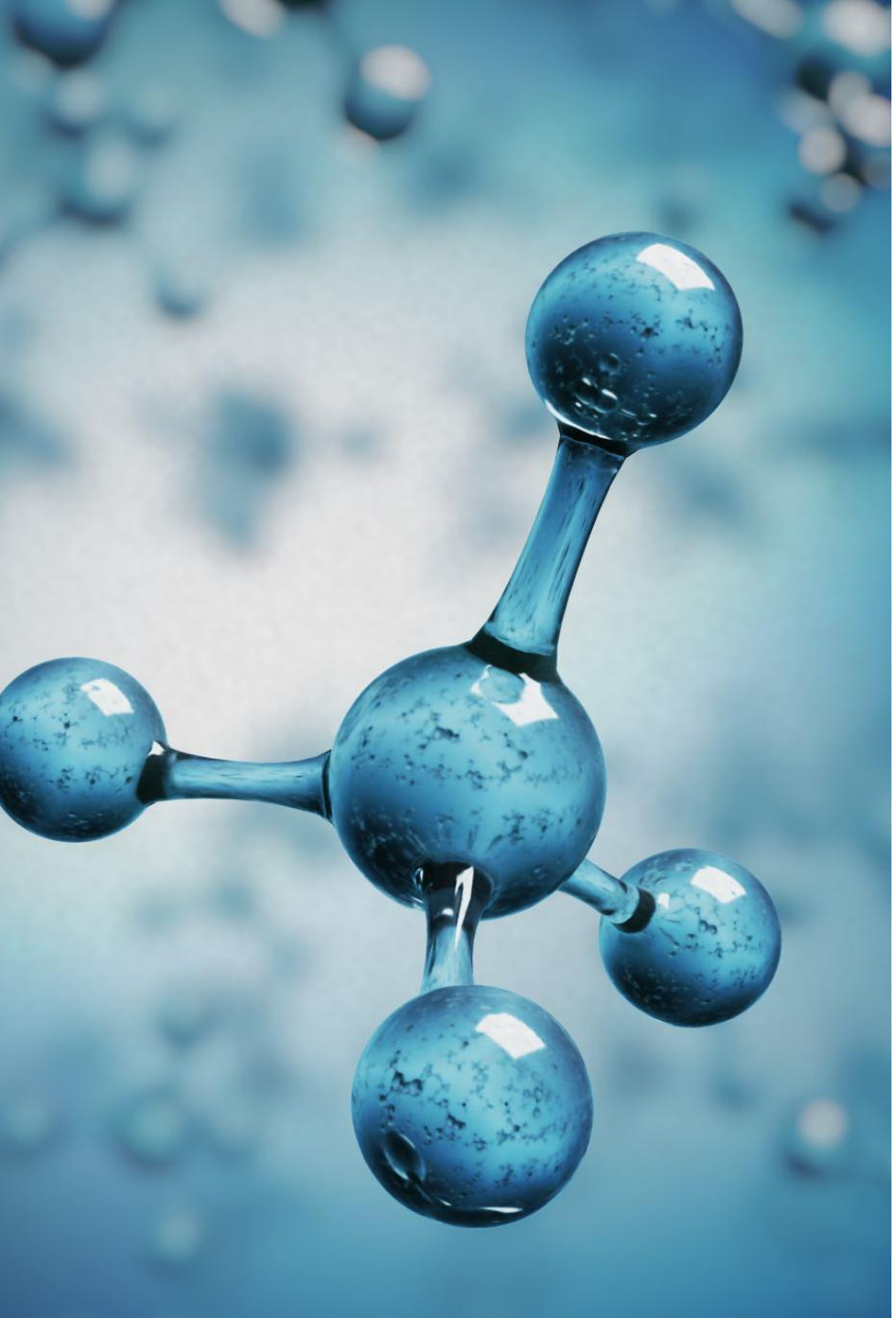
- We see a tiny percentage of the light spectrum and are consciously aware of a tiny percentage of what our brains detect.
- Similarly, very little of the activity of neurotransmitters creates detectable feelings or otherwise rises to the level of conscious awareness.
- Mostly they carry out mundane functions of keeping us alive – breathing, blood flow, temperature regulation, nutrient distribution.

Sometimes We Become Aware

- The brain cannot do everything without our help and sometimes needs to send us a message.
- We are made aware of the work of neurotransmitters when volitional action is necessary.
- Think of getting food, move your hand off hot stove, or stop eating bad food.
- It can also be higher level emotional signals that help us guide our behavior.

Listen To What Your Brain is Saying

- The brain realizes we have limited conscious thought capacity and cannot survive or will not pay attention if we overload it.
- When it brings something to our conscious awareness, the combination of architecture and learning tells the brain it is important.
- When we feel emotions, it is helpful to understand the reasoning behind them and appreciate the message.
- But remember, just as using optics to fool us, those with an agenda have learned how to manipulate our neurotransmitter messages also.
- Trust but verify.



Common Neurotransmitters

- We will review a few of the more common neurotransmitters and discuss how we assume they operate.
- They will all be far more complex than we can imagine and new research appears almost daily further complicating what we think we know.

Dopamine

- We often think of dopamine as the ‘feel good’ agent, forming the basis of our reward system. If it causes the release of dopamine, we will do it more often and try to get more of it.
- Dopamine also is involved, among other things, in learning, heart rate regulation, blood vessel and kidney functioning, lactation, sleep, attention, control of nausea, pain processing, and movement.
- Nausea is critical since it is the body’s way of ridding itself of harmful toxins and pathogens.

Was That Mr. Dopamine or Ms. Dopamine

- Understanding neurotransmitters is not for the faint of heart, with more complications than simple explanations.
- Researchers at UNC studied dopamine and pain using male rats.
- Tried analysis of one dopamine channel in both male and female rats and found different pathways.
- In males, dopamine lowered pain experience. In females, led to more activity and attention to stimuli. In other words, females dealt with pain by directing attention elsewhere. Article

Parkinson's Disease (PD)

- PD is characterized by misfolds of certain proteins and the formation of toxic clumps that destroy nerve cells that produce dopamine.
- Symptoms include loss of motor and cognitive functions and gastric distress.
- PD may be many different diseases but many, if not most or all cases arise from the gut.
- Recent studies show serotonin disruption may precede dopamine disruption and may explain why motor and cognitive symptoms often appear rather late in the progression of the disease.

Medical Science Does What It Can

- We know PD sufferers have lower dopamine levels so drugs developed to increase amount of dopamine available to the brain.
- L-Dopa (levodopa) is a precursor to dopamine that our bodies convert to dopamine.
- Carbidopa prevents the conversion of L-Dopa to dopamine outside the brain.
- The combination has brought significant relief but current research indicates it may be at best symptomatic.

Serotonin

- 95% of serotonin is created in the gut and is also found in red blood cells.
- As with other neurotransmitters, acts as hormones when operating outside of the nervous system.
- The body ingests tryptophan, an essential amino acid, through our diet and converts it into serotonin.
- We think of serotonin as a mood regulator, and it is, but it is also involved in regulating bowel movements, nausea, sleep, blood clotting, and bone health.

Selective Serotonin Reuptake Inhibitors (SSRI's)

- Known that many suffering from depression have lower levels of serotonin but no proof it causes depression.
- When a nerve cell releases serotonin, they float around to attach to receptors.
- Some that do not attach are reabsorbed by the nerves that released them in the first place. Process is called reuptake.
- SSRI's prevent the releasing cell from taking them back.
- Psychedelics such as psilocybin and LSD work on serotonin receptors.
- In later classes we will discuss why psychedelics are so much more effective than SSRI's.

Other Neurotransmitters (1)

- Oxytocin – hormone produced in the pituitary gland but also neurotransmitter produced in the brain. Relates to bonding and trust but also intricately involved in multiple reproductive and maternal functions.
- Endorphins (contraction of endogenous morphine) – also produced as a hormone in the pituitary gland and neurotransmitter in the brain. Attaches to opioid receptors and relieve pain and enhance pleasure. Not particularly well understood, nor is connection to dopamine.
- GABA (Gamma-Aminobutyric Acid) – primarily inhibitory effect by reducing ability to produce action potentials. Appears to have an excitatory role in brain development. Often related to stress reduction and immune system regulation but turned off when no longer needed.

Other Neurotransmitters (2)

- Endocannabinoids – Involved in memory, appetite, energy metabolism, stress response, digestion, and female reproduction. Active ingredient in marijuana.
- Adrenaline (Epinephrine) – Fight/flight response. Released as a hormone by the adrenal gland but triggered by the amygdala. Only released in response to threat of harm.
- Noradrenaline (Norepinephrine) – Similarities to adrenaline but ongoing as opposed to episodic and works only in the blood vessels as opposed to the heart and lungs.
- Glutamate – most abundant excitatory neurotransmitter, involved in over 90% of all transmissions. Major element of cognition, learning, and memory.

Rat Park Experiment

- Historically, rat studies showed that morphine addiction was hardwired into the brain. Rats were in small, austere cages with no other activities.
- Bruce Alexander, a Canadian psychologist, ran experiments in the late 1970's, using rats in healthy surroundings, including activities, socialization, space, etc., and found that they tended to resist morphine use.
- Both views are oversimplified and replication is inconsistent but they do establish that the environment is a critical factor in drug addiction.
- May help to differentiate endorphins and dopamine in distinguishing between pleasure and relief of pain.

Runner’s High

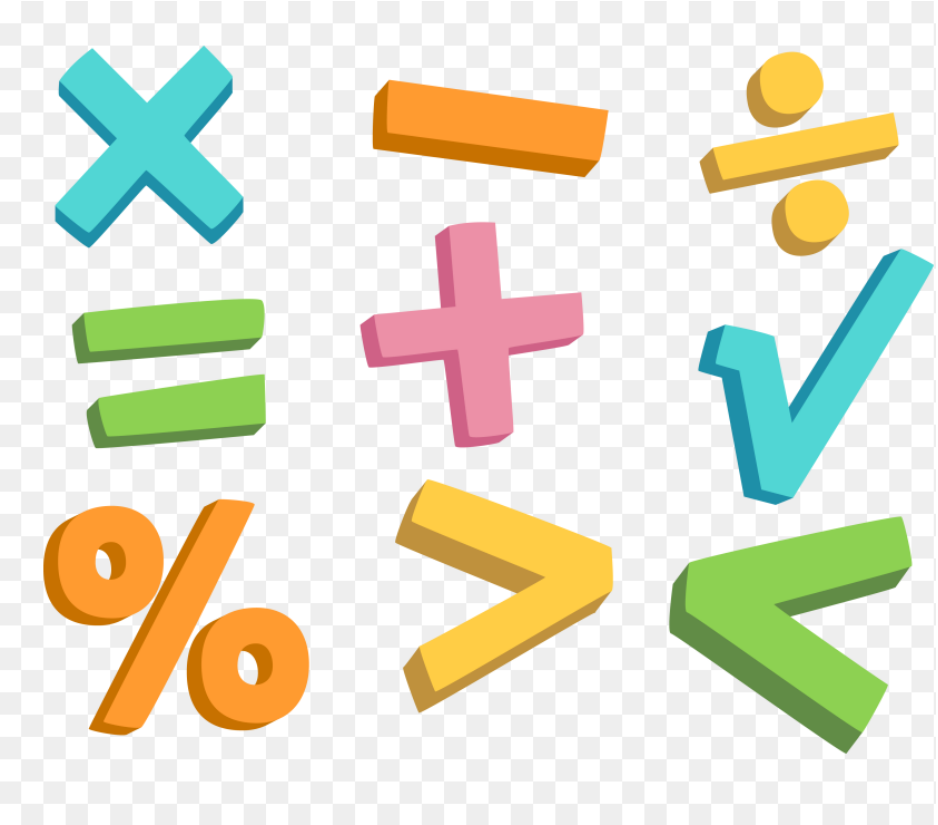
- Historically thought to be based on Endorphin release.
- Now appears to be Endocannabinoids (eCB’s) – Study
- Used naloxone to block opioid receptors that endorphins attach to.
- Measured higher levels of eCB’s.

Long Term Potentiation

- Fancy word for learning
- When neurotransmitters bind to receptors on other neurons, they help create new receptors and enhance electric current.
- That it turn makes it easier to respond to those neurotransmitters in the future.
- In effect, create patterns that increase efficiency but can also accentuate unhealthy patterns that are difficult to overcome.

Do the Math

- GABA inhibits and Glutamate excites.
- Which is better for learning math?
- In children, greater math fluency was associated with higher GABA levels and lower glutamate levels.
- In adults, it was the opposite. Greater math fluency was associated with lower GABA levels and higher glutamate levels. Study

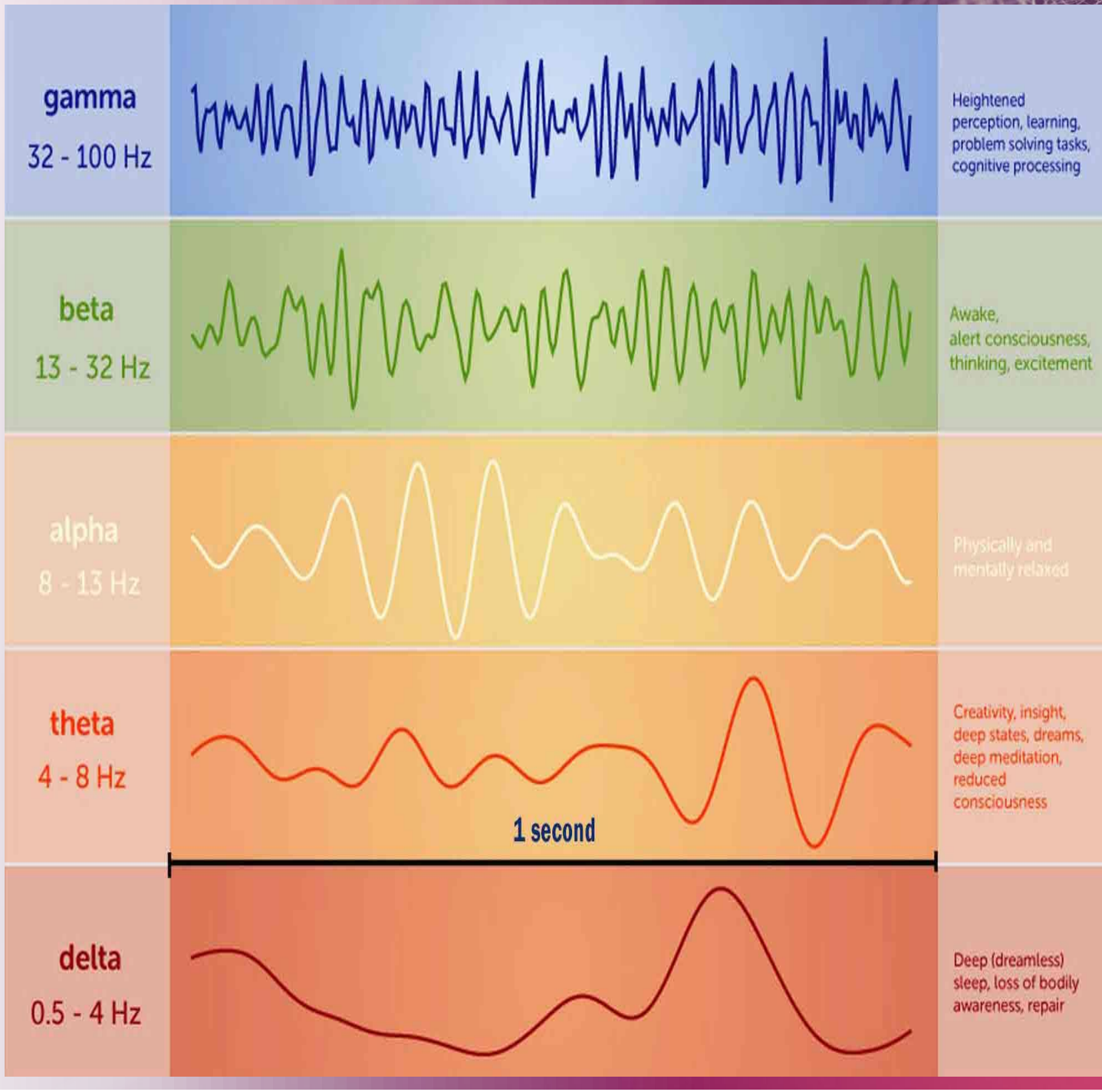



combined effects of inhibitory and excitatory neurotransmitters
may or may not be enough to reach threshold pote

Summation

Brain Waves

- Produced by synchronized electrical pulses from masses of neurons communicating with each other.
- Oscillating electrical voltages measuring just a few millionths of a volt.



Categorization of Brain Waves

- Measured by Amplitude (height) and Frequency - Hertz (Hz) – cycles per second
- Demarcations between types of waves are inexact
- Predominate wave function does not preclude others from occurring simultaneously

Delta Waves

- 1.5-4 Hz
- Dreamless sleep, unconsciousness
- Releases melatonin, DHEA, and human growth hormone.
- Suspend external awareness and allow for brain rejuvenation and healing.
- Conditions that prevent delta sleep, such as sleep apnea, can result in serious damage to the brain.

Theta Waves

- 4-8 Hz
- Reduced consciousness between waking and sleep
- Hypnogogic and hypnopompic states, between wakefulness and sleeping are either theta states or transitions from alpha to theta.
- Reduces mental fatigue, anxiety, and stress
- Experienced meditators and shamans maintain awareness during a prolonged theta state. Shamans sometimes use ayahuasca.
- The rest of us ordinarily cannot maintain such awareness.

Alpha Waves

- 8-12 Hertz
- Think of rest and relaxation and alleviating stress
- Awake but not processing much information
- Releases endorphin, noroepinephrine and dopamine.
- Tends to reduce anxiety and stress, reduce high blood pressure, increase happiness.

Beta Waves

- 12-40 Hz
- Normal waking state, aroused, engaged.
- Improves concentration and alertness, including logic, reasoning, and critical thinking.
- State we are in during fight-flight response.

Gamma Waves

- 40-100 Hz
- Associated with intense bursts of creative insight, higher states of consciousness, peak concentration, and high levels of cognitive functioning.
- Meditation increases gamma waves. Highly experienced meditators, such as Tibetan monks can maintain high levels of gamma waves for extended periods.
- Originate in the thalamus and move from back of brain to the front.
- Neuroscientists believe gamma waves link information from all parts of the brain and influence the entire brain.
- Unknown prior to digital EEG's since frequency too high to be picked up by analog EEG's. Originally dismissed as spare brain noise.

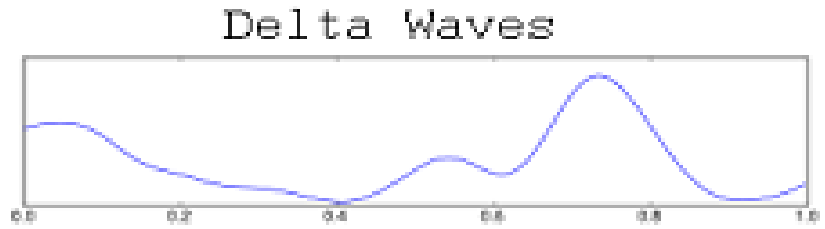
Other Brain Waves

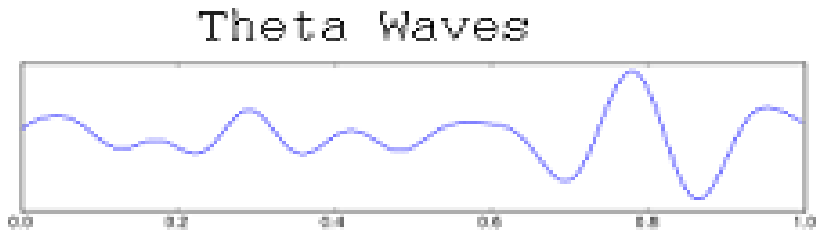
- Rapid Eye Movement (REM)
  - Dreaming
  - Alternates between Delta and Theta
  - Voluntary motor activity inhibited, can cause sleep paralysis

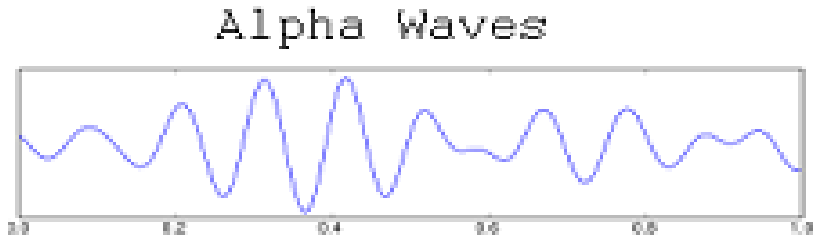
- Infra-Low (<.5HZ)
  - Also known as Slow Cortical Potentials (SCP's)
  - Relatively recent discovery, very little known, and difficult to detect.
  - Appears to be subject to volitional control and is the subject of neurofeedback studies
  - Divided into excitatory electrically negative shifts and electrically positive shifts that are inhibitory
  - Appears to arise from the highest levels of the cortex and able to control faster brain waves

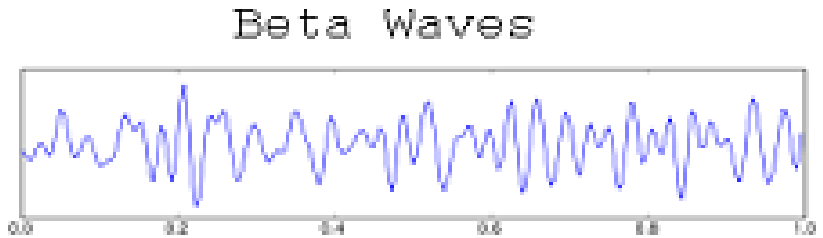
Neurofeedback with SCP’s

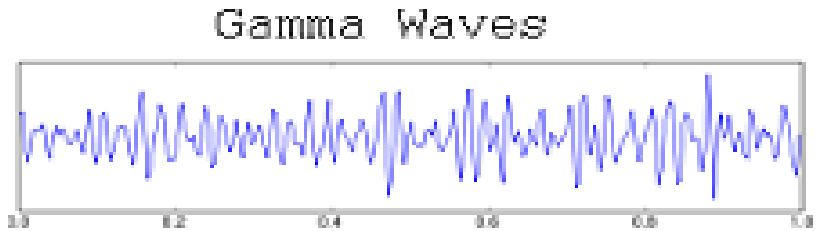
Brain Waves Shown by EEG











Review High Insight States

- Highly insightful states often created by conscious awareness in theta or delta state
  - Tibetan monks awake during delta
  - Shamanic Journeying (drumming, ayahuasca, etc.) – awareness during theta state
  - Hypnagogic (waking) or hypnopompic (falling asleep) – limited awareness during changes between alpha or beta and theta
- Super Meditators and Gamma Waves

Video

Lucid Dreaming

- Aware you are dreaming during dream
- May or may not be able to control dream
- Similar delta and theta activity to REM but additional gamma activity - Link
- Lucid dreaming, often natural in children, can be trained or self taught
- People use lucid dreaming for Problem Solving, Increasing Creativity, Facing Fears, Practicing New Skills, Exploring Conscious Mind, or Developing Sense of Self

Next Week – Cognitive Biases

- Like optical illusions, they are strengths that sometimes work against us.
- If you are interested, the seminal book on the subject was written by Daniel Kahneman, Thinking, Fast and Slow.
- His work opened up the whole field of study, including behavioral economics.
- It is a bit simplistic for our purposes but a classic nevertheless.