# Brain Resource Creation Workshop:
## Chapter 9 - Brain States

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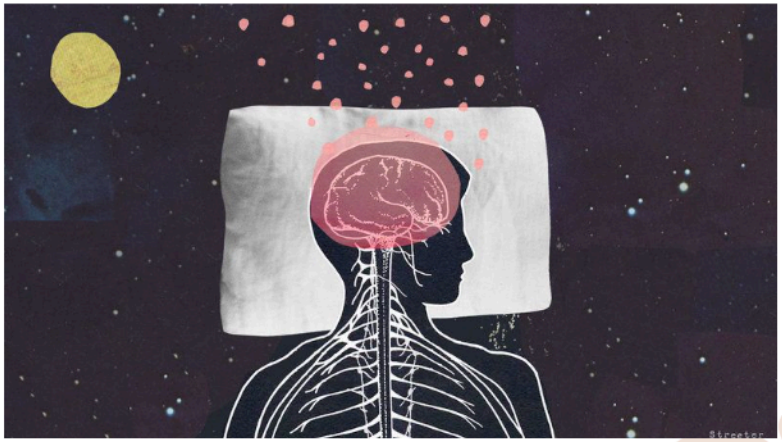
# The Importance of Sleep

**Sleep:**

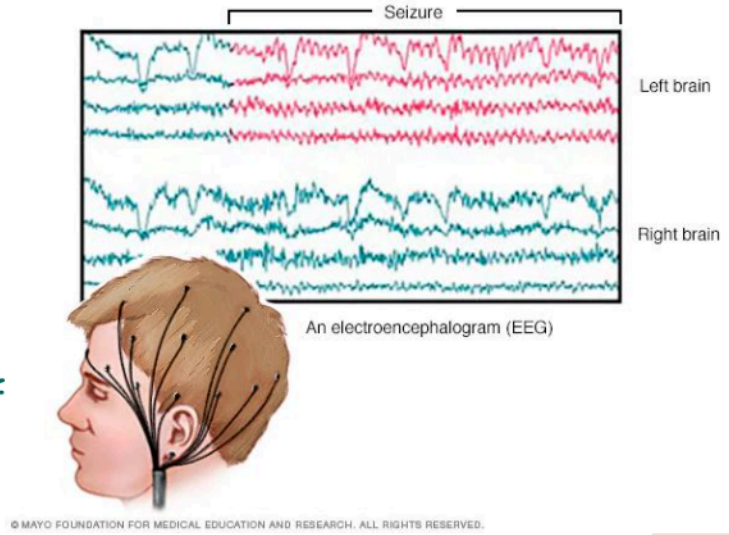
- Most individuals sleep for a third of their life
- Brains are active during sleep
  - Important for brain health and establishing memories
- Sleep deprivation decreases focus and can impair driving abilities
  - Long term risks: development of health issues
    - Ex: Diabetes, Stress, Obesity, Anxiety



# Brain Activity During Sleep

## Electroencephalography (EEG):

- Electrodes bound to the scalp record cortical nerve cells' electrical activity
- Ions move in and out of cell when a neuron is active
  - EEG detects this new electrical charge
- "Brain waves" are the rise and fall of brain activity in cycles
  - These help indicate brain function

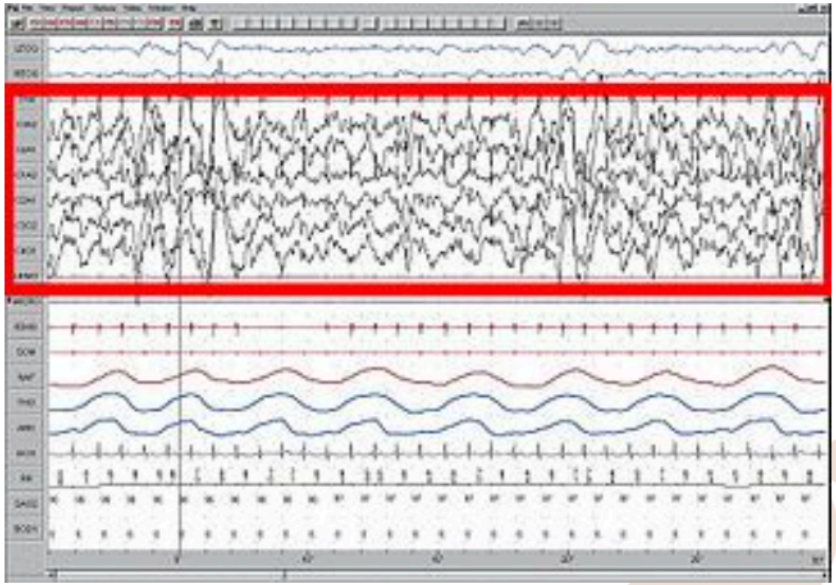


An electroencephalogram (EEG)

# Brain Activity During Sleep

## Slow wave sleep (SWS):

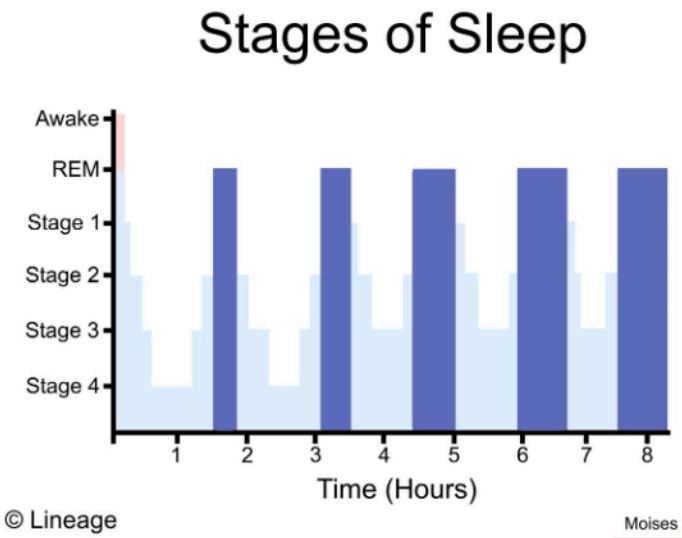
- Has high amplitude and low frequency brain waves
- Shows that a lot of cortical neurons switch activity from a depolarized state (more excited) to a hyperpolarized state (less excited)
- The longer you stay awake, the greater the number of slow waves



# Brain Activity During Sleep

## REM Sleep:

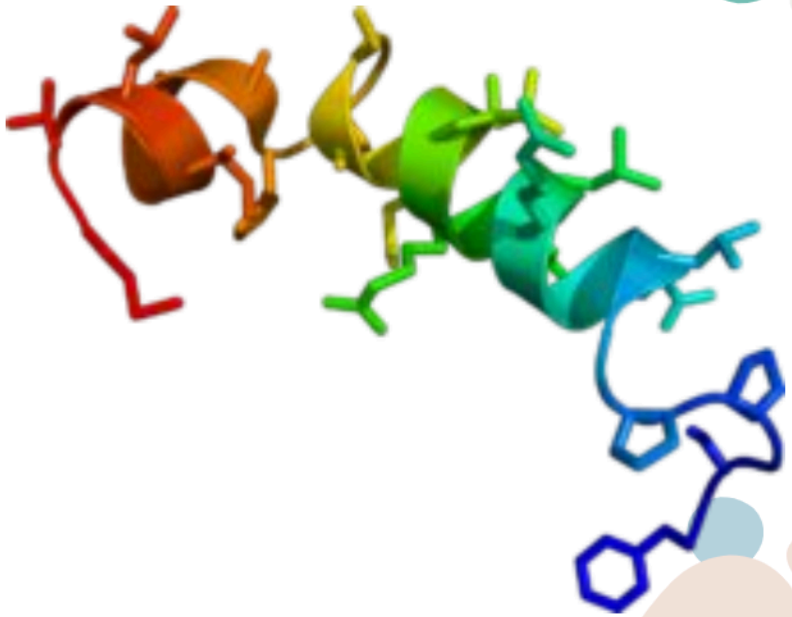
- Rapid eye movements during sleep
- Lower amplitudes than SWS slow waves in EEG recordings
  - Less synchronized neuron activity
- Causes atonia: loss of muscle tone when body is temporarily paralyzed
- Motor cortex neurons fire at the same fast pace while sleep *and* walking



# Sleep Regulation

## Orexin-producing neurons:

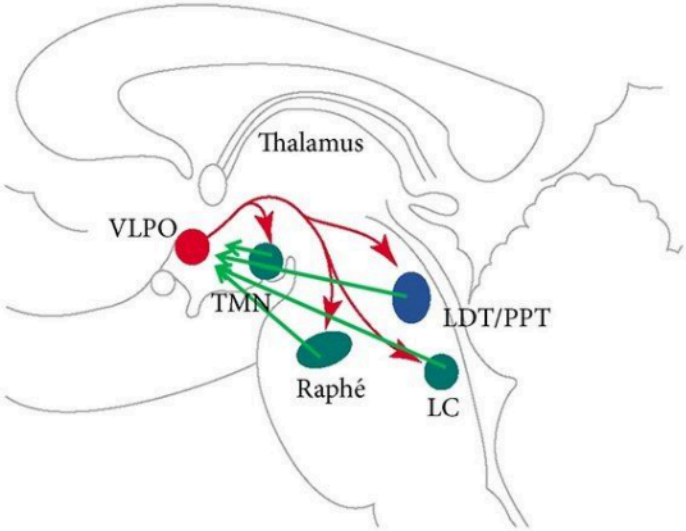
- Sends projections to...
  - Brainstem and spinal cord, thalamus and basal ganglia, forebrain, amygdala
- Orexins increase metabolic rates
  - Activated by insulin-induced low blood sugar
- Loss of these neurons causes narcolepsy
- Connects hypothalamic neurons to histamine, which helps one stay awake



# Sleep Regulation

## Balance of neurotransmitters:

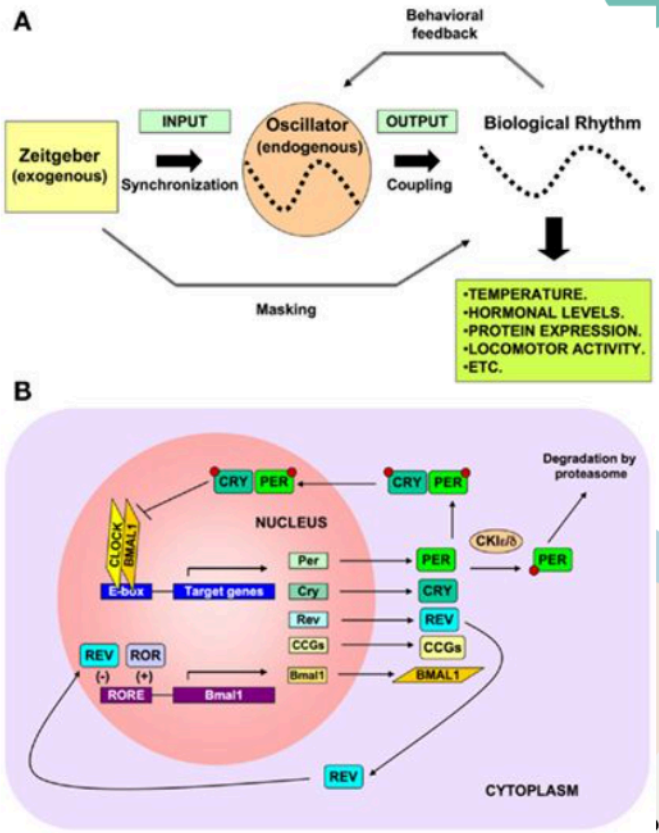
- REM: norepinephrine is low, acetylcholine is high
  - Dreaming occurs because the thalamus and neocortex are activated
- Forebrain is excited by REM sleep generator's signals
  - Causes rapid eye movement
- VLPO in the hypothalamus causes active suppression of brain systems that keep us awake
  - Damage of VLPO (ventrolateral preoptic nucleus) causes permanent insomnia



# Sleep-Wake Cycle

## Circadian timing system:

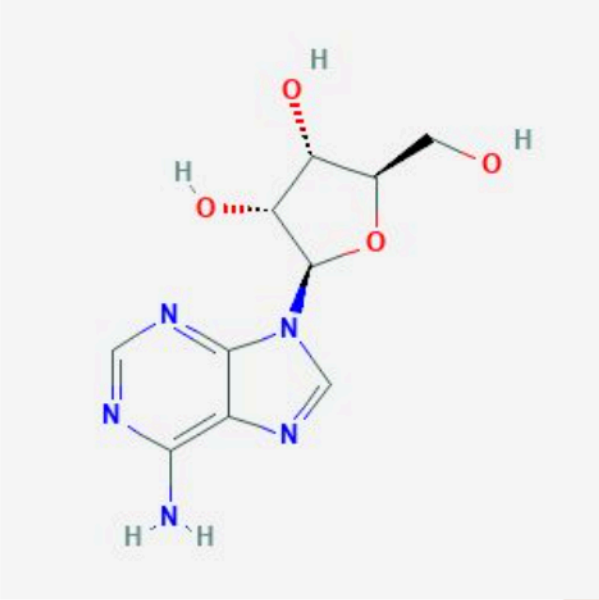
- Regulated by suprachiasmatic nucleus (nerve cells in hypothalamus)
- Cells express "clock proteins"
  - Establishes daily activity cycles, sleep, hormonal releases, etc
- Suprachiasmatic nucleus sends signals to different parts of the brain
  - Later contacts the VLPO and orexin neurons, regulating arousal



# Sleep Wake Cycle

## Homeostatic System:

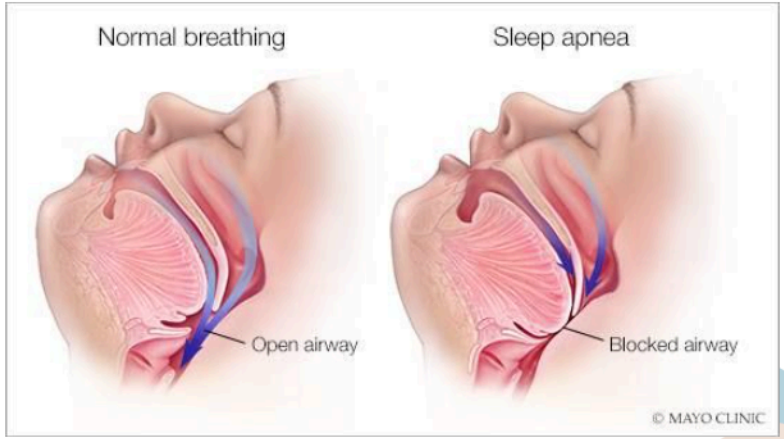
- Adenosine levels are heightened when one stays awake for too long
- In specific centers, they bind to receptors in nerve cells
  - Slows activity and decreases arousal
  - Increases number of slow waves during SWS
- Caffeine is a stimulant
  - Binds to adenosine receptors and blocks them from interacting with adenosine



# Sleep disorders

## Sleep apnea:

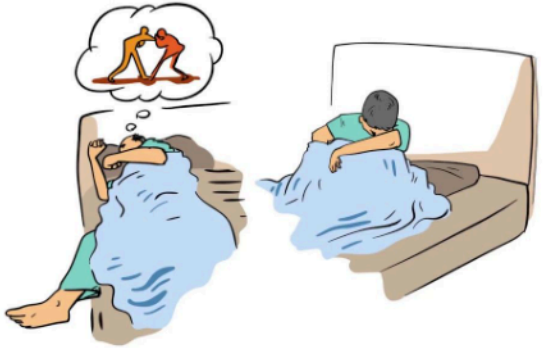
- Airway muscles in throat relax until it collapses during sleep
- Causes difficulty breathing without entering SWS stages
- Causes high blood pressure and increases risk of heart attack
- CPAP: airway pressure machine
  - Helps keep airway open during sleep



# Sleep disorders

## REM sleep behavior disorder:

- Malfunction of nerve pathways that prevent muscle movement
- Common in people with neurodegenerative diseases
  - Parkinson's, stroke, other types of dementia
- Can be treated with Clonazepam: amplifies inhibitory neurotransmitter GABA effects



# Narcolepsy: Example of Sleep Disorder Research

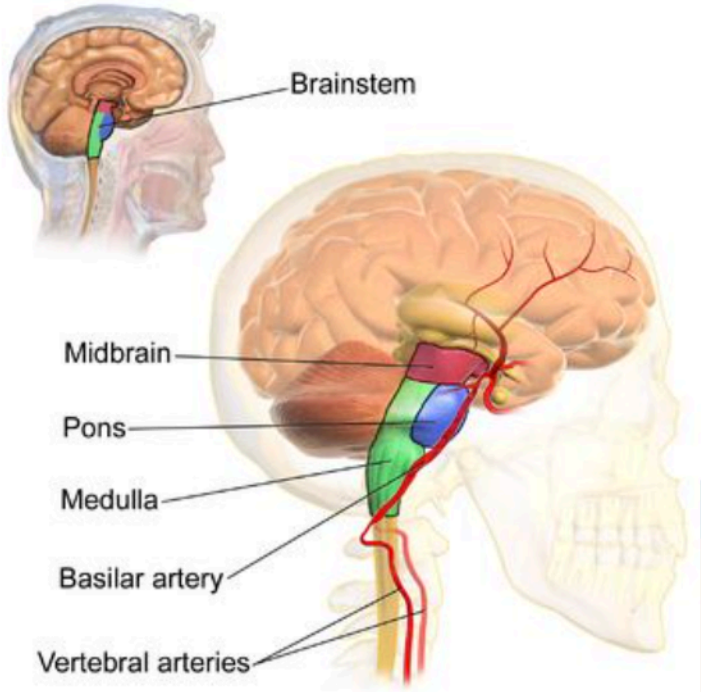
## Narcolepsy:

- Having sleep attacks during the day
  - Is dangerous while driving
- Due to loss of orexin neurons in the lateral hypothalamus
- Hypnagogic hallucination
  - Can enter REM sleep and dream, while still being partially awake
- Can have cataplexy
  - Paralysis attacks that causes loss of muscle tone

# Arousal

## Arousal:

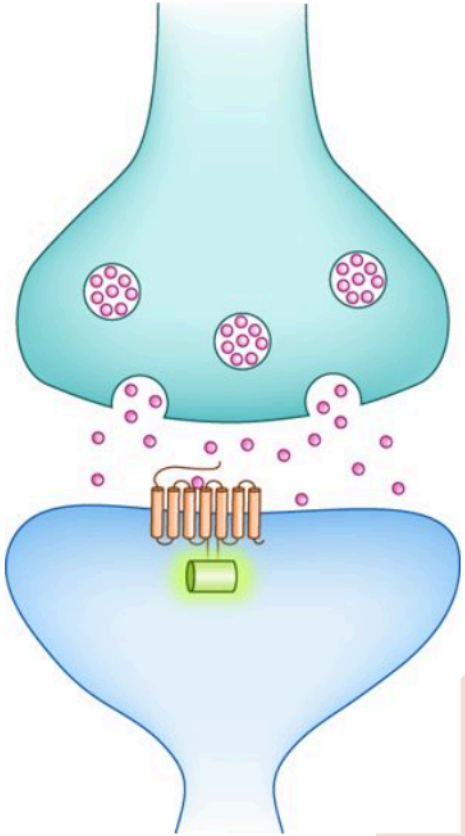
- Involves body and brain alterations that motivate a person to complete an action
- Important for reproduction and avoiding dangerous situations
- Level varies from low to high
  - Arousal is below a certain level, one can sleep
  - Arousal is above a certain level due to factors such as anxiety, one stays awake



# Arousal

**Neurotransmitters:**

- Released by specific types of neurons in specific brain regions for arousal
- Dopamine = movement
- Norepinephrine = alertness
- Serotonin = emotion
- Acetylcholine and histamine: increases arousal in the body



# Arousal

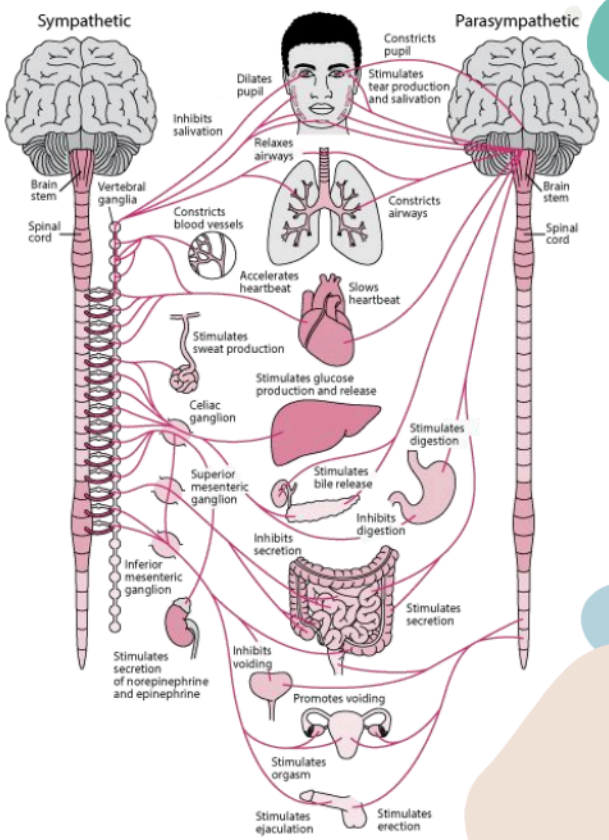
## Sensory Input:

- External signal that stimulates arousal
- Sorted in a region of the brain called the thalamus
- Receives and processes sensory inputs from regions of the brain
    - Essential to senses such as vision and hearing
    - Important for relaying inputs to the cortex

# Arousal

## Autonomic Nervous System:

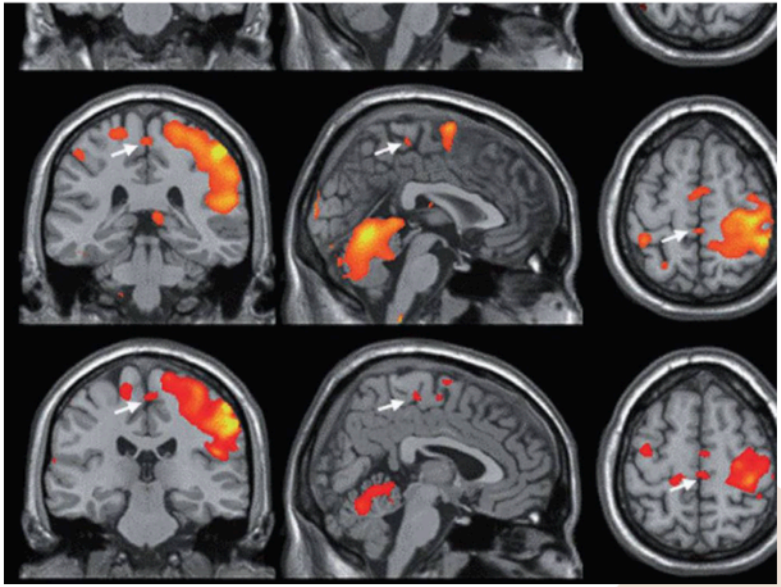
- Controlled by the reticular activating system
  - Regulates signals from neurotransmitters to cause a series of responses in the body
- Located in the brainstem
- Impacts heart rate, blood flow, and breathing
- Transports important substances like oxygen and nutrients



# Sexual Arousal

## Estrogen and testosterone:

- Hormones that activate neurotransmitter-releasing neurons
  - The same neurotransmitters as those involved in general arousal
- Brain regions contain many estrogen and progesterone receptors
  - Includes the hypothalamus, amygdala, and hippocampus
  - Includes brain regions that regulate rewarding feelings and sexual behaviors



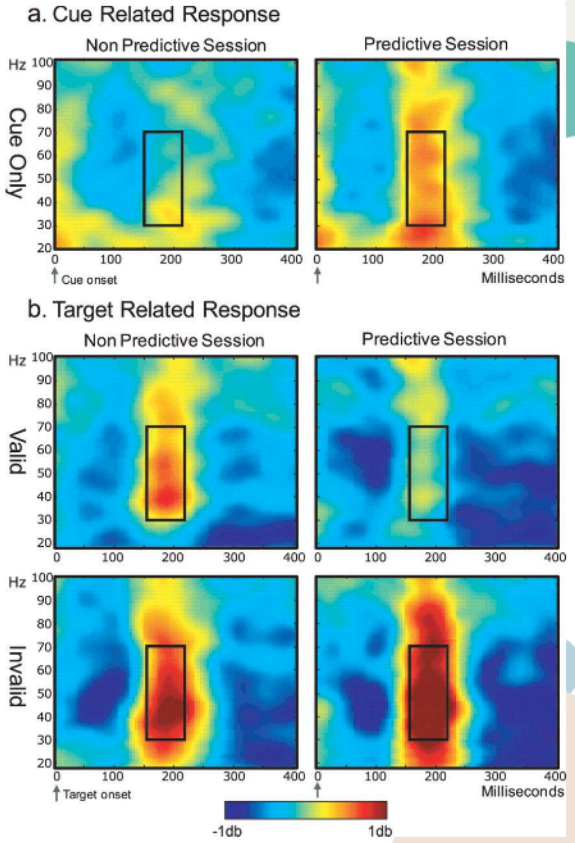
# Focus

## Voluntary attention (endogenous):

- Frontal and parietal cortex are active
- Happens when you choose to focus on a specific object or location

## Involuntary attention (exogenous):

- Happens when one's attention is caught by the environment
- Can be a distraction/random stimuli
  - Processed by the ventral frontoparietal network



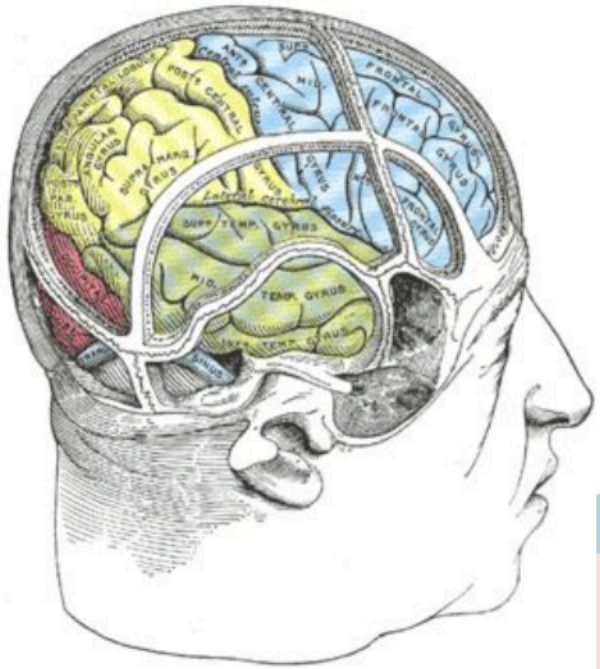
# Disorders of Attention

- **Schizophrenia:** inability to control selective attention
- **Prosopagnosia:** face blindness, being unable to recognize faces
  - Can be a result of genetic factors
- Other disorders include hyperactivity disorder (ADHD) and ADD

# Disorders of Attention

## Hemineglect syndrome:

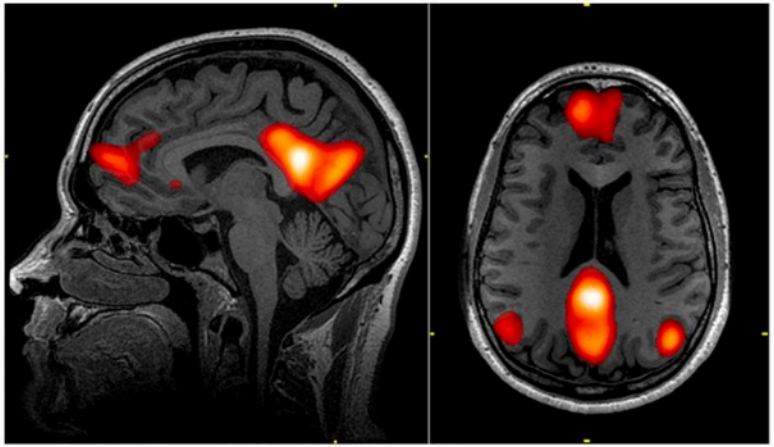
- Right parietal cortex (aids perception and attention) is damaged
  - Harms involuntary attention abilities
- Usually experienced immediately after a stroke
- Left side of the visual field is ignored
  - In addition to the left side of the body & objects
- Helps us understand rehabilitation after stroke



# Rest: Default Mode Network

## Default Mode Network:

- Activity decreases when doing a demanding task
- fMRI and PET (human imaging techniques) identify which brain regions are in default mode network
  - Involved in emotion, personality, introspection, and memory
- Includes frontal brain regions, posterior cingulate cortex, lateral parietal cortex, and precuneus



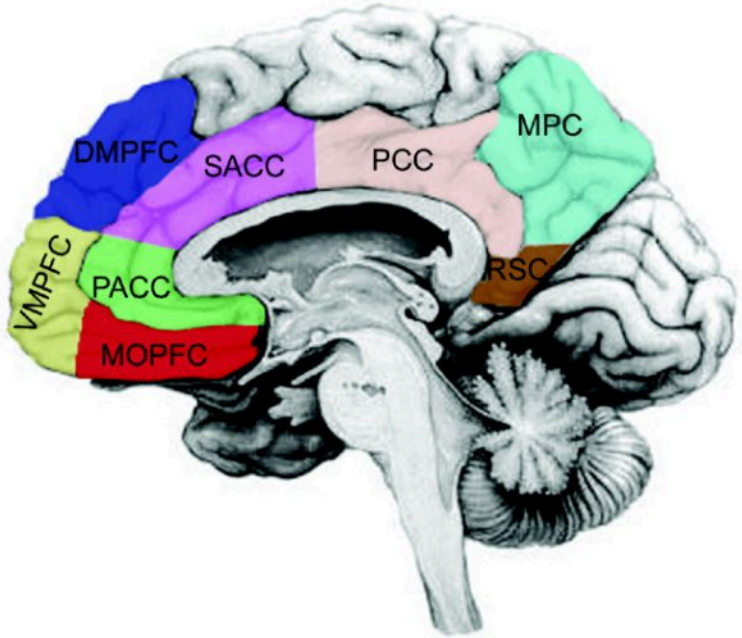
# Rest: Default Mode Network

## Dorsomedial PFC:

- Involved in introspective thoughts
- Increases when one is resting and daydreaming
- Involved in thoughts about the past, present and future self

## Ventromedial PFC:

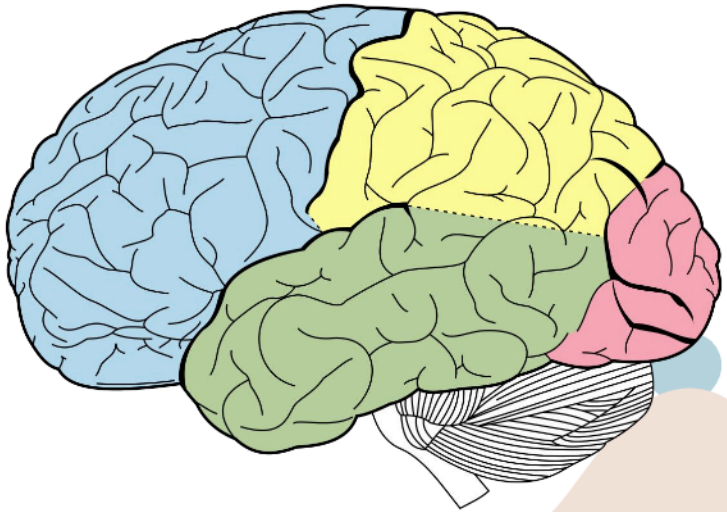
- Involved in the level of anxiety of a subject, when performing a task



# Rest: Default Mode Network

## Posterior brain regions:

- Includes posterior cingulate cortex, lateral parietal cortex, precuneus
- Activates when remembering memories from past experiences
- Brain regions connected with hippocampus
    - Important for learning and forming memories



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# We hope you enjoyed the workshop!

**Any questions?**

You can email us at

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