DMET 1058: Brain Computer Interfaces

Lecture 1

Dr. Hisham Othman [Office: C7.308]
hisham.othman@guc.edu.eg

Dr. Wael Aboulsaadat [Office: C7.208]
wael.abouelsaadat@guc.edu.eg

Administrative

- Two lecturers
  - Dr. Wael (CSEN)
  - Dr. Hisham (DMET)
- Two TAs
  - *Ethar Elhinamy* (CSEN)
  - *Yasmine Azzazi* (IET)

- Rubric

– 3 Quizzes	20%	(best 2)
– Project	30%	(team-based)
– Final Exam	50%	

Course Material

- Lecture slides + practice assignments
- Matlab Code
- Designated chapters from textbooks made available on gdrive

Course Textbooks

- Brain-Computer Interfacing by Rao

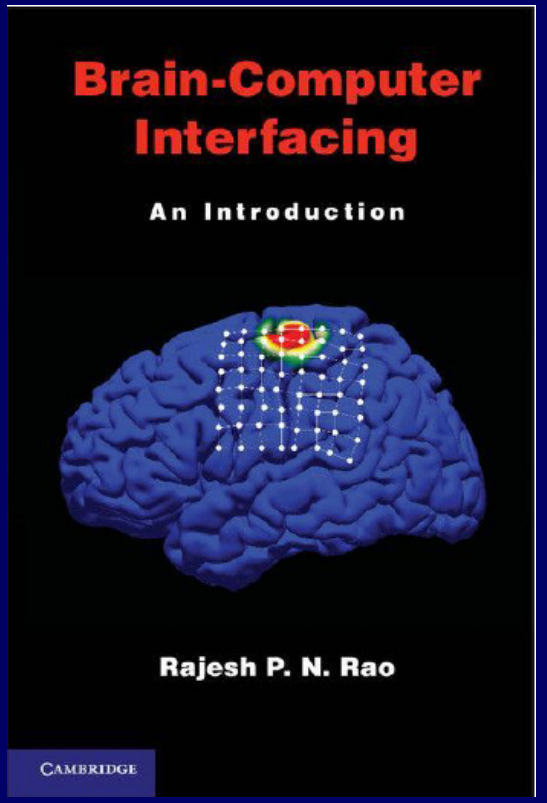
https://drive.google.com/open?id=1giiB5BFRW18Yo0-J_IZOCjixvNilbj8i

+

- Chapters from other textbooks

will be used.

- reference to such will be included in last slide if there is one.



Course Content

- Brain Anatomy
- Brain Recording Technology
- Brain Signal Analysis
- Artifact Removal
- Feature Selection
- Feature Classification
- Evoked Related Potential

Lecture Take-aways

- Because BCI is a multidisciplinary area, it builds on findings from many other scientific, engineering, and medical sciences, take-away points are added to the lecture slides to ensure that you learn the important finding for the purpose of usage in BCI.
- Take-aways are numbered starting from lecture 1
- Take-aways are abbreviated like this: **TA**

Brain Computer Interfaces Applications

- BrainBall

https://www.youtube.com/watch?v=7I1RFJnOaTY

Brain Computer Interfaces Applications

- Moving around
  - Quadruple paraplegic users: moving wheelchair using brain signals to select from menu showing directions

Brain Computer Interfaces Applications

- Controlling artificial limbs
  - Quadruple paraplegic users: moving arm by thinking of intended motion

Read More: http://www.dailymail.co.uk/sciencetech/article-2249321/The-mind-controlled-robot-arm-lets-paralysed-write-eat.html

Brain Computer Interfaces Applications

- BCI Speller;
  - Typing text by thinking of letter to be typed

Brain Computer Interfaces Applications

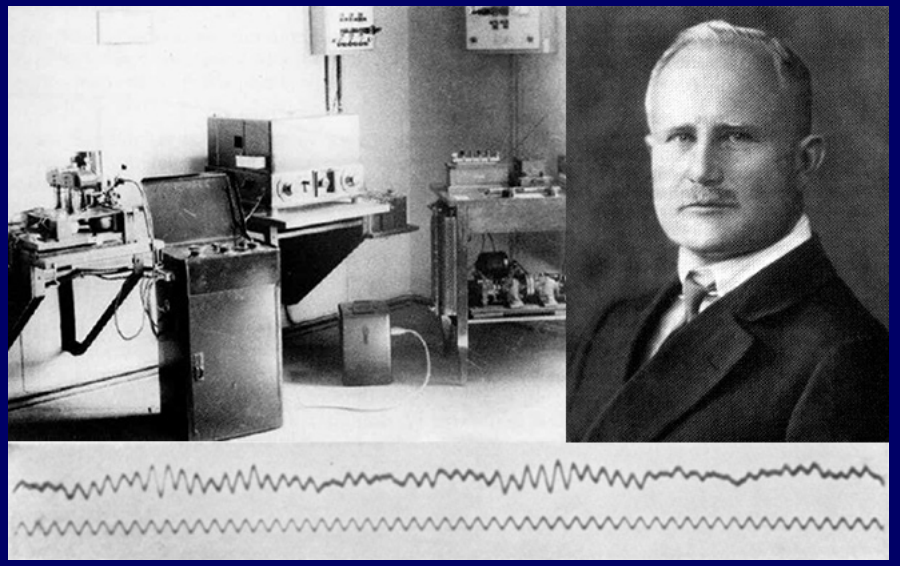
- Controlling characters in a game;

Brain Computer Interfaces Applications

- Detecting emotions;
  - Detecting mental and emotional state in a certain task

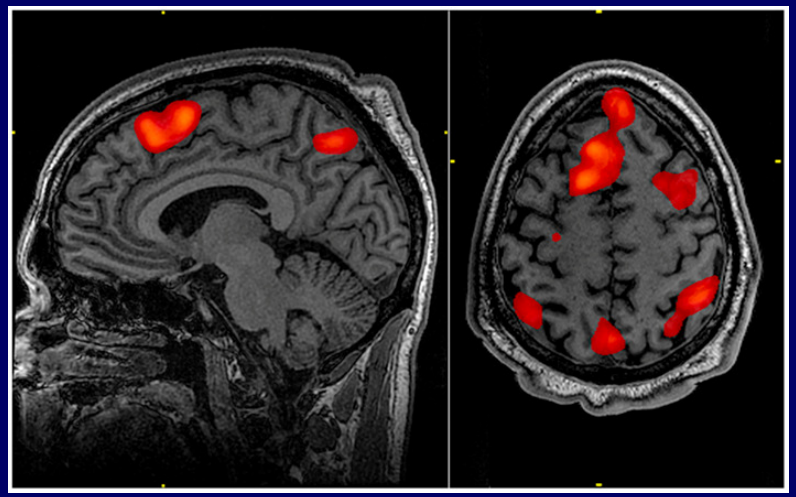
Brain Recording: Historical Perspective

- In 1924, Hans Berger in Jena, Germany, succeeded in recording the first human brain signal.
  - Filled with doubt, he took five years to publish his first paper in 1929 which demonstrated the technique for "recording the electrical activity of the human brain from the surface of the head".



Brain Signal Recording Techniques:

- Functional magnetic resonance imaging (fMRI)
  - measures brain activity by detecting changes associated with blood flow. This technique relies on the fact that cerebral blood flow and neuronal activation are coupled. When an area of the brain is in use, blood flow to that region also increases.

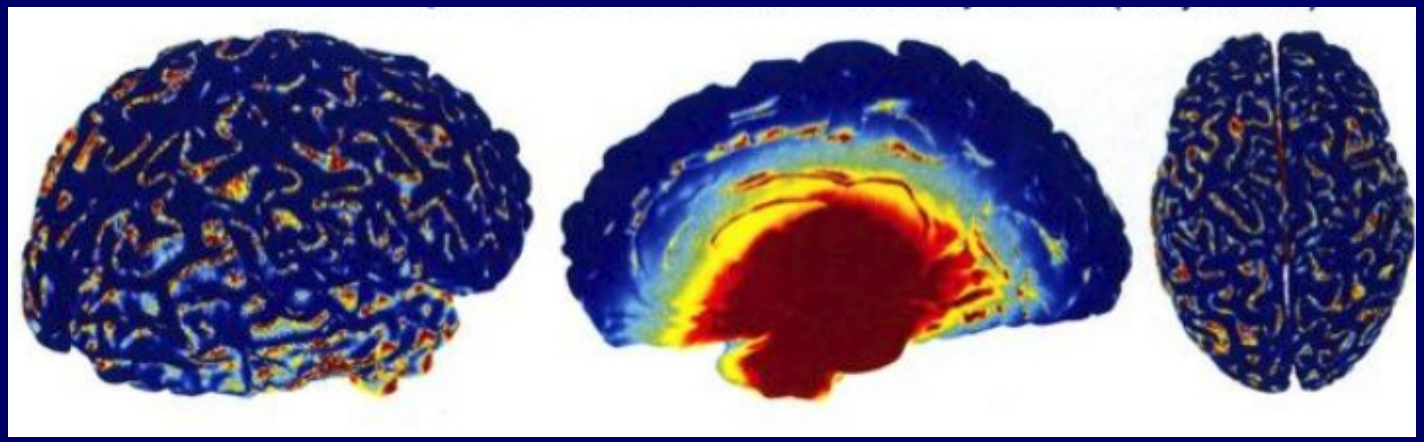


Brain Signal Recording Techniques

- Functional magnetic resonance imaging (fMRI)

Brain Signal Recording Techniques

- Magnetoencephalography (MEG)
  - A functional neuroimaging technique for mapping brain activity by recording magnetic fields produced by electrical currents occurring naturally in the brain, using very sensitive magnetometers.



Brain Signal Recording Techniques

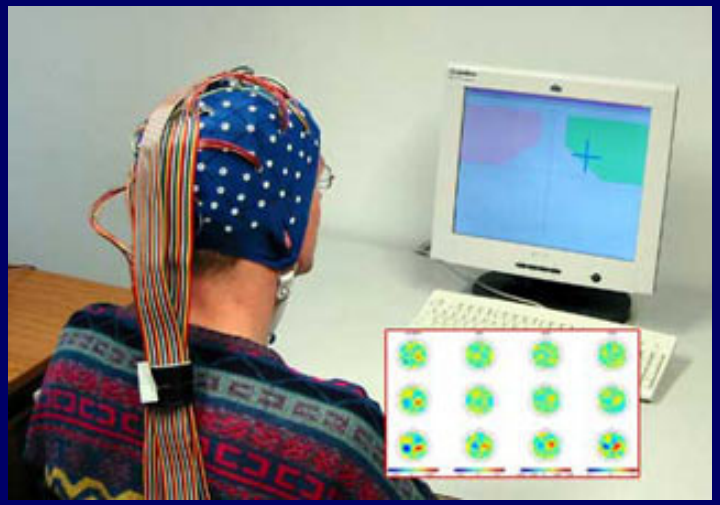
- Magnetoencephalography (MEG)

Brain Signal Recording Techniques

- Electroencephalogram (EEG)
  - a technique to record electrical activity of the brain using electrodes placed directly on the scalp

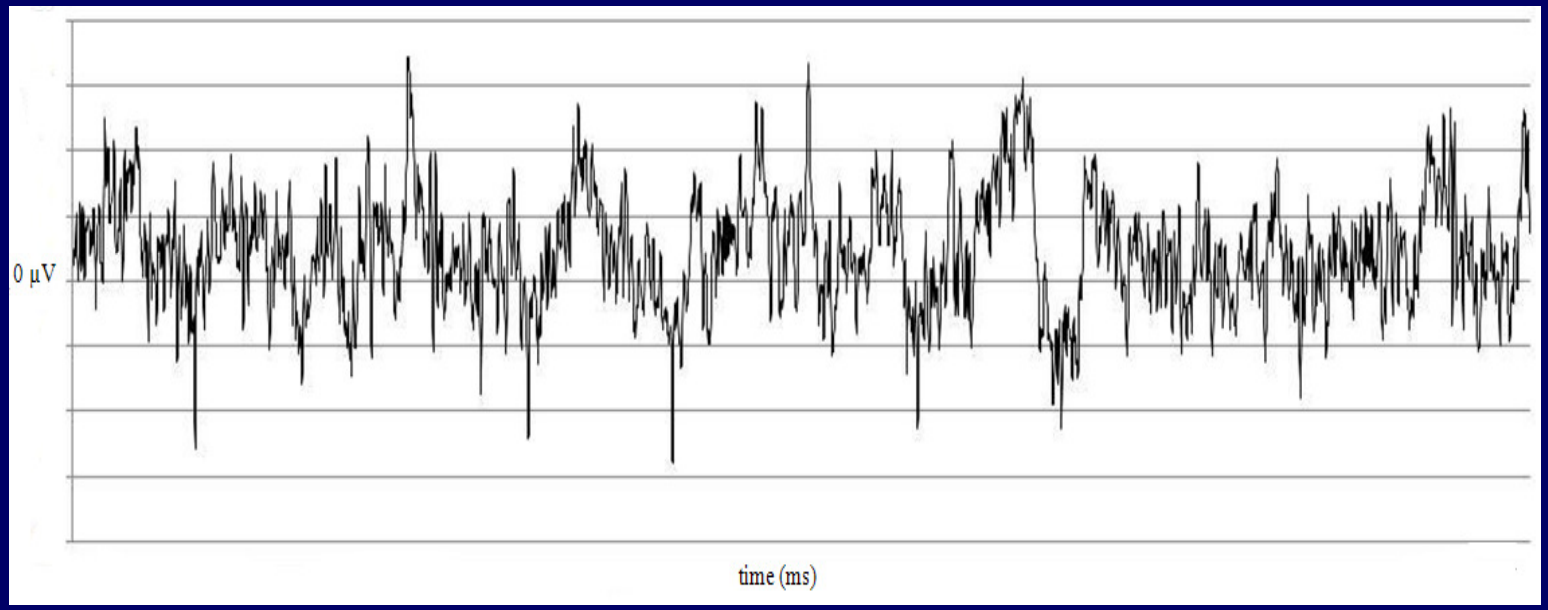
Brain Signal Recording Techniques

- EEG



Brain Signal

- From 1 location:



Brain Signal

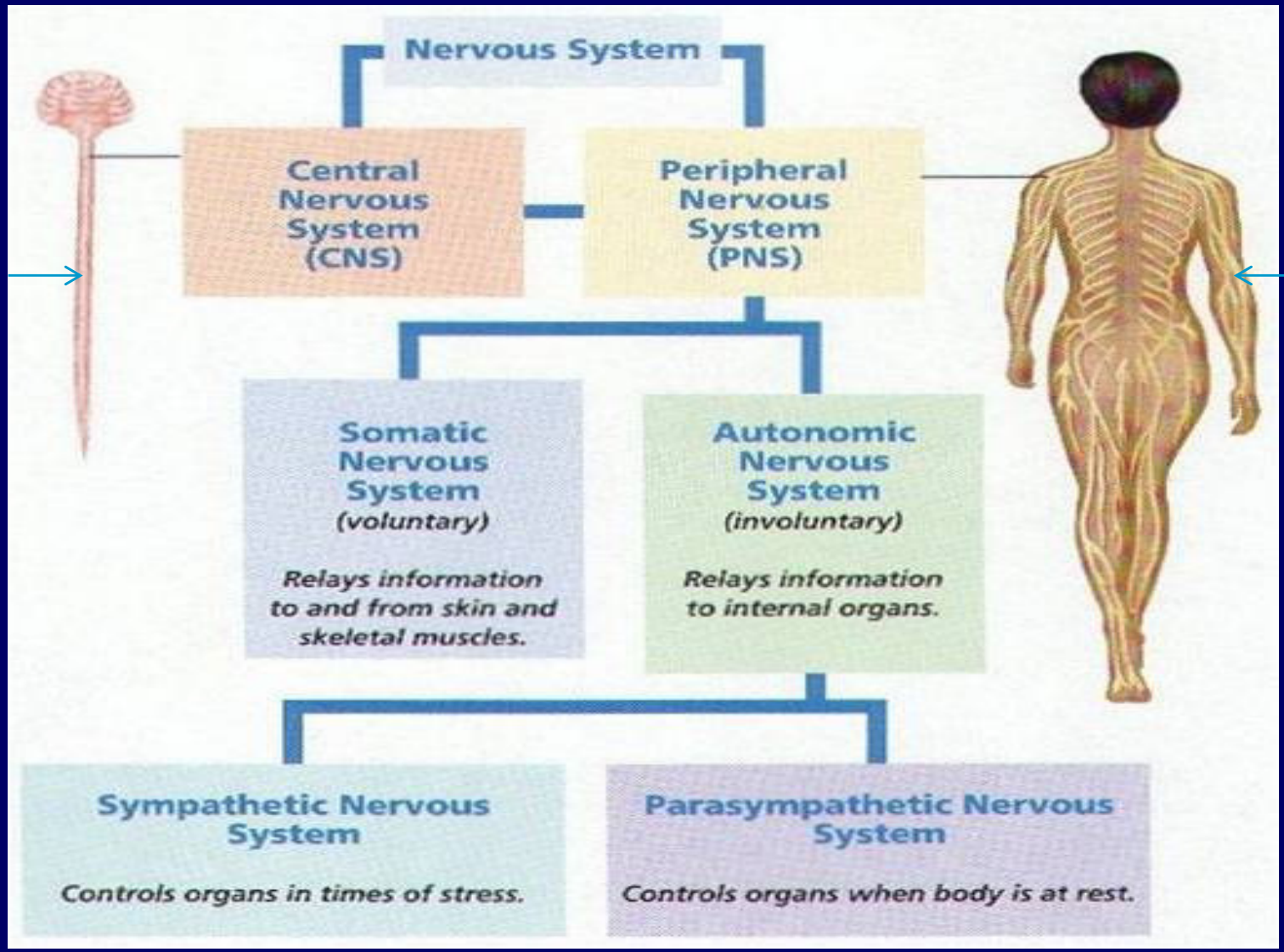
- From several locations:

The Brain

- Getting Beyond the gray matter

Divisions of the Nervous System

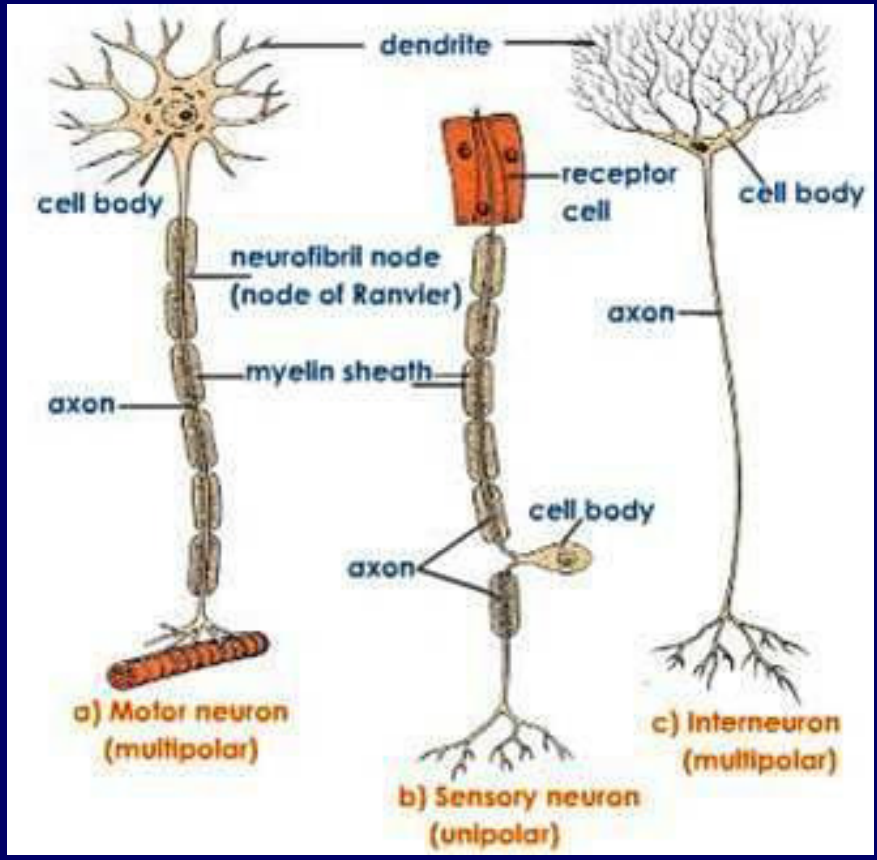
Brain & Spine



Rest of Body

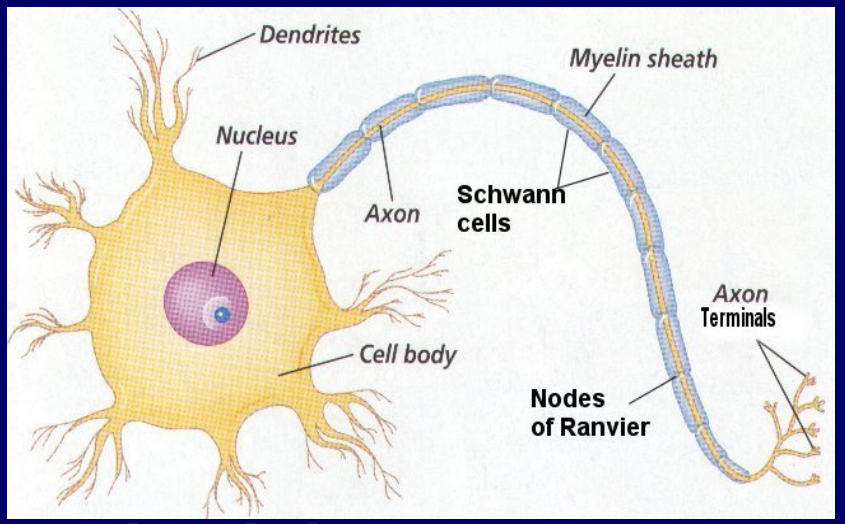
Neuron

- Basic functional cell of nervous system
- Transmits impulses



- Three types
  - Sensory neurons – bring messages to CNS
  - Motor neurons - carry messages from CNS
  - Interneurons – between sensory & motor neurons in the CNS

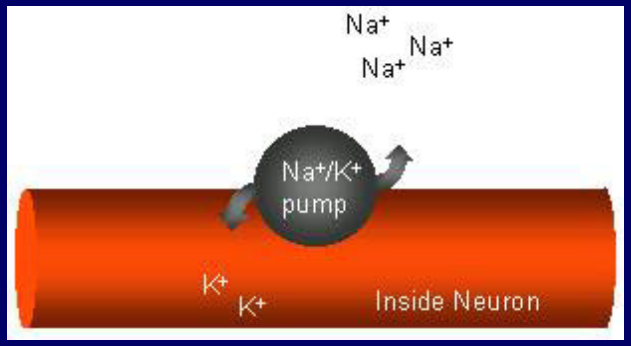
Neuron

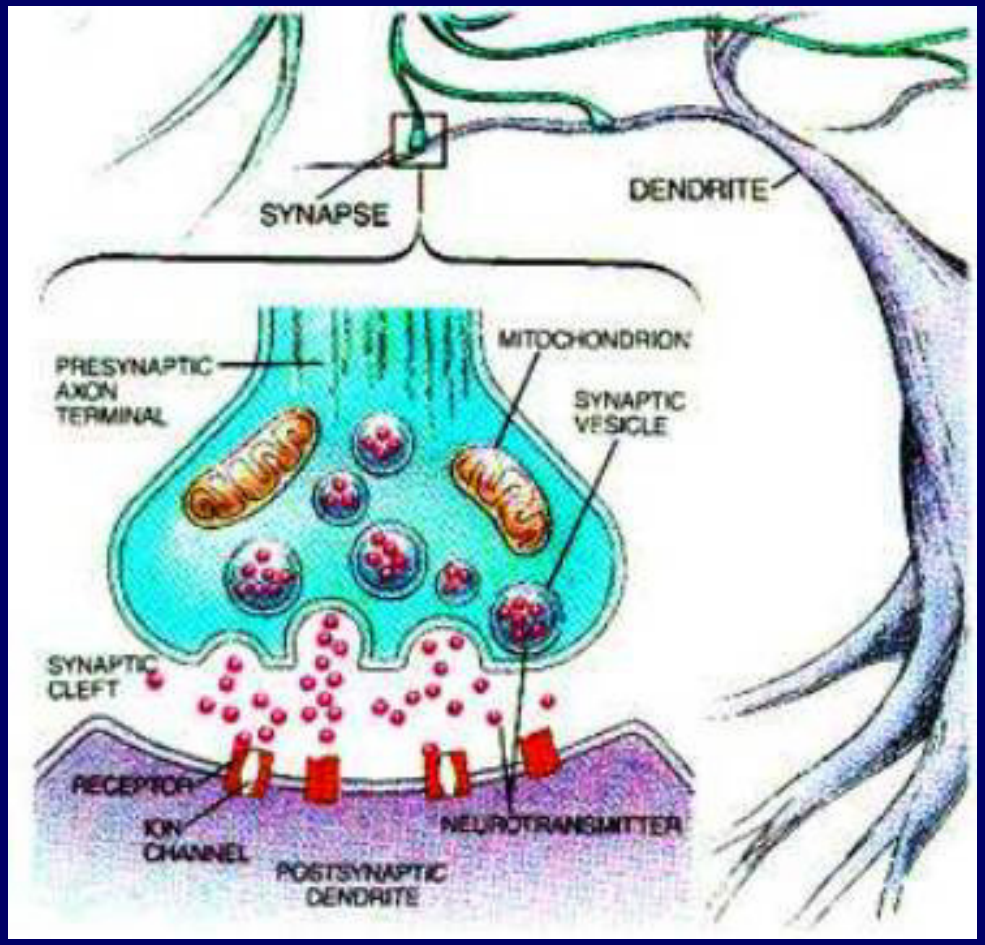


- Dendrite – receive stimulus and carries it impulses toward the cell body
- Cell Body with nucleus – nucleus & most of cytoplasm
- Axon – fiber which carries impulses away from cell body
- Schwann Cells- cells which produce myelin or fat layer
- Myelin sheath – lipid layer around the axon
- Node of Ranvier – gaps or nodes in the myelin sheath
- Impulses travel from dendrite to cell body to axon

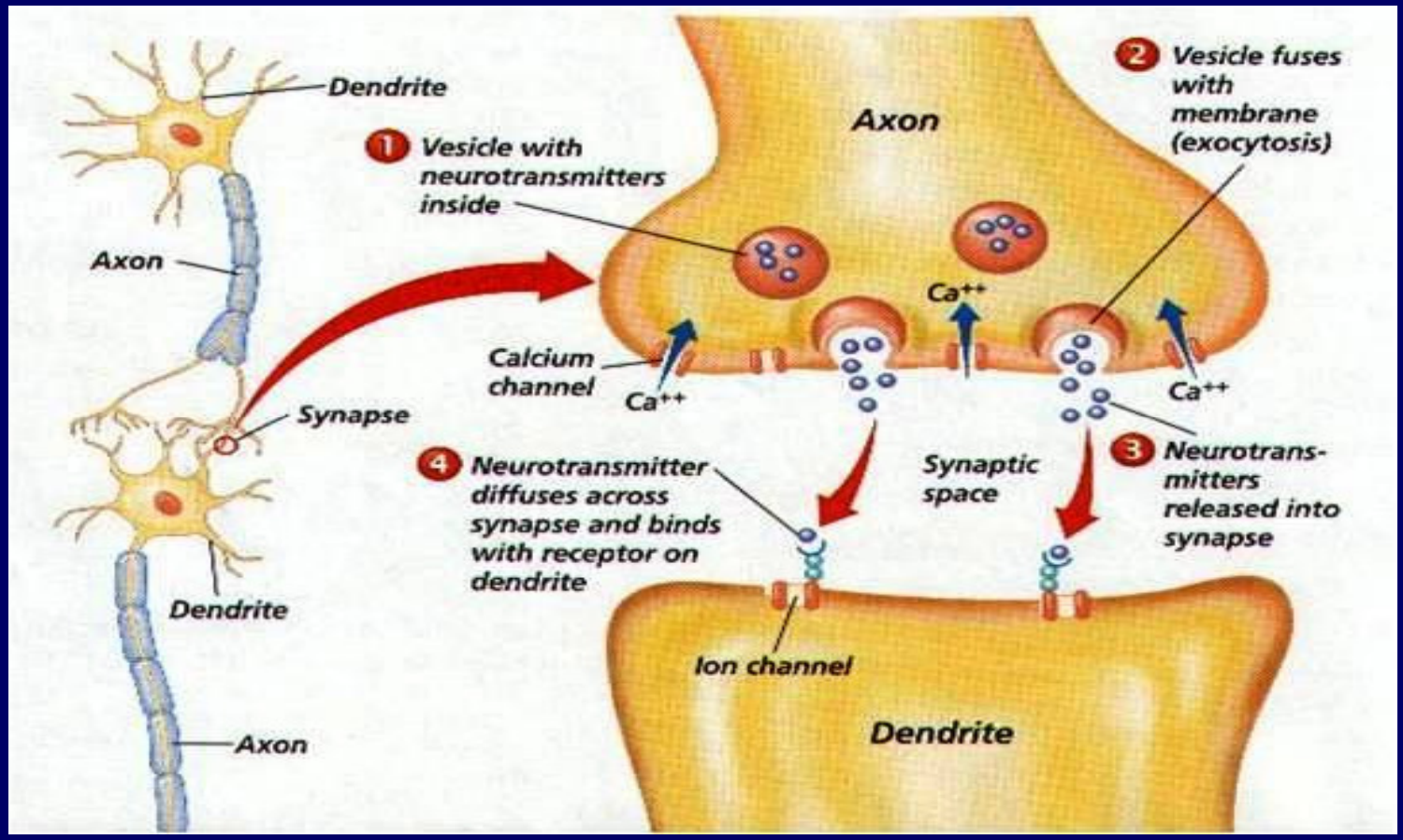
Impulses

- Impulse
  - Self propagating
  - Mechanism – Na^+ K^+ pump
- Synapse
  - Junction between neurons
  - Neurotransmitters





Synapse



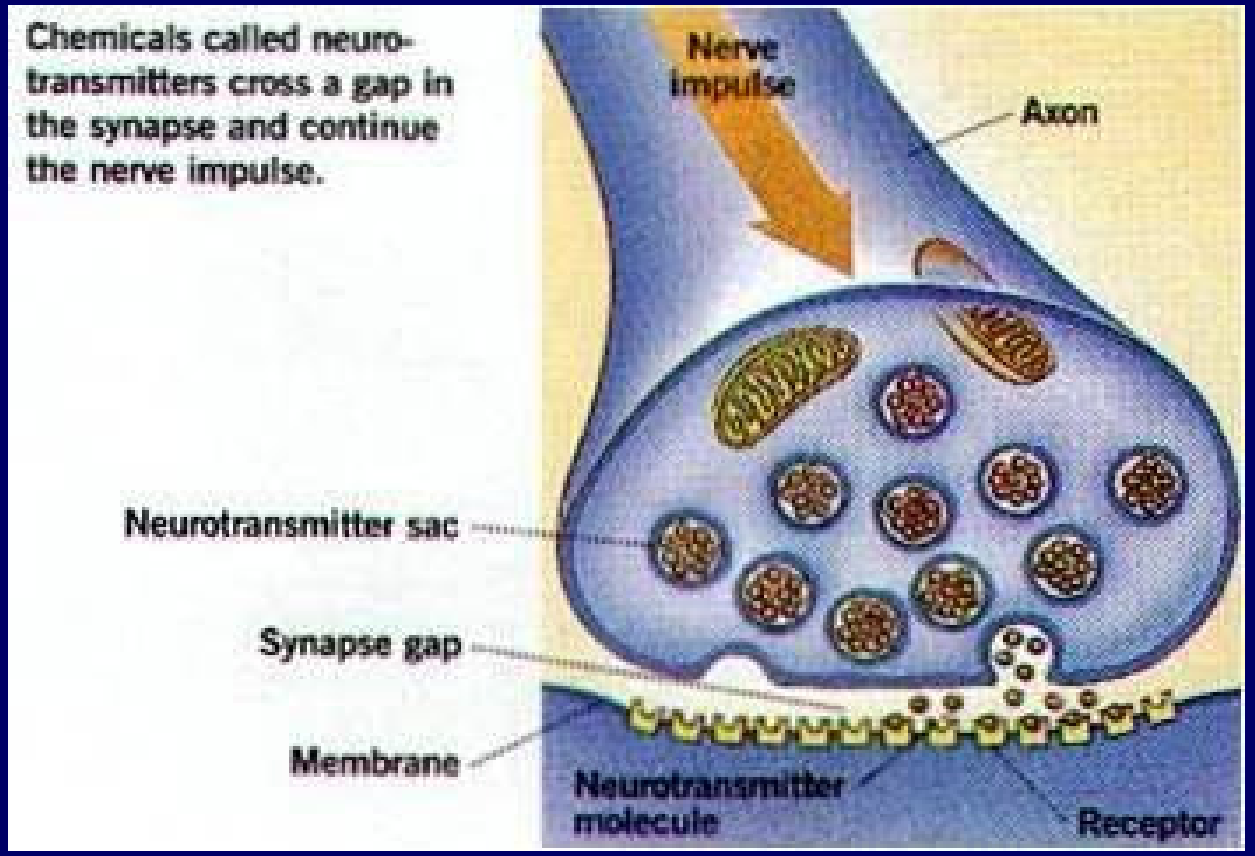
Junction between neurons

The neurons do not actually touch at the synapse

Neurotransmitters used to restart impulse in dendrite of 2nd neuron

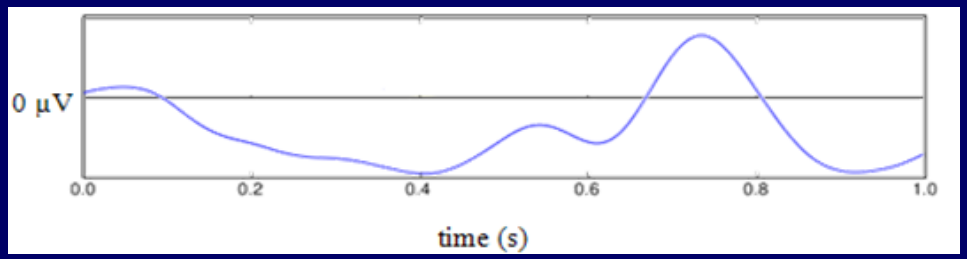
Neurotransmitters

- Chemicals in the junction which allow impulses to be started in the second neuron

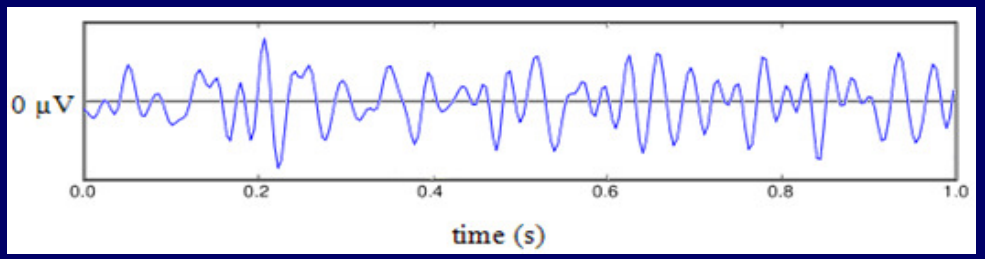


The Brain: brain waves

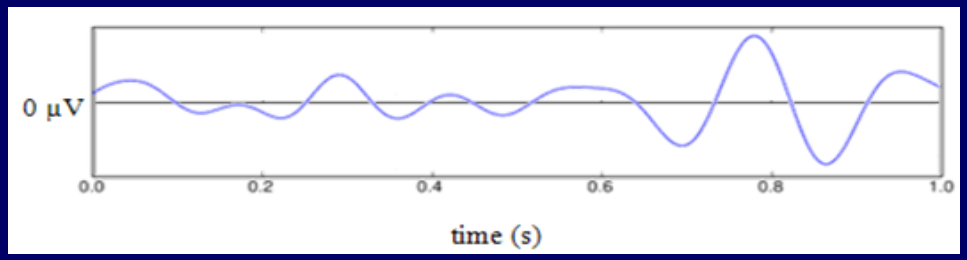
- 5 brainwave types



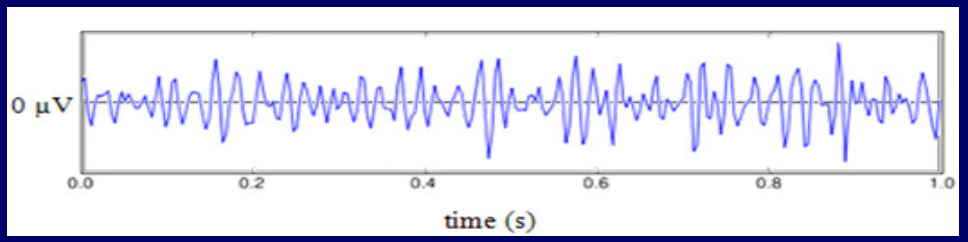
Delta: up to 4 Hz.



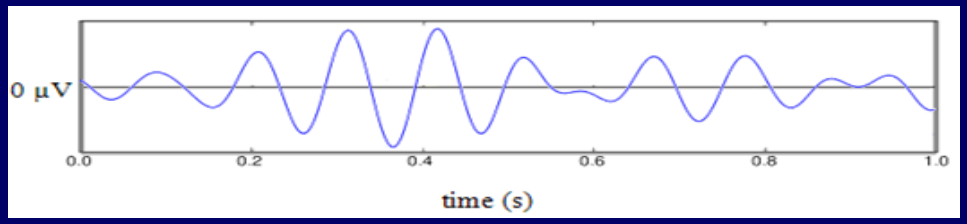
Beta : 16 – 32 Hz.



Theta: 4 - 8 Hz.



Gamma: > 32 Hz



Alpha: 8 – 16 Hz.

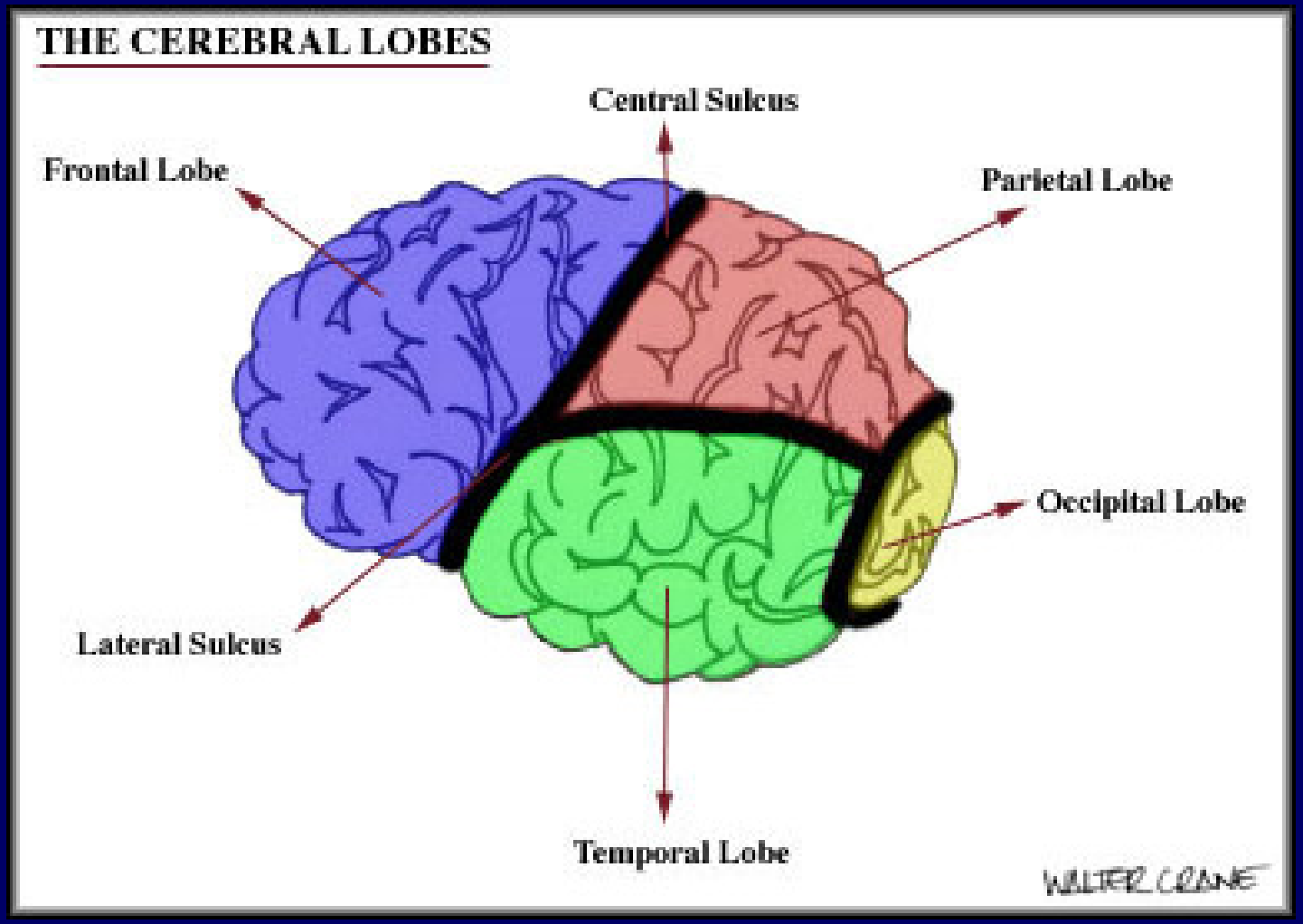
Th Brain

- **TA1:** the brain waves is divided to 5 types based on frequency range: delta, theta, alpha, beta and gamma. Each wave type is associated with a specific set of tasks, functionalities, modes, etc..

The Brain: lobes

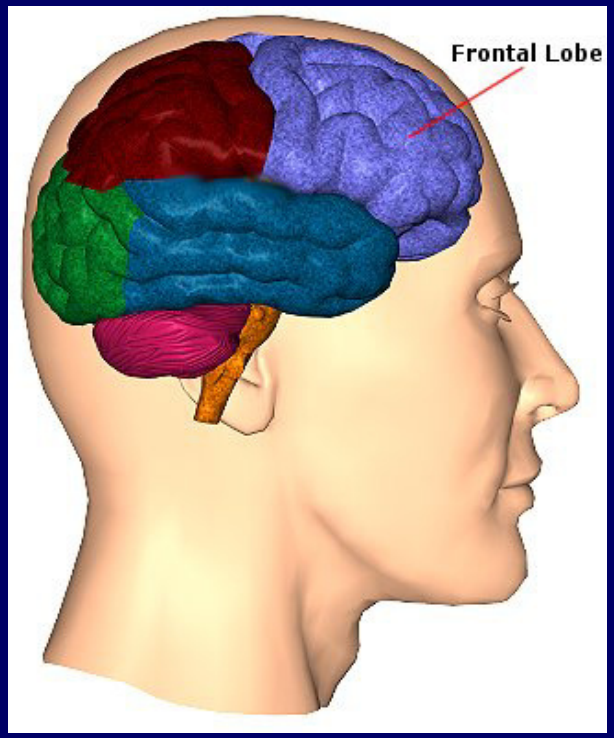
- Brain has 4 distinct lobes + special motor area called central sulcus
- Each area is responsible for certain functionality.
- Each area has many processing centers, each responsible for a task.
- Performing a complex task might involve activating more than 1 brain processing center

The Brain: lobes



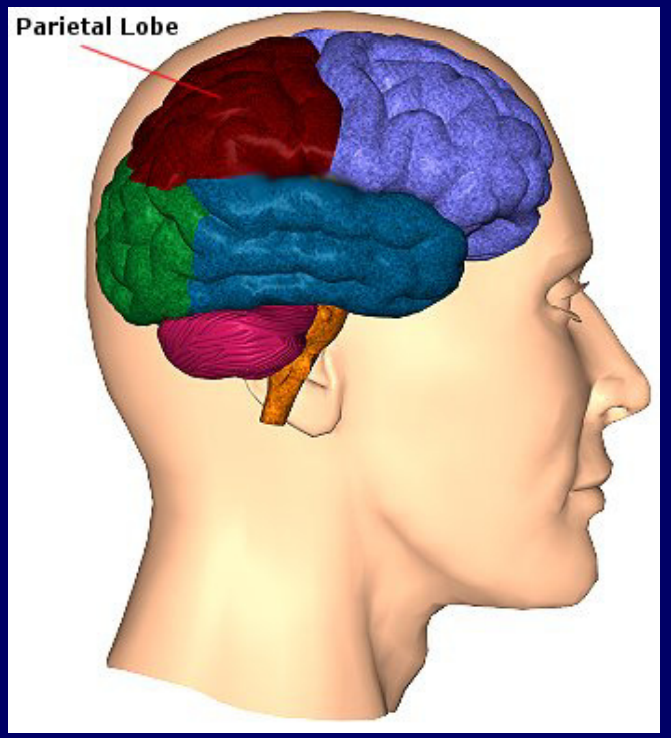
The Brain: frontal lobe

- Cognition and memory
- Ability to concentrate and attend, elaboration of thought.
- Personality and emotional traits.



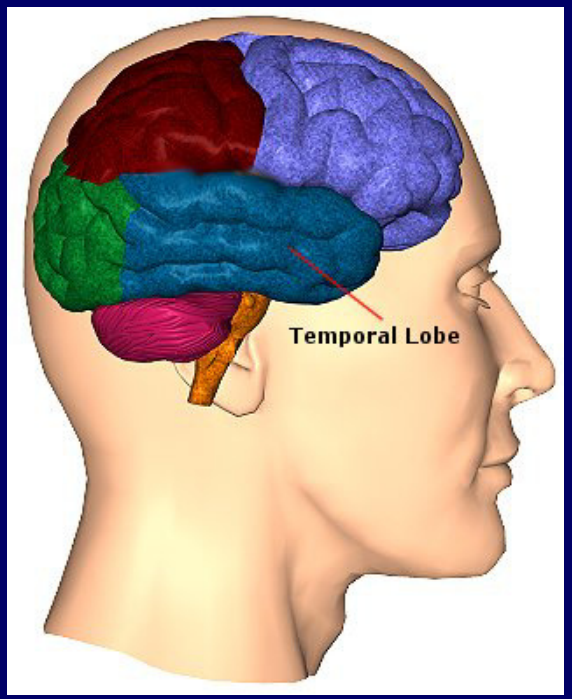
The Brain: parietal lobe

- Processing of sensory input, sensory discrimination.
- Body orientation.



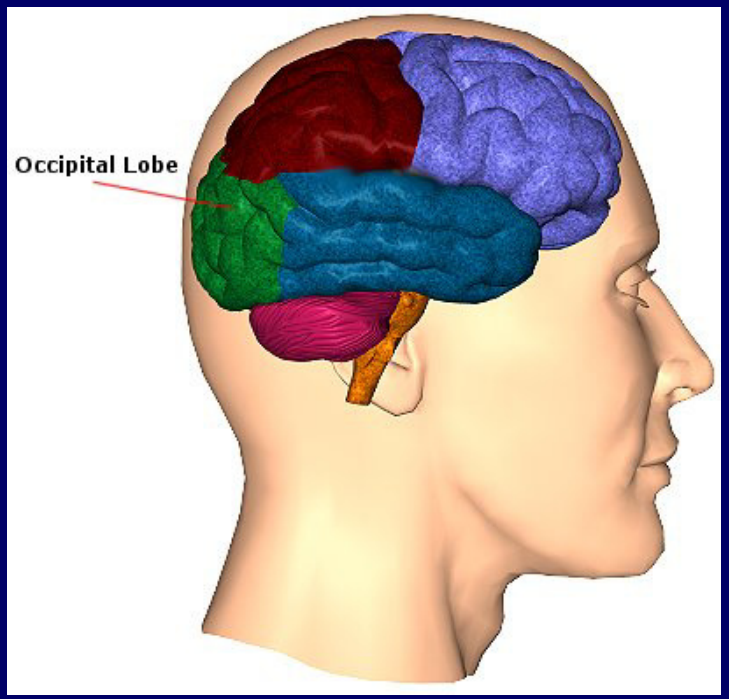
The Brain: temporal lobe

- Auditory receptive area and association areas.
- Expressed behavior.
- Language: Receptive speech.
- Memory: Information retrieval.



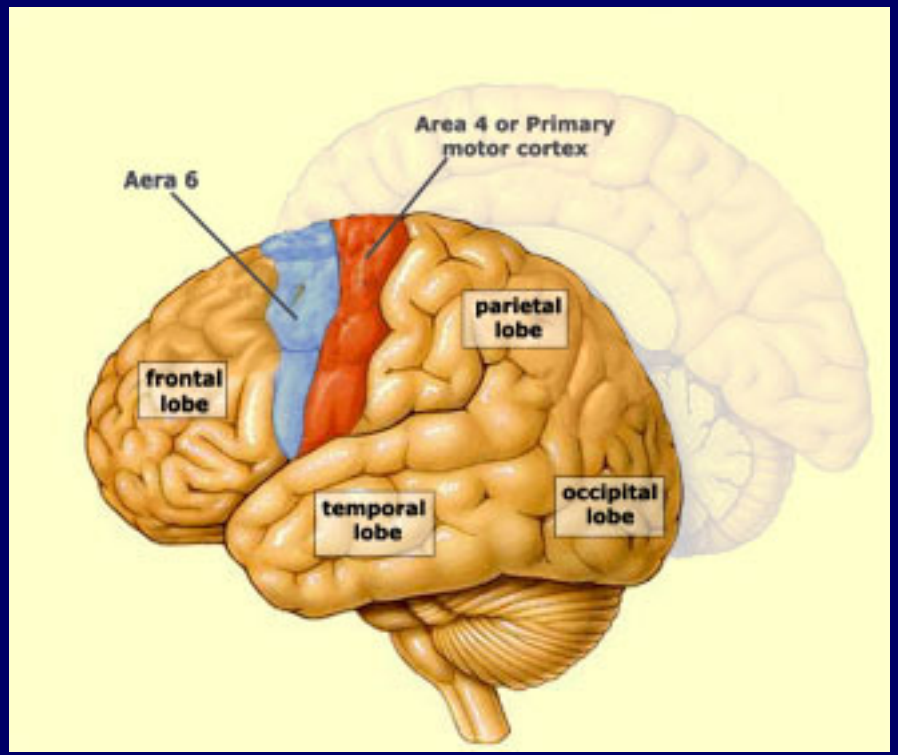
The Brain: occipital lobe

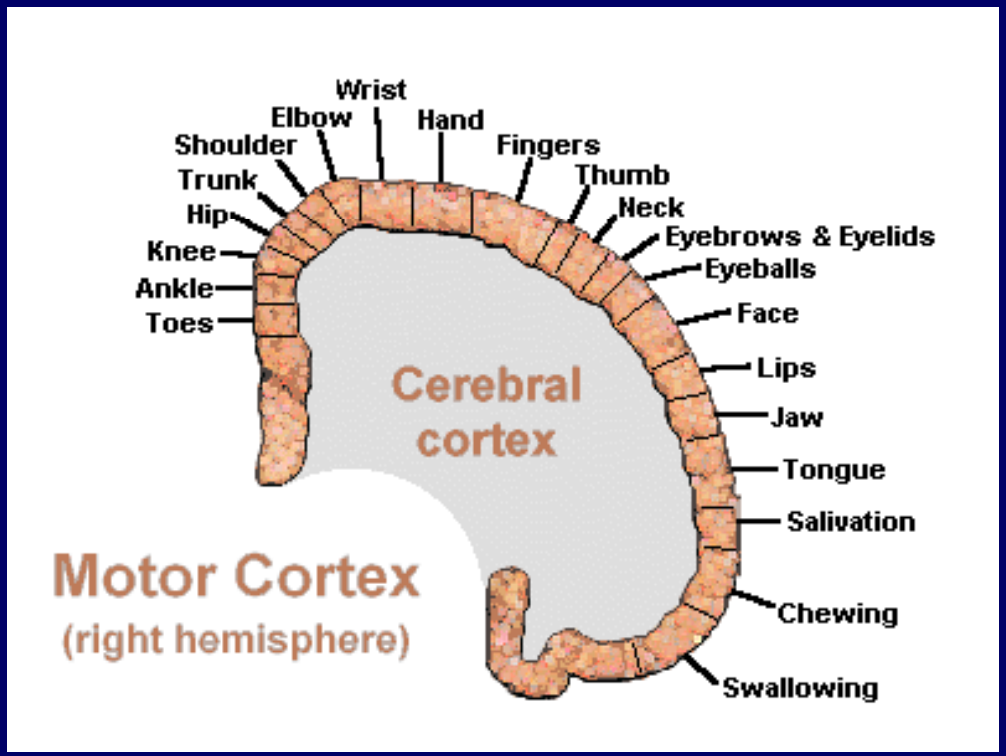
- Primary visual reception area.
- Primary visual association area:
  allows for visual interpretation.



The Brain: motor cortex

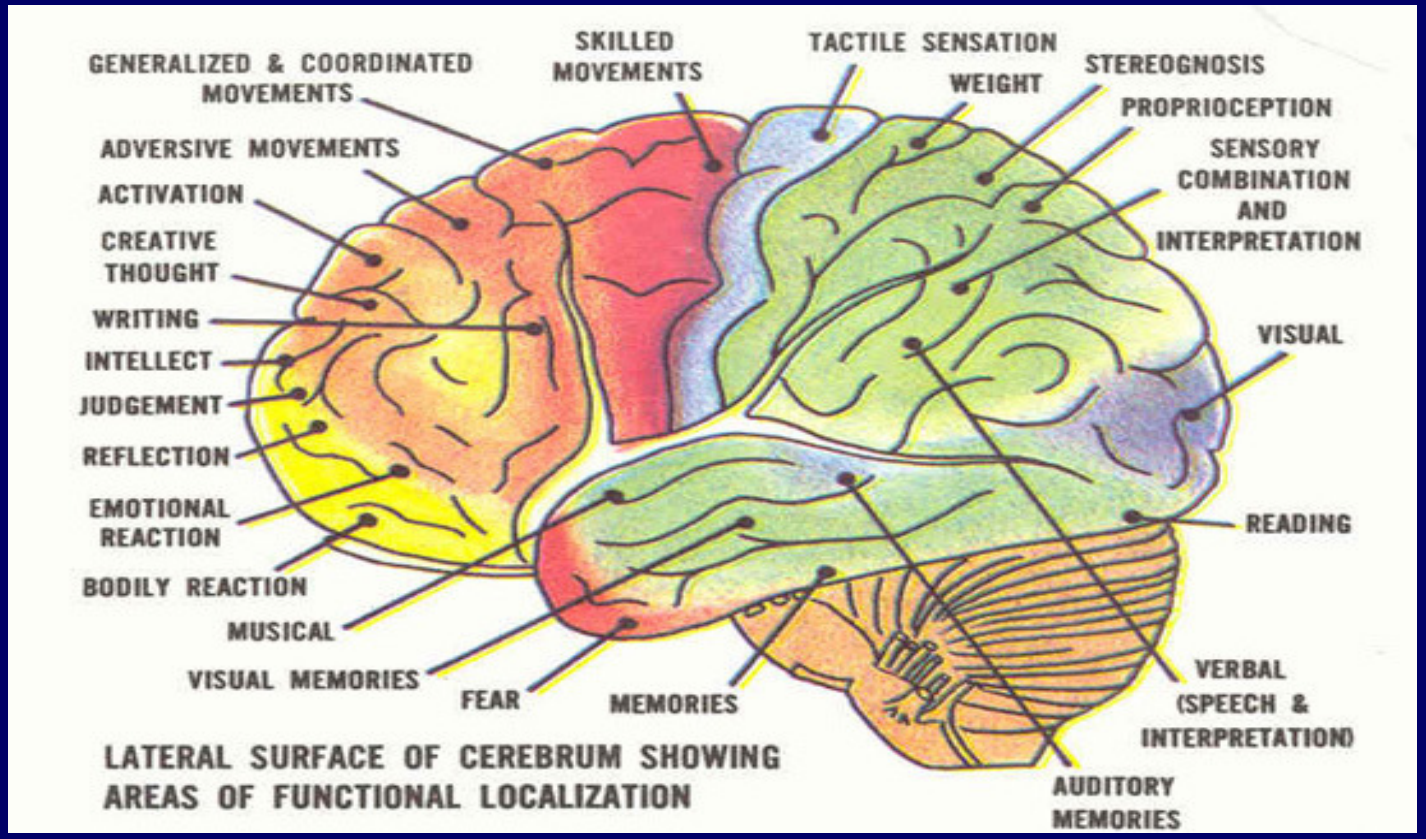
- Where all the actions start

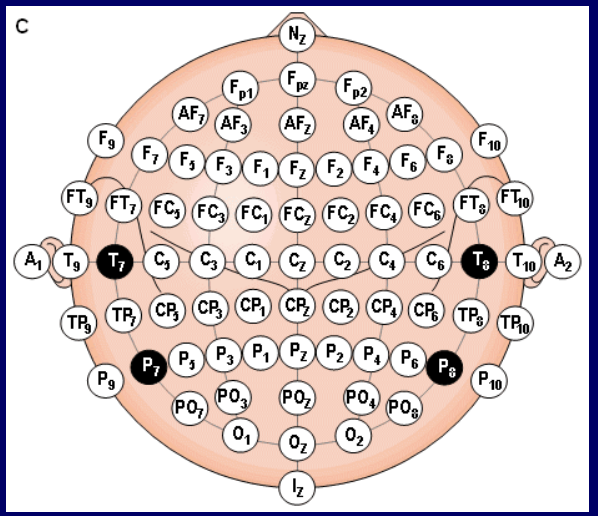




The Brain: specialization

- Functional specialization suggests that different areas in the brain are specialized for different functions.





10/20 montage: standardized locations

References

- Course Textbook:
  - https://drive.google.com/open?id=1giiB5BFRW18Yo0-J_IZOCjixvNilbj8i

- Lecture 1 Videos:
  - https://drive.google.com/open?id=0B03SaNyIsL_2YlJFRHlWSnlSaVU