Lecture 17: Learning & Memory

November 17, 2016

Outline

- What are memory and learning
- Types of memory
- How are memories formed
- Where in the brain is memory located
- How can memory be maintained and improved
- Alzheimer's Disease

What is Memory?

- **Memory** is our ability to encode, store, retain, and subsequently recall information and past experiences.

- It can be thought of in general terms as the use of past experience to affect or influence current behavior.

Memory vs Learning

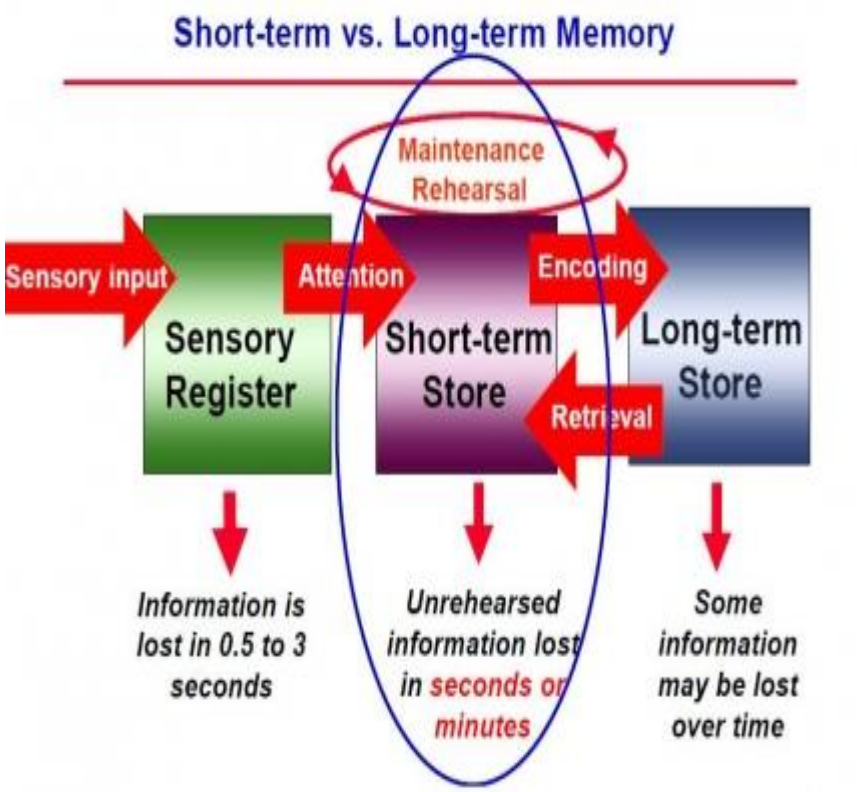
- Memory is related to but distinct from **learning**, which is the process by which we acquire knowledge of the world and modify our subsequent behavior.

- During learning, neurons that fire together to produce a particular experience are altered so that they have a tendency to fire together again.

Types of Memories in the Brain

- Long term vs short term (working) memory
- Declarative vs non-declarative
- Episodic vs factual
- Emotional memories
- Fear memories

Short-term vs. Long-term Memory



http://studydroid.com/printerFriendlyViewPack.php?packId=334821

- Sensory information is quickly lost
- Short term memory can hold about 7 items for about 20-30 seconds
- Strategies to help with memory
- Important information is gradually transferred to long term memory

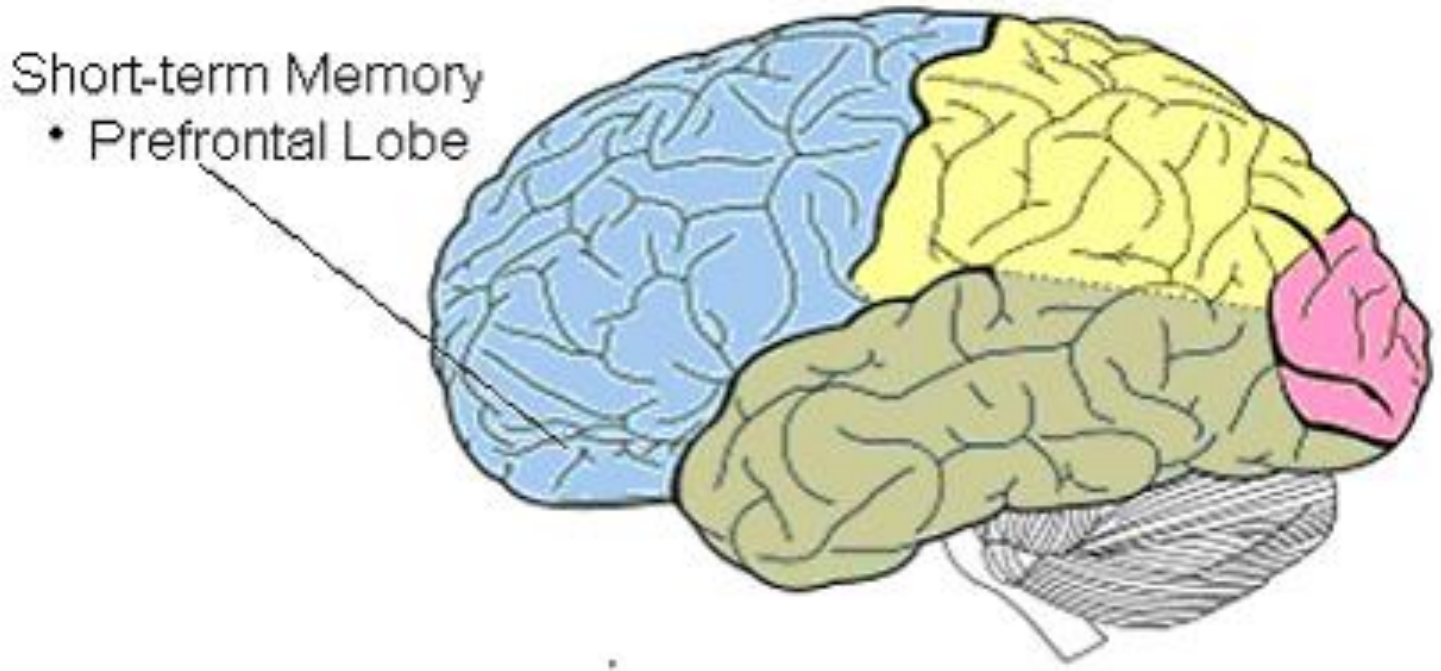
Sensory & Short-term Memory

- **Sensory memory** corresponds approximately to the initial 200–500 milliseconds after an item is perceived

- **Short-term memory**
  - allows recall for a period of several seconds to a minute without rehearsal.
  - Limited capacity
  - Can store 4–5 items
  - Can be increased through a process called chunking For example, in recalling a ten-digit telephone number a person could chunk the digits into three groups (the area code, then a three-digit chunk, and lastly a four-digit chunk)

Short Term Memory

- The ability to maintain information temporarily over periods of seconds



Long-Term Memory

- Long-term memory can store much larger quantities of information for potentially unlimited duration (sometimes a whole life span)
- Its capacity is immeasurably large
- Maintained by more stable and permanent changes in neural connections widely spread throughout the brain
- The hippocampus is essential (for learning new information) to the consolidation of information from short-term to long-term memory, although it does not seem to store information itself
- Hippocampus may be involved in changing neural connections for a period of three months or more after the initial learning

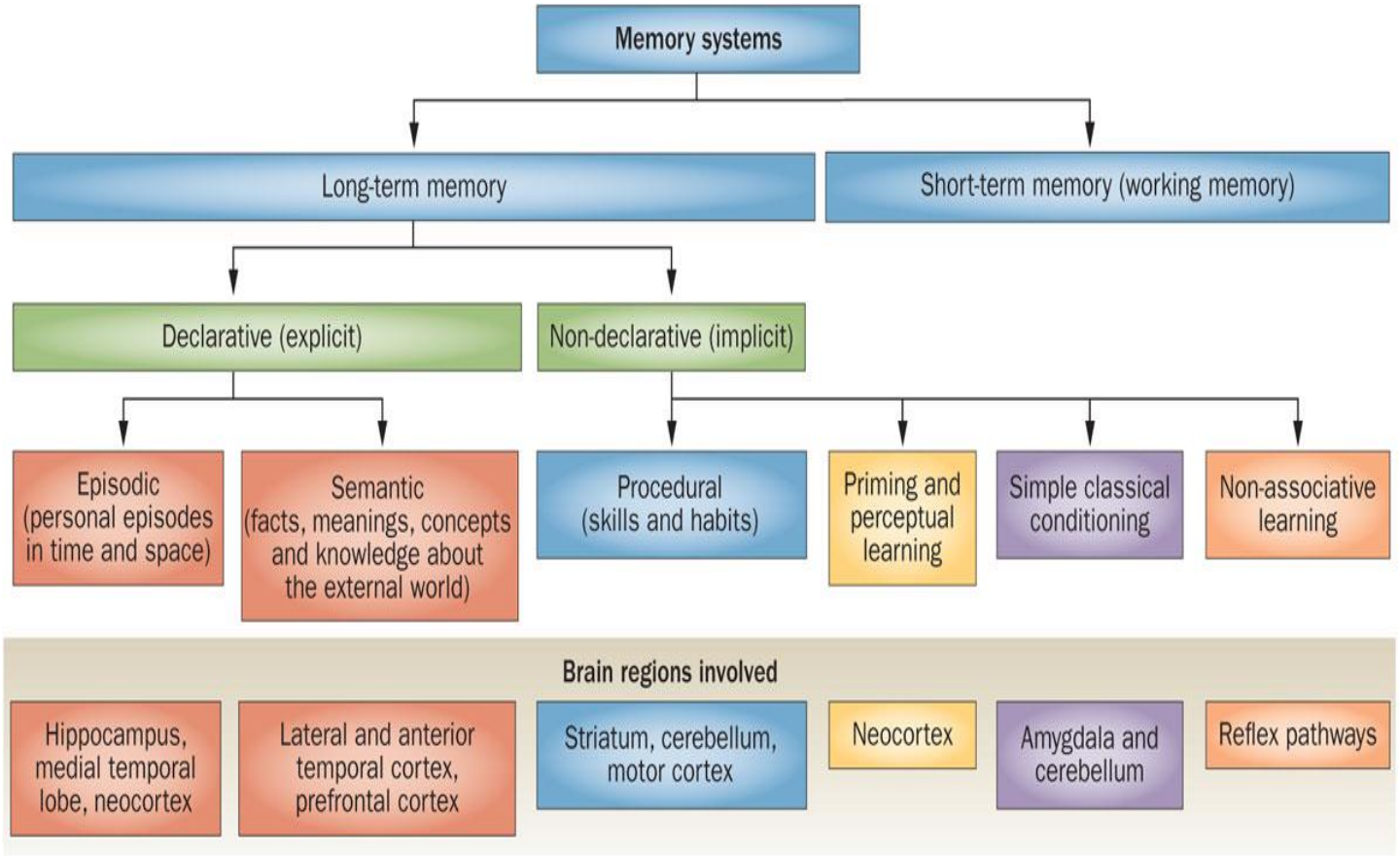
Long-term Memories

- Many types of memories, multiple brain systems for memory

1. Cognitive/Declarative memory – explicit, facts and events
    a. Information that is stored and retrieved
    b. Memories that can be consciously recalled
    c. Example, history lesson, facts, dates

2. Non-declarative – implicit, skills, habits, emotional, skeletal
    a. Does not require conscious thought to recall
    b. Procedural memory
    c. Example, driving a car, tying your shoe

Figure 1 Classification of memory systems in the human brain



Bartsch, T. & Butler, C. (2013) Transient amnesic syndromes
Nat. Rev. Neurol. doi:10.1038/nrneurol.2012.264

Types of Memories (Priming)

- Priming = Implicit memory effect where exposure to a stimulus influences the response to a later stimulus

- Example: Read the following words:
  - Night, moon, sleep

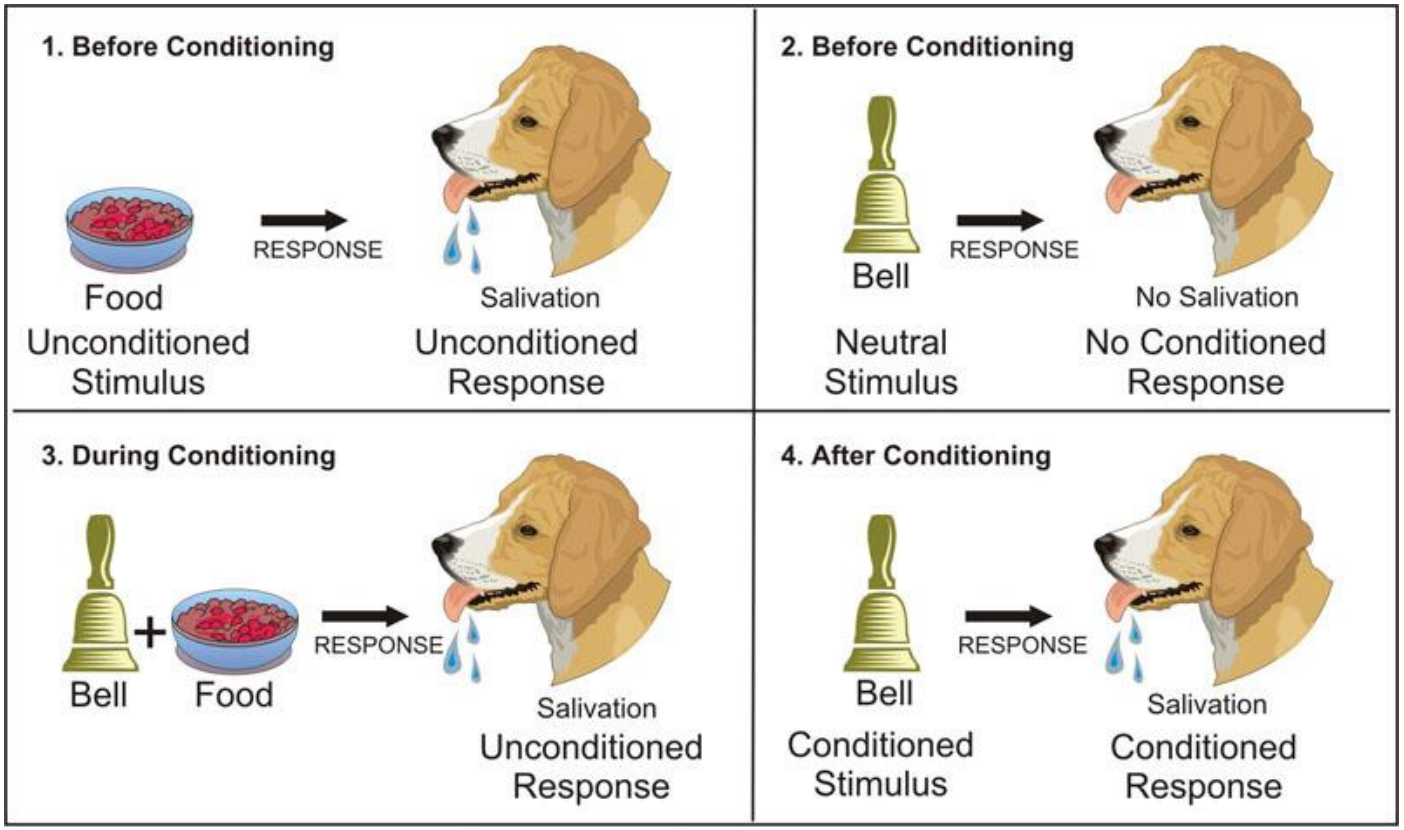
- What is the following word:
  - D_ _ k

Types of Memory (Perceptual Learning)

- **Perceptual learning**, process by which the ability of sensory systems to respond to stimuli is improved through experience.

- Example: A radiologist who looks at brain images everyday would be more likely to distinguish a tumor in the tissue than someone who is less familiar with the images.

Types of Memory (Classical Conditioning)



Classical Conditioning

https://www.emaze.com/@AOWOOOQZ/Classical-Conditioning-

Types of Memory (Non-associative Learning)

- **Non-associative learning** refers to "a relatively permanent change in the strength of response to a single stimulus due to repeated exposure to that stimulus".
- Habituation or desensitization
- Example: Exposure to a loud noise repeatedly may no longer cause a startle response

The Case of HM

- HM video

Forming Memories

- How do we create long-term memories, and where do we store them?
- One of the primary functions of sleep is thought to be improving consolidation of information, as several studies have demonstrated that memory depends on getting sufficient sleep between training and test.
- Data obtained from neuroimaging studies have shown activation patterns in the sleeping brain which mirror those recorded during the learning of tasks from the previous day, suggesting that new memories may be solidified through such rehearsal.

Synaptic Plasticity

- The ability of neurons to change their synaptic connections over time
- These connections can strengthen or weaken
- Connections are changed by increasing or decreasing the quantity of neurotransmitter in the synapse
- The adaption of neurons due to learning and memory is called Hebbian Theory (Donald Hebb, 1949)

Long-Term Potentiation and Depression

- Forms of synaptic plasticity (changes in the brain that support learning and memory)
- **Long-term potentiation** (LTP) is a persistent strengthening of synapses based on recent patterns of activity.
- Long–term depression (LTP) is an activity-dependent reduction in the efficacy of neuronal synapses lasting hours or longer following a **long** patterned stimulus.

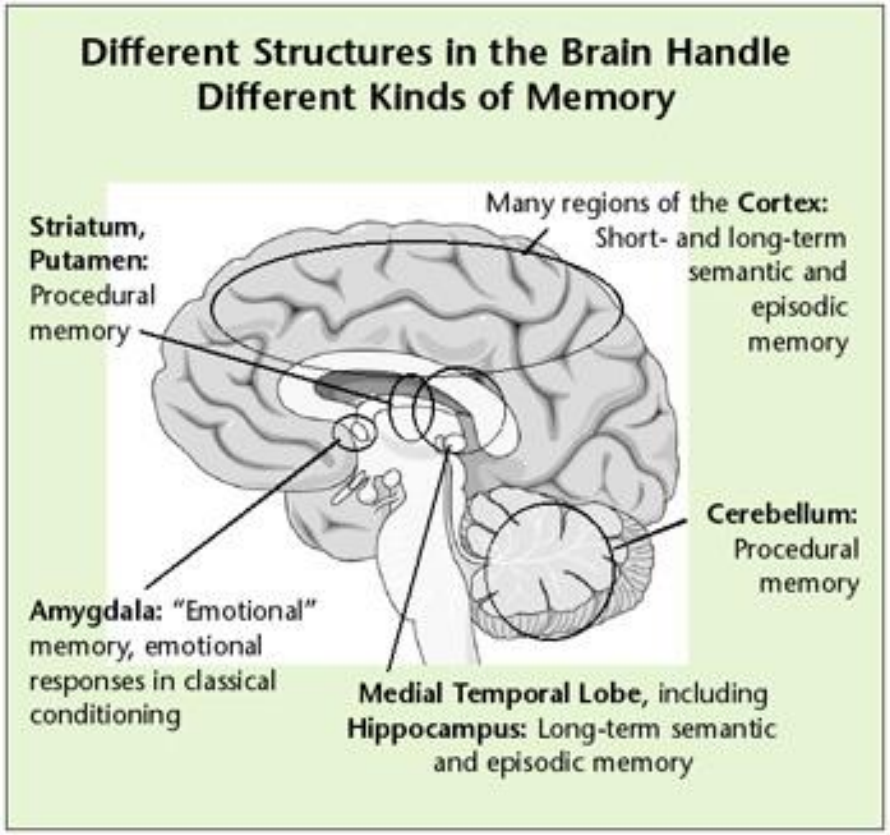
https://en.wikipedia.org/wiki/Long-term_potentiation
https://en.wikipedia.org/wiki/Long-term_depression

Where is Memory?

- Hippocampus – major part of the brain involved in declarative memory
- Memories are not stored here
- Memories are distributed throughout the brain
- Location depends on the type of memory

http://neuroscience.uth.tmc.edu/s4/chapter07.html

Memory Location Depends on Type



https://appsychologybhs.wikispaces.com/memory

Improving Memory (5 simple techniques)

1. **Chunking**

   Organize the material as meaningfully as you can and think out relationships among each group. This not only improves learnability and retention but also aids in faster and effortless recollection.

- Limit chunks to include 5 to 9 items. (short-term memory capacity)

- Example: The list apple, cucumber, paper, ink, cabbage, banana, grapes, beans, stapler, orange can be better learned by rearranging and applying chunking as:
  - Apple, banana, grapes, orange, cucumber, cabbage, beans, paper, ink, stapler
  - 4 fruits, 3 vegetables and 3 stationary items.

Improving Memory (continued)

2. Rhyming

- One of the most popular and oldest methods in memorization. This technique makes use of the fact that we have a natural tendency to remember rhymes and rhythms.

- *"Thirty days hath September; April, June, and November; Once short February's done'; All the rest have thirty-one"*

Improving Memory (continued)

3. Mediation/Bridging

- In this method, a bridge is built in between the items given to be memorized. This technique is best suited for learning material involving word pairs or material that can be reduced to word pairs.
- An example often cited by memory experts is the learning of the capital of Poland. The capital of Poland is Warsaw. World War II started with Germany's attack on Poland. Thus it may be arranged as Poland SAW War first.

Improving Memory (Continued)

4. Bed-time Recital

- In this technique, you do your recital or rote learning just before going to bed. The mind in the process of sleeping would then arrange the information in a systematic and effective way when you are sleeping. Psychologists have also found that if you sleep after thinking about your problems there is a better chance that you arrive at a solution the next day.
- *Steps for Memory Improvement*
  - Be in a relaxed mood
  - Write down the things that you are supposed to remember in a piece of paper.
  - Read it aloud (if possible) once or twice and recite it two to three times.
  - Now go to sleep without worrying or thinking about anything.
  - You will surely retain the item longer and find it more easy to recall it when in need.

Improving Memory (continued)

4. Trying by Not Trying

- All of us apply this method knowingly or unknowingly. Sometimes when you try to recall you may not be able to recall it at that time even if you are sure that you know it very well. You experience a blocking that prevents you from recalling it. Normally you tend to try again and again but in vain.
- To handle this situation you just keep away from trying to recollect it and do something else
- To your pleasant surprise that information automatically pops up into your mind after some time.
- This is because even if you stopped trying, the mind is searching for that information and brings it to awareness when it is found.
- Sometimes the information was blocked when you wanted, and mind brings it forward when the blocking is removed. This is where stress plays its role in hindering recall.

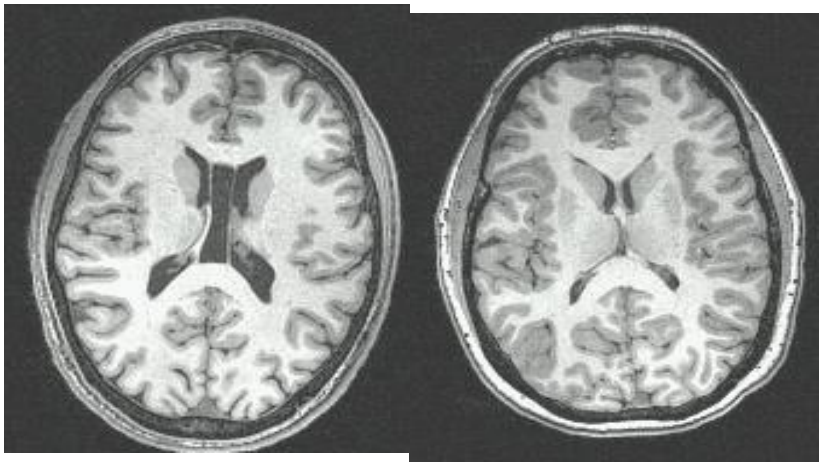
Alzheimer’s Disease

- **Alzheimer's is a brain disease that causes problems with memory, thinking and behavior.**

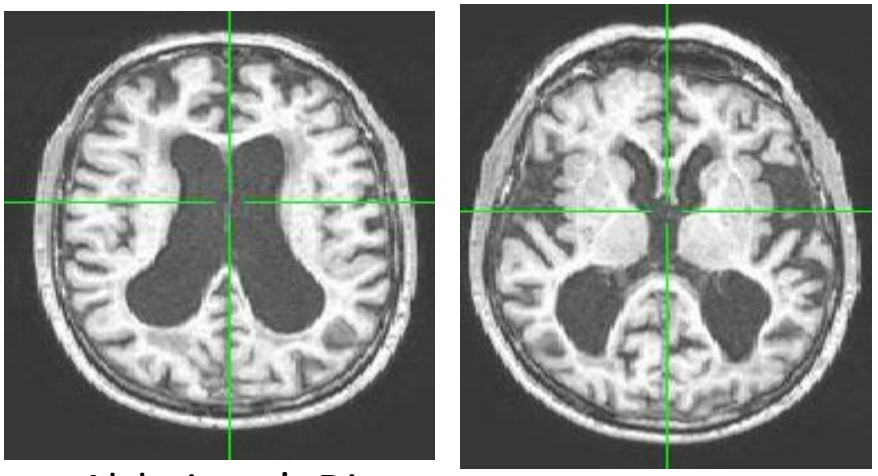
- Most common form of dementia
- Not a part of normal aging
- Worsens over time
- Has no cure, research continues

Alzheimer's Disease

- Characterized by loss of neurons and synapses in the cerebral cortex and certain subcortical regions.
- This loss results in gross atrophy of the affected regions, including degeneration in the temporal lobe and parietal lobe, and parts of the frontal cortex and cingulate gyrus



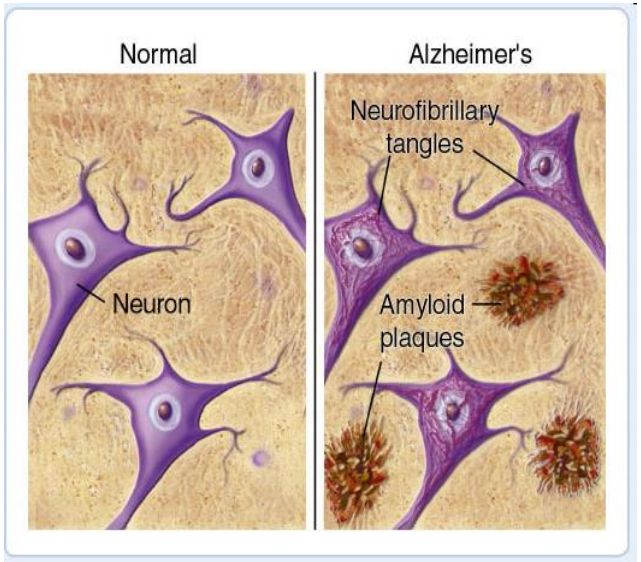
Normal

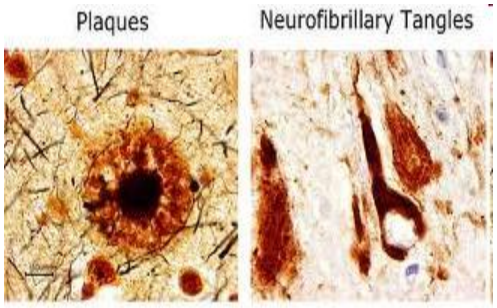


Alzheimer's Disease

Alzheimer's Disease

- Both amyloid plaques and neurofibrillary tangles are clearly visible by microscopy in brains of those afflicted by AD
- Plaques are dense, mostly insoluble deposits of amyloid-beta peptide and cellular material outside and around neurons
- Tangles (neurofibrillary tangles) are aggregates of the microtubule-associated protein tau which has become hyperphosphorylated and accumulate inside the cells themselves





http://www.alz.org/alzheimers_disease_4719.asp