

# *The Physiology of Memory*

**Craig E. Geis, M.B.A., Management; M.S. Psychology**

1831 Quail Court

Saint Helena, CA 94574

Phone: 707-968-5109

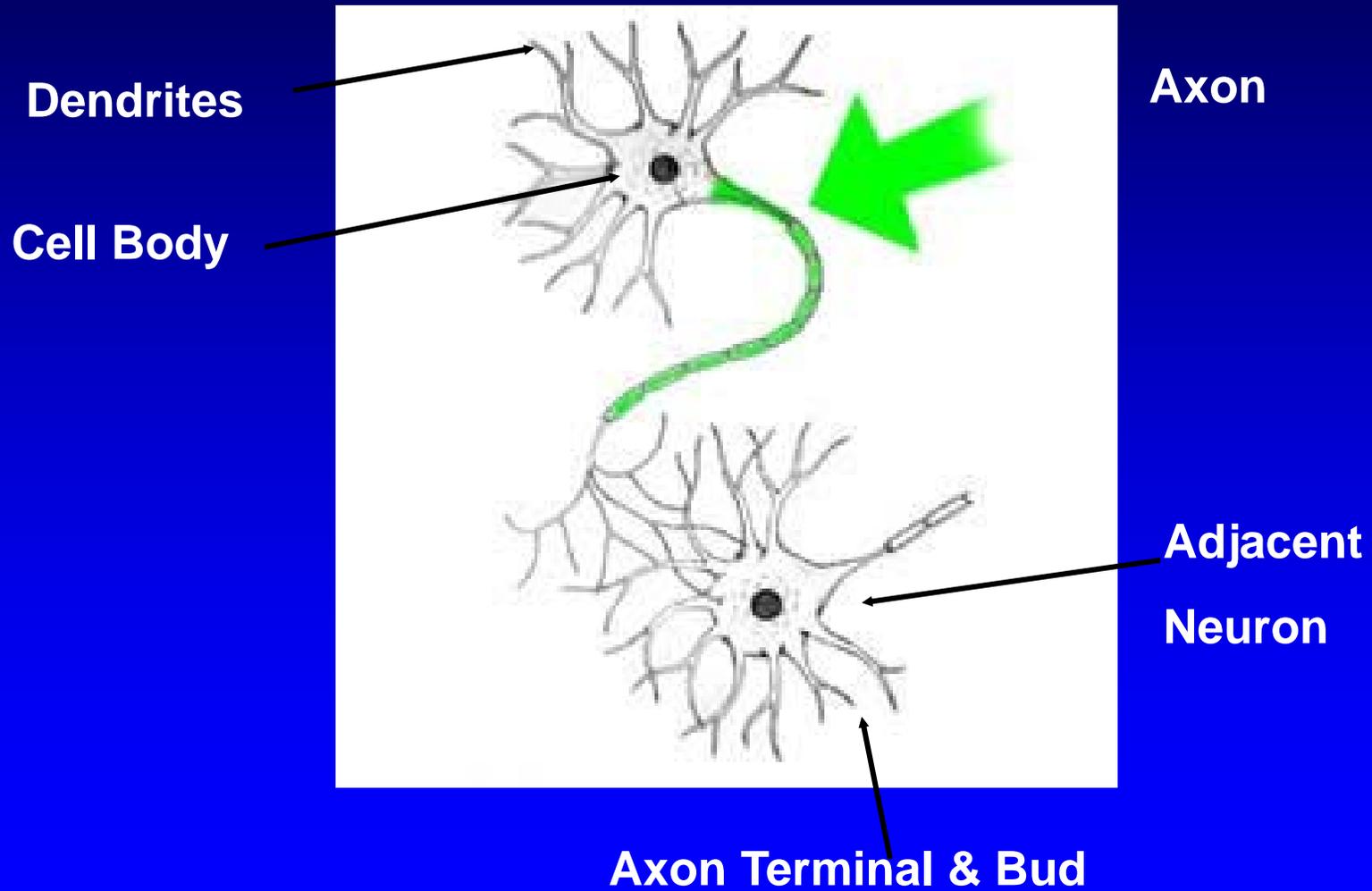
[craiggeis@cti-home.com](mailto:craiggeis@cti-home.com)



# *Physiology of Memory*

- ❖ Neurons are the basic means of information transfer within the nervous system
- ❖ Information in the form of a stimulus is detected by a specific type of neuron (sensory neuron).
- ❖ The information is then passed to an adjacent neuron (interconnecting neuron) and so on till it gets to where it's going in the brain
- ❖ It is an electro-chemical process that allows this to happen

# Structure of A Neuron



# *Types of Neurons*

- ❖ Sensory Neurons: These detect the stimulus from each of the senses and communicate the information to the interconnecting neurons.
- ❖ Interconnecting Neurons: These transfer information throughout the nervous system and also connect to the motor neurons.
- ❖ Motor Neurons: These connect to and activate muscle tissue.

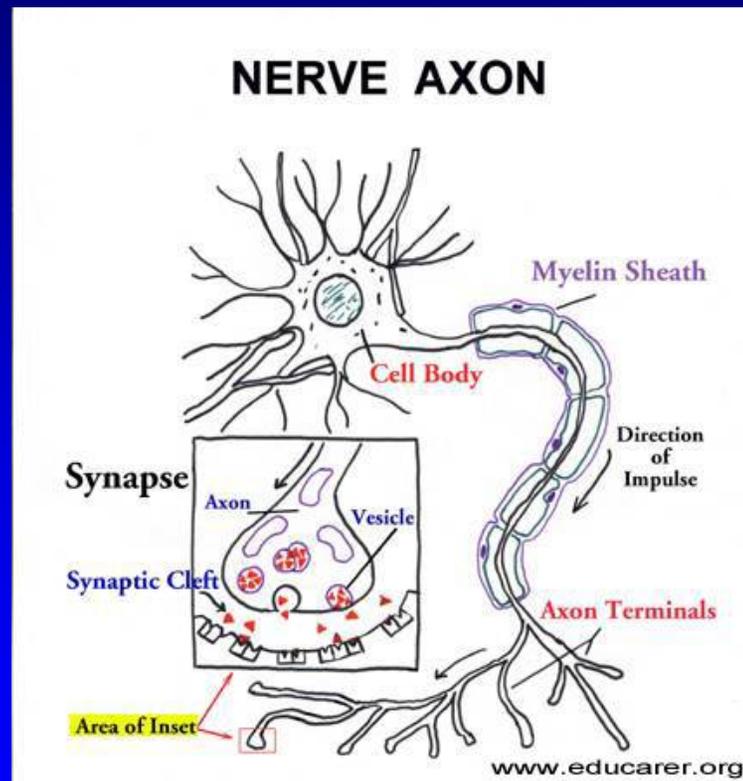
# ***How Information Is Moved***

- ❖ All stimulus or nerve messages are picked up by the dendrites protruding from the cell body.
- ❖ When the stimulus is strong enough, the cell body fires an electrical impulse.
- ❖ An electrical impulse travels down the axon or “outgoing branch”. Then the axon terminals and buds at the end are stimulated to release chemicals called neurotransmitters (tiny molecules that send specific messages).

# ***How Information Is Moved***

- ❖ Neurotransmitters are chemicals that are used to relay, amplify and modulate signals between a neuron and another cell.
- ❖ The dendrites or “incoming branches” of other neurons pick up these chemicals as they cross the synapse.
- ❖ The synapse is the space between the buds of one neuron and dendrites of the adjacent neuron.
- ❖ What it comes down to is brain cells, or neurons, communicating with each other through electro-chemical pathways.

***Here is another picture of a neuron showing the transfer of neurotransmitters at the synapse***

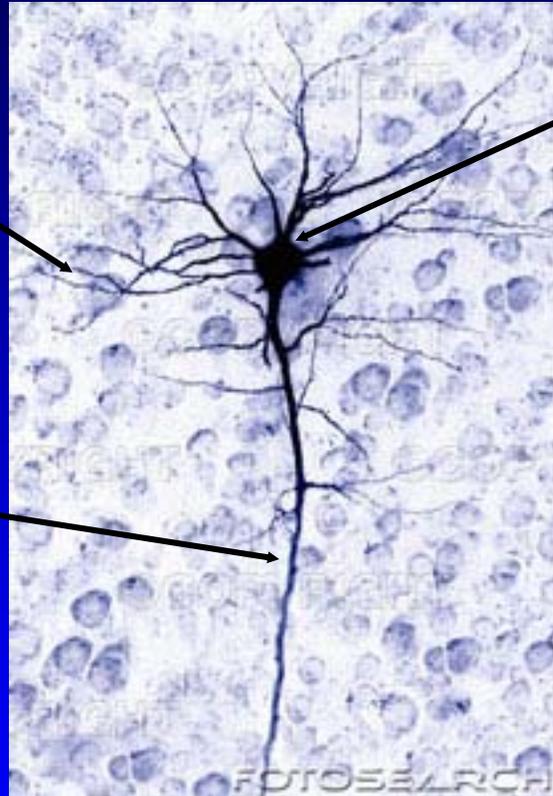


# *Actual Neuron*

Dendrites

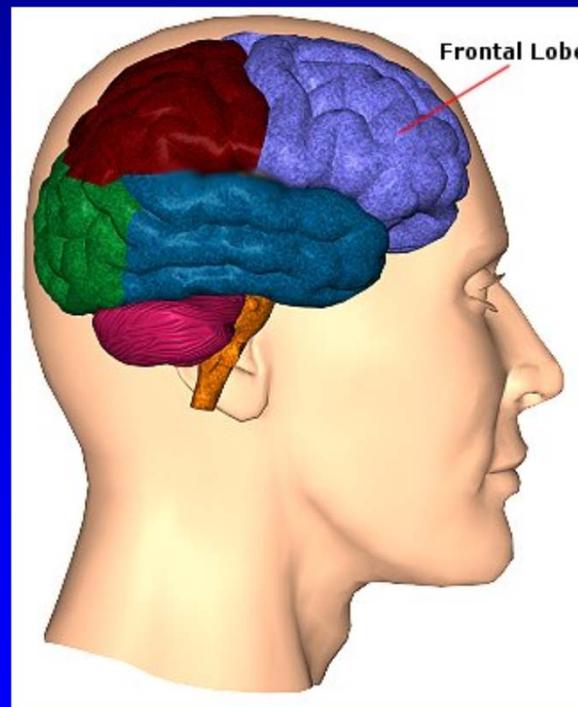
Cell Body

Axon



# *Following the Pathway*

Most nerve messages from the senses are first routed to the frontal lobe of the brain).



# *Types of Storage*

- ❖ Neurologists divide memory into sensory storage, short-term memory, or "working" memory, and long-term memory.

# *Sensory Storage*

- ❖ In the sensory storage the stimulus is held for a fraction of a second.
- ❖ If the information has some meaning it will be moved to short-term memory.
- ❖ If it has no importance it will be dumped.

# *Short-Term Memory*

- ❖ Short-term memory (STM) is the brain's system for remembering information in use.
- ❖ Most people can only hold five to nine items in their short-term memory at one time. If they try to remember more than that, they will often end up forgetting the middle items.
- ❖ Unless an individual pays attention to encode the stimulus into short-term memory, it will be lost.
- ❖ The memory is stored on something akin to an electronic tape loop. Once a complete loop is made, three things can happen:

# *Shot-Term Memory*

1. The information can be "rehearsed" (repeated) silently or aloud, which will provide auditory cues and the tape loop continues. This will keep the information in short-term memory.
2. The information can be transferred into long-term memory.
3. The information can be lost.

Research has shown that short-term memory involves chemical modifications that strengthen existing connections, called synapses, between neurons.

# *Long-Term Memory*

- ◆ In the past, it was thought that all memory was stored in the cerebral cortex of the brain. We have now learned that long-term memories are stored in multiple regions throughout the nervous system. (In other words, they are not localized but stored through circuitry).

# *Long-Term Memory*

- ◆ Research has also shown that some memory is stored throughout the body. So every thought you have is “felt” throughout your entire body because the receptors for the chemicals in your brain are found on the surfaces of cells throughout your body.
- ◆ Thus when the chemicals are activated across synapses in the brain, the message is communicated to every part of your body by chemotaxis, a process that allows cells to communicate by “neurotransmitters” or remote travel using blood and cerebrospinal fluid.

# *Long-Term Memory*

- ◆ Research has shown that some memory may even be stored in muscle tissue.
- ◆ This became evident with organ transplants. People who have received donor organs have reported experiencing cravings or emotional reactions to certain incidents that they never had before.

# ***Primary Storage Area***

The cerebral cortex is the primary area of storage in the brain. The cerebral cortex is often referred to as gray matter and covers the outer portion (1.5mm to 5mm) of the brain.



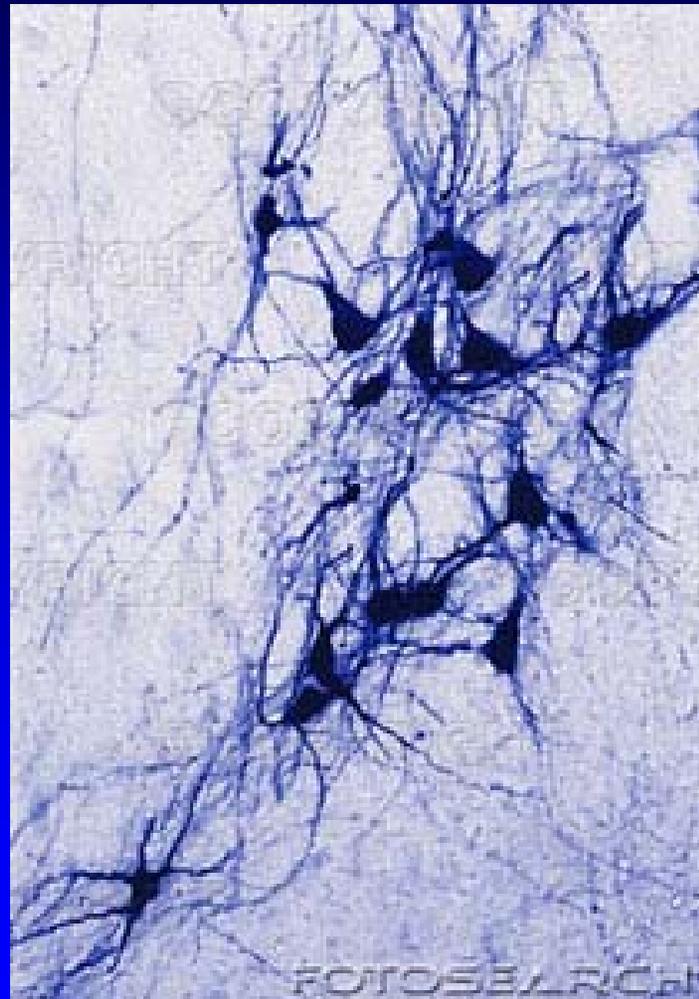
# *Getting Learning To Stick*

- ❖ For learning to “stick”, the synapses need time to “gel” (create new connections and synapses). If the synapse doesn’t “gel” then recreating the event (recalling the memory) is difficult, if not impossible.

# *The Memory Process*

- ❖ Simply put, memories are stored in subgroups of neurons that are activated in response to various sensory experiences.
- ❖ The interconnections which are formed are subject to continual change. If you look at the next slide you will see a group of neurons. This is what takes place as learning occurs. You can see the neurons start to line up and new connections are formed.
- ❖ The storage of information in LTM is a function of new interconnections and synapses and the production of new protein molecules.

# *Memory Bundle*



# *Implications*

- ❖ Training leads to denser dendrite growth. This is important because we now know that areas of the brain continue to produce new neurons even as we age.
- ❖ If we have to learn a new, similar task, we have to overcome the memory bundle and create a new one that is stronger or think before we act.

# *Implications*

- ❖ Recent studies have found patterns of neural activity during sleep that is identical to those seen when learning a new task. It is believed that this aids in the consolidation and storage of memory. Adequate sleep is important to memory.

# *Implications*

- ❖ Excessive stress and obesity produce an over-production of a complex set of stress hormones called glucocorticoids (cortisol being one example). Over exposure to glucocorticoids damages and destroys neurons in the brain's hippocampus – a region critical to learning and memory.
- ❖ One really good way to burn off excess cortisol is through exercise. So for those experiencing particularly high stress levels exercise is not only beneficial, it is necessary.

# *Why Do We Forget?*

- ❖ This is a difficult and complicated area for researchers. I will try to point out the different theories and give you some personal thoughts.

# ***Decay Theory***

- ❖ A memory trace is created every time a new memory is formed. Decay theory suggests that over time, these memory traces begin to fade and disappear. If information is not retrieved and rehearsed, it will eventually be lost.
- ❖ Memories fade away rapidly when not reviewed or used. The curve of forgetting is like a playground slide; we forget most immediately after we learn - in the first 24 hours; then it proceeds slowly.

# *Decay Theory*

- ❖ Motor learning seems to be better retained than verbal learning because a motor act has to be completely done to be done at all and so requires a higher degree of organization and competency which involves over learning.

# *Personal Thoughts*

- ❖ One problem with this theory, however, is that research has demonstrated that some memories which have not been rehearsed or remembered are remarkably stable in long-term memory.
- ❖ When we don't use a connection or recall a memory the memory trace (connection) is weak. With some memories the initial memory trace (connection) was extremely strong for some reason. This could be due to motivation, association, importance, fun, emotion, etc. The initial strong trace makes it easier to remember even if we don't use it.

# *Personal Thoughts*

- ❖ Another reason is that under high stress (cortisol production) cortisol interferes with the retrieval of information from long-term memory. The synapses are blocked by the cortisol and make it difficult to find the right connections. This can delay our response or make it impossible to find until the stress declines.

# ***Interference Theory***

- ❖ **This suggests that some memories compete and interfere with other memories.**
- ❖ **When information is very similar to other information that was previously stored in memory, interference is more likely to occur. There are two basic types of interference: Proactive and retroactive**

# ***Proactive Interference***

- ❖ **Proactive interference is when an old memory makes it more difficult or impossible to remember a new memory.**
- ❖ **A task you have done for years makes it more difficult to make minor changes. This is also known as “habit capture.”**

# ***Retroactive Interference***

- ❖ **Retroactive interference is when a new memory makes it more difficult or impossible to remember an old memory.**
- ❖ **You learn your new phone number and forget your old one.**

# *Personal Thoughts*

- ❖ **There is more interference between two similar subjects, ideas, or tasks than between two that are unlike. (Follow the study of history with chemistry rather than English history with literature.)**

# ***Storage Failure***

- ❖ **We also forget information because it never actually made it into long-term memory. *Encoding failures* sometimes prevent part of the information from entering long-term memory.**
- ❖ **When we have to fill in the missing parts on retrieval we use assumptions and make mistakes**

# *Personal Thoughts*

- ❖ **Very often only information that is important is encoded. We don't encode a lot of the details and they are not stored in memory.**
- ❖ **Another reason is that under high stress (cortisol production) cortisol interferes with the transfer of information from short-term memory to long-term memory. The synapses are blocked by the cortisol and make it difficult to transfer the information.**

# *Personal Thoughts*

- ❖ **Try this test: Draw both sides of a penny from memory, and then compare your results to an actual penny.**
- ❖ **How well did you do? Chances are that you were able to remember the shape and color, but you probably forgot other minor details. The reason for this is that only details necessary for distinguishing pennies from other coins were encoded into your long-term memory.**

# ***Motivated Forgetting***

- ❖ **Sometimes, we may actively work to forget memories, especially those of traumatic or disturbing events or experiences.**
- ❖ **The two basic forms of motivated forgetting are:**
  - ◆ **Suppression, a conscious form of forgetting**
  - ◆ **Repression, an unconscious form of forgetting.**

# ***Why Do We Remember Negative Events***

- ❖ Whenever emotions are activated, especially strong emotions, the information or experience is entrenched into memory.
- ❖ Often times we tend to dwell on it, thereby rehearsing it and entrenching it even further.
- ❖ It is also easier to recall negative memories when we are in a bad mood. Why? Because we remember things in the state that we learned them so whenever you are feeling angry you will more easily recall other situations in which you were angry.

# ***Why We Forget***

- ❖ **It's complicated and it is probably a combination of all the theories we discussed.**
- ❖ **Enjoy your happy memories.**
- ❖ **Thank you to the student who asked about this subject.**