Learning about how people learn

Page 1: Why is it important to understand how learning works?

We are developing a new program for students. We would like to invite you to help improve it.

The goal of this program is to provide you with scientific knowledge about how human learning works in the brain and body, and how your body responds to various situations.

For example, did you know that:

- The brain has the capacity to change neuron connections with new experiences.
- One subpart of the brain, the hippocampus, is largely responsible for memories about facts, events, sensory information, and navigation. *Physiological reactions associated with emotions both influence and receive feedback from processes in the brain and body.

If we can learn from your experiences, we can teach these powerful ideas to more students more effectively in the future.

Why Did We Make This Program?

This program was developed by scientists at Stanford University and the University of Texas at Austin, building on the work of many other researchers. We developed this program because many students say the brain is a mystery and they don't know much about its anatomy, processes, or functions. Knowledge about the brain isn't always taught in school curriculums but it is important to know how the human brain works.

TEXAS

The University of Texas at Austin

The goal of this program is to equip students with the science behind how many human brain processes work. Doing so provides a strong foundation for understanding the relationship between the brain, body, and experiences.

But the program needs more feedback from Stanford students. After all, we're not the experts on what it's like to be students. You are. That's why the program needs your input.

In the activity below, we invite you to share one or two brain-related concepts or facts you already know, which we hope to learn from to improve this program next year.

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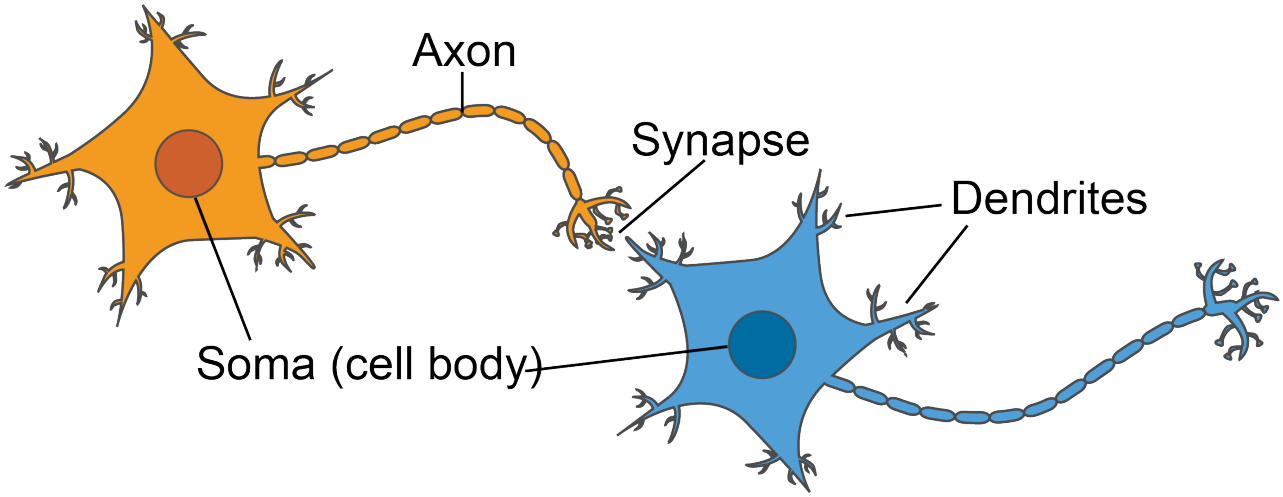
Page 2: What have scientists discovered about how learning works?

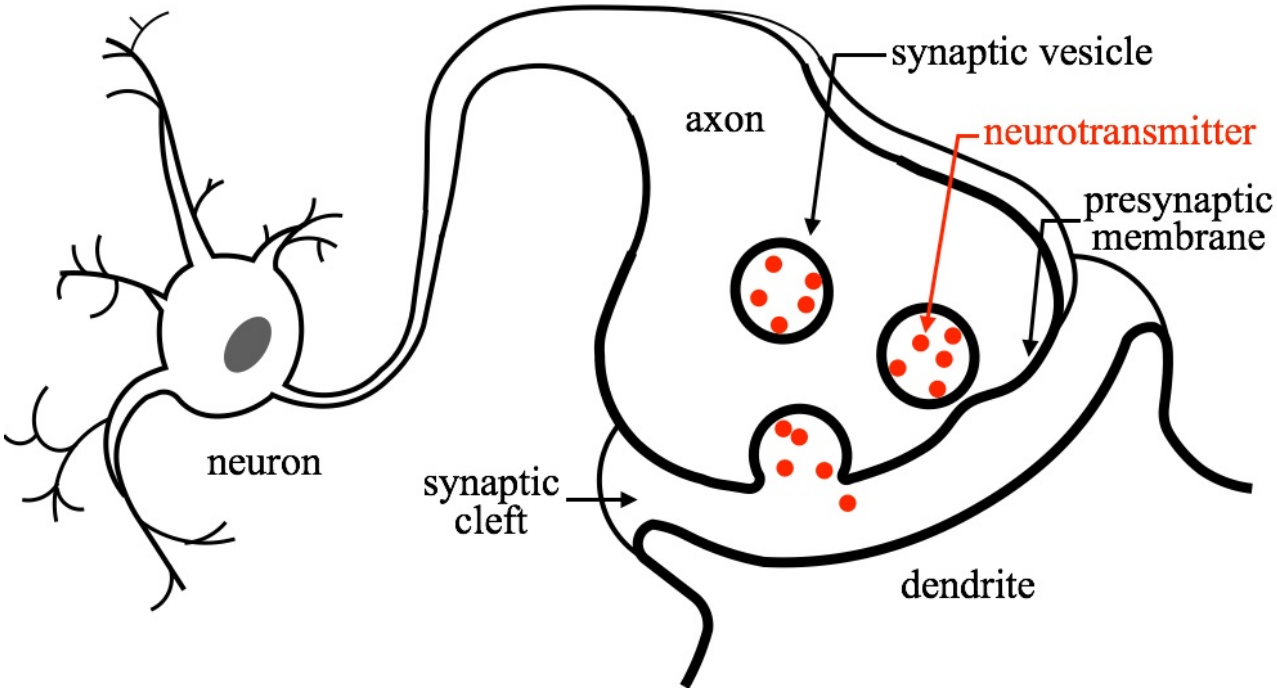
Neuroscience is the study of the brain

Neuroscience is the scientific study of how the brain works. Many neuroscientists study what happens in the brain while learning from new experiences.

Your brain has billions of tiny cells called neurons. A neuron has a cell body (soma), a long branch (axon), and tiny branches (dendrites). Signals are transmitted from the axon from one neuron to the dendrites of another neuron across a small gap (synapse).



To transmit information, neurons convert electrical to chemical signals. When an electric signal (action potential) arrives at the axon end of the synapse, it causes a packet of neurotransmitters (vesicle) to exit that neuron, diffuse across the synaptic gap (cleft), and bind to receptors on the dendrites of the other neuron. In the receiver neuron, the neurotransmitters may activate another electric signal – leading down a chain of action potentials – or they may prevent electric signals from being sent. In the long run, neurotransmitters impact many processes in the nervous system, including how learning and memory may be encoded, stored, or retrieved.



What happens in the brain when learning something new?

The brain's ability to change and adapt in response to experiences, known as neuroplasticity, is the foundation of learning and memory. This process involves strengthening some synaptic connections and weakening others and persists throughout a person’s lifetime.

Learning primarily occurs through changes in the strength and number of synaptic connections between neurons. Although it might seem natural to believe that individual neurons encode memory for specific experiences, a substantial body of evidence indicates that memories are instead stored in networks of connected neurons, and these networks can change over time in the face of new experiences.

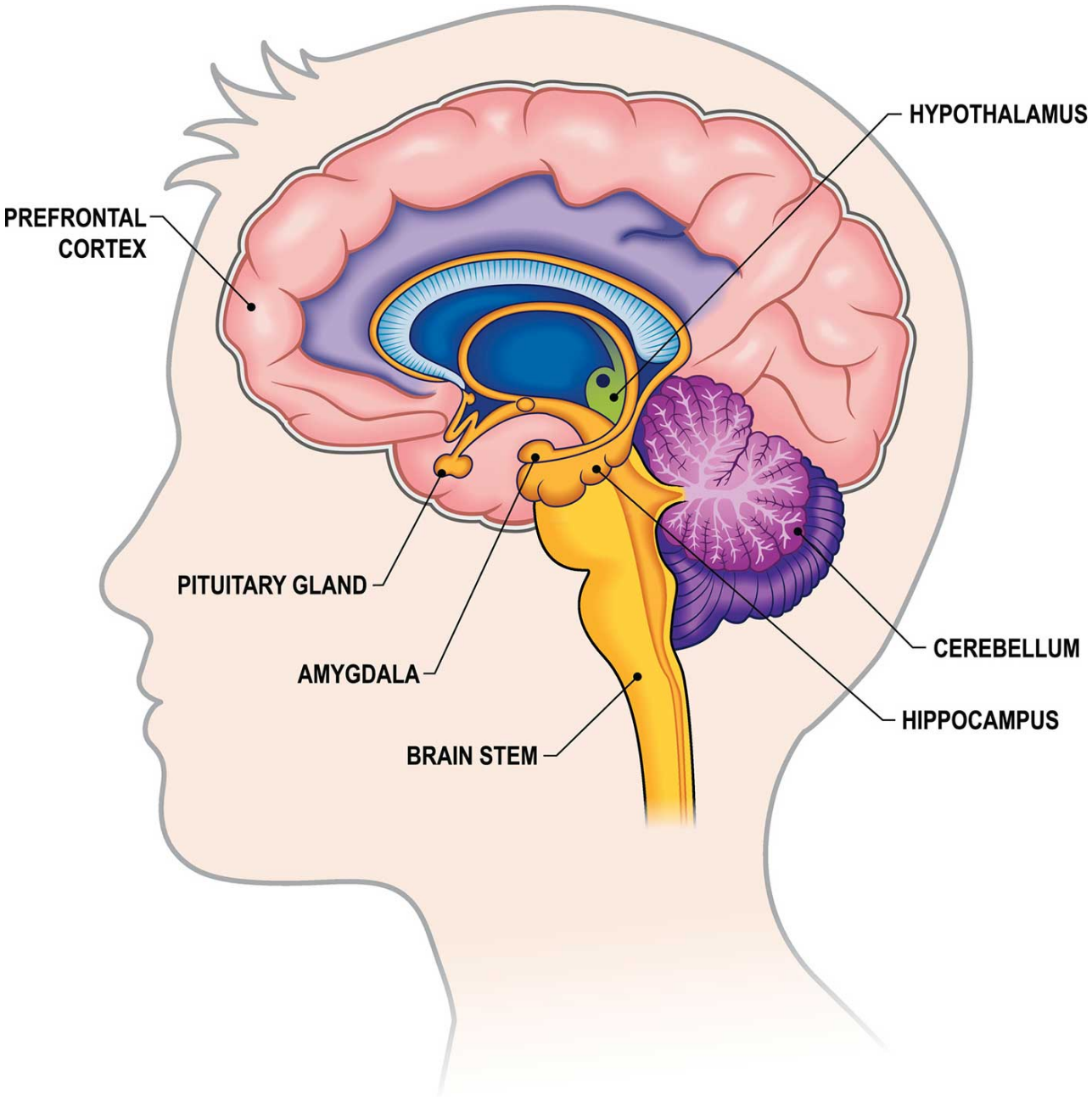
In particular, how these networks change can be influenced by many factors, including emotional states and environmental conditions. Neurotransmitters, chemicals that are involved in the communication between neurons, can be released in response to stressful stimuli and potentially enhance the encoding of memories by boosting activity in key brain regions and neurons involved in memory consolidation.

Where does learning occur?

Neurons are one of the fundamental building blocks of the brain. They work with other supporting cells (Glia) to make up larger structures of the brain (i.e. frontal cortex, temporal lobe) with specialized functions. Two of the key brain structures involved in the network for learning, memory, and neuroplasticity are the hippocampus and amygdala.

The hippocampus is essential for the formation, organization, and storage of new memories, particularly those related to facts and events. It replays networks of connected neurons to convert short-term memories into stable, long-term memories. The hippocampus also integrates some memories with sensory information so stored knowledge is linked to imagery, sounds, and smells. Another kind of memory information associated with the hippocampus is spatial memory – mental maps of environments important for navigation and other tasks.

The amygdala, located next to the hippocampus, processes emotional responses and assigns significance to memories associated with strong positive and negative emotions (e.g. stress, pleasure). This weighting of memories contributes to how strongly they are formed, stored, and recalled. The amygdala is linked with responses in the sympathetic nervous system, discussed more on the next page.



How do scientists study the brain?

Studying the brain can be challenging because it is difficult to directly access it and invasive techniques involving surgery are risky. In the past, one way scientists would understand processes in the brain was from the experiences of people with brain injuries. For example, injuries to the hippocampus may disrupt memory processes, leading to trouble storing new information and/or trouble recalling past events and familiar facts. Additionally, injuries in the amygdala can contribute to emotional and behavioral changes, difficulty recognizing certain emotions in others, and challenges with forming and recalling emotion-related memories.

There are now many new technologies to study the brain that are safer and more precise, including the fMRI scanner. fMRI scanners record brain activity, and scientists use them to study what happens in people's brains while they do different activities. For example, scientists might want to know which parts of the brain a person uses to learn and store information about the location of objects. First, a person will lie down in an fMRI scanner. The scientists will show the person videos of objects in a scene, then ask them to recall where they saw each object later. Some parts of the brain will be more active when the person is learning information while other parts might be more active when recalling information, revealing which brain regions are likely involved with the memory process.

Takeaways

In summary, neuroscientists study the brain using many methods and have found that learning and memory processes are grounded in the connections between neurons, especially within specific brain structures, as they change in response to new experiences.

Next, let's learn about how challenging experiences affect the body and brain.

What questions do you have about this topic?

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Page 3: What have scientists discovered about how the brain and body are connected in challenging situations?

Connections between the body and mind

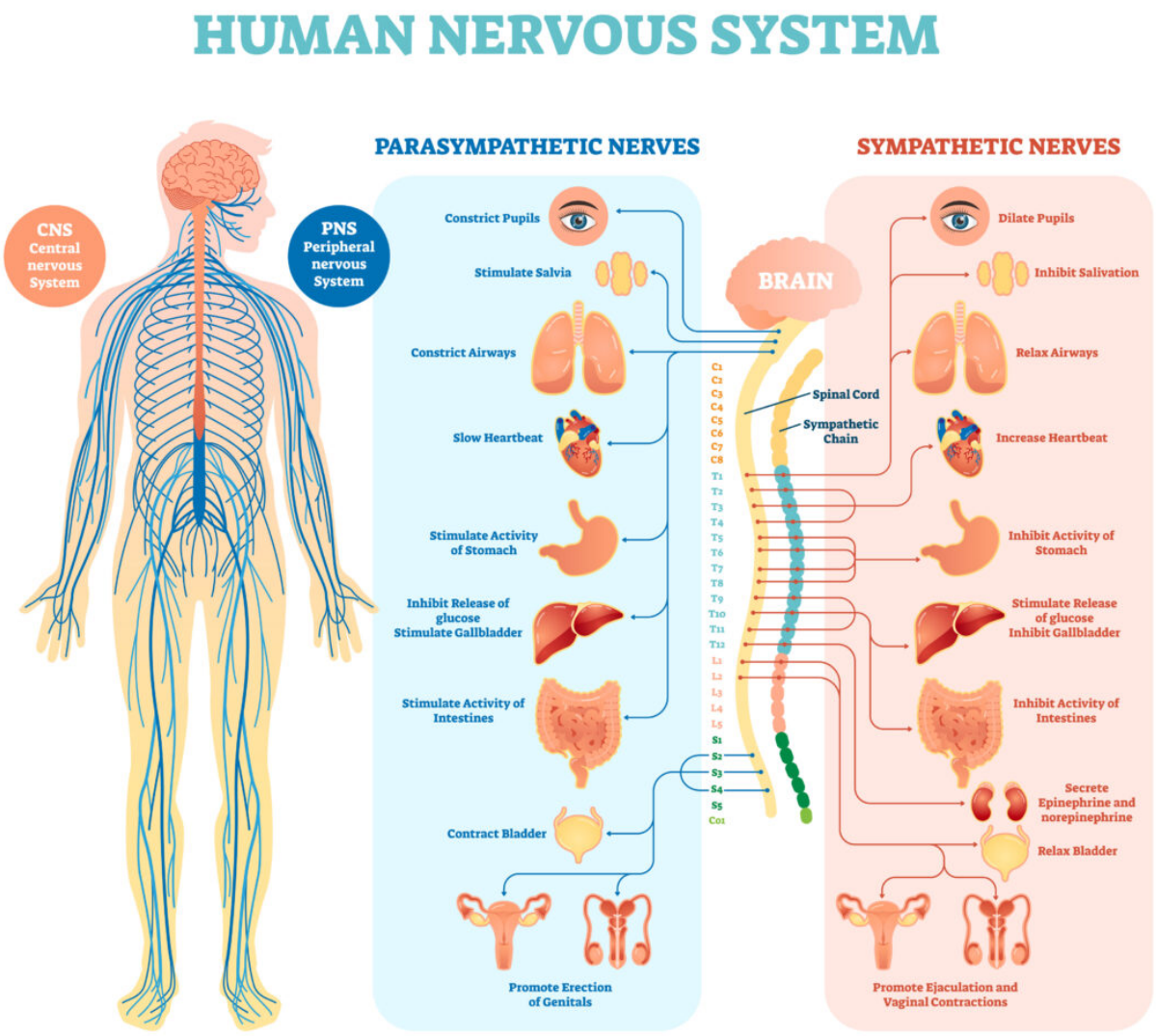
Your body has two main nervous system components: the parasympathetic and sympathetic nervous systems. They work together to support your body systems to respond to challenges and opportunities.In your body, there are two nervous subsystems working in concert as part of an overall nervous system: the parasympathetic nervous system and the sympathetic nervous system.

The parasympathetic nervous system is in charge of maintaining your body’s normal healthy

functioning—normal heart rate, breathing, and sweat to keep you cool.

The sympathetic nervous system is in charge of your body's automatic responses to unexpected stimuli. This system helps with any necessary quick reactions and following actions.

These two systems help regulate various organ functions in the body, including when the pancreas releases insulin, how much light enters the pupil, and when to activate the immune system.



Consequences of stress on the brain and body

When faced with stress, the brain orchestrates a complex chemical response, primarily driven by the sympathetic nervous system.

This "fight-or-flight" response often involves the release of norepinephrine and epinephrine, sharpening focus and preparing the body for rapid response. Simultaneously, cortisol released by the hypothalamus helps to mobilize energy resources and modulate the immune system.

The dominance of the sympathetic system temporarily suppresses the calming influence of the parasympathetic "rest-and-digest" system.

Meanwhile, glutamate levels increase, potentially enhancing cognitive function in the short term, while changes in serotonin can impact mood regulation.

This intricate dance of neurotransmitters allows the body to respond swiftly to stressors. However, prolonged activation of the sympathetic system, without adequate parasympathetic counterbalance, can have detrimental effects on overall health and well-being, emphasizing the importance of stress management techniques that activate the parasympathetic response.

Feedback for the program: Please put a check in front of the things you've learned so far and leave the other choices unchecked.

- The brain doesn't change at all after birth except when accidents or disease occur.
- Neurons communicate by sending electrical signals directly across synapses to other neurons.
- The hippocampus plays a role in the storage of spatial and sensory information.
- The parasympathetic nervous system is responsible for normal, resting functions like breathing and sweating.
- The sympathetic nervous system releases chemicals like norepinephrine to help the body respond to challenges.

Page 4: Applying what you have learned here

Think back on the neuroscience or psychology-related topics you wrote about at the beginning of this program.

We're going to share three important concepts to remember.

Think about the following topics related to the neural mechanisms underlying learning, memory, and emotion. Then summarize what you have learned in this program about each of the topics. You can also write about any questions you may still have.

A. Neurons communicate via electrochemical signals: action potentials trigger the release of neurotransmitters, allowing them to cross the synapse and transmit signals between neurons.

B. The brain changes and adapts through neuroplasticity, a process that leads to changes in the strength and number of synaptic connections.

C. The sympathetic nervous system is responsible for the body's stress response, releasing chemicals to prepare the brain and body for quickly responding to stimuli.

"Neurons communicate via electrochemical signals: action potentials trigger the release of neurotransmitters, allowing them to cross the synapse and transmit signals between neurons."

Let's review what you learned! Also, feel free to list any questions or confusions you may still have.

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"The sympathetic nervous system is responsible for the body's stress response, involving the release of chemicals into the body and brain to quickly respond to the stimuli."

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Page 5: Sharing what you have learned with others

Write About What You Learned

Imagine you and a younger student are having a conversation about the brain and what it does. They haven't gone through this program and don't know about the knowledge you learned.

The student says, "I definitely want to learn more about the brain in the future. I know what it does in general but never really learned specific details. But I remember hearing somewhere that the brain doesn't change after childhood and puberty. Each brain cell has its own specialized function, so when we lose brain cells throughout adulthood, those memories are gone forever."

The student is interested in learning more about the brain but has some misconceptions that might confuse them in trying to learn more. Please propose a helpful response to them. What did you learn about the brain today?

For example, you can write about:

- How the brain's connections transmit information with both electrical and chemical signals.
- How learning and memory processes change connections in the brain.
- How specific regions in the brain play important roles in storing and recalling information.
- How processes in the brain and body produce physiological responses to stress.

You can include any other facts that you learned or that you already knew.

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Conclusion

Thank you for your participation! We hope you learned a lot about your brain and what role it plays in everyday life.

Do you have any other reflections or feedback that you'd like to share? Any questions you have about the information presented? If you'd like to share anything, please type it in the box below. (If you have no feedback to share, just write "None.")

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