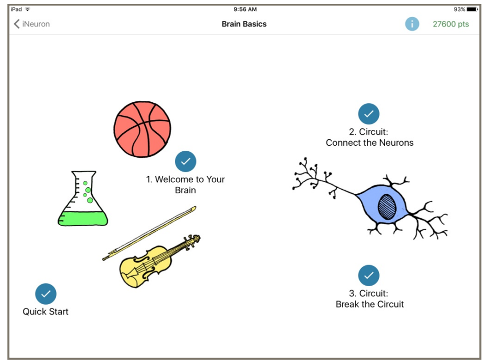
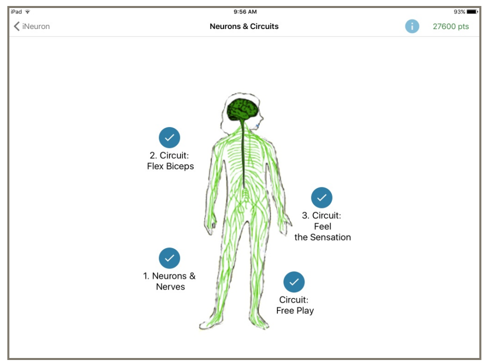
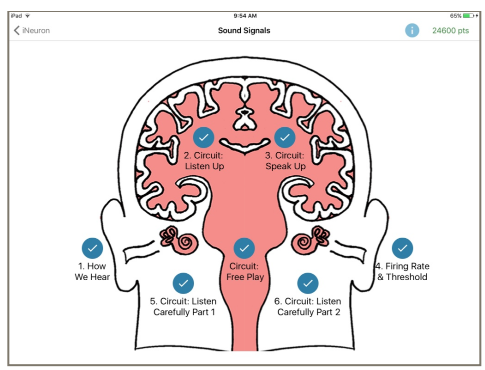
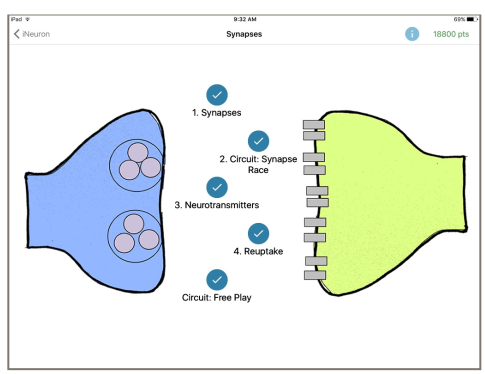
Table of Contents: iNeuron Curriculum Guide







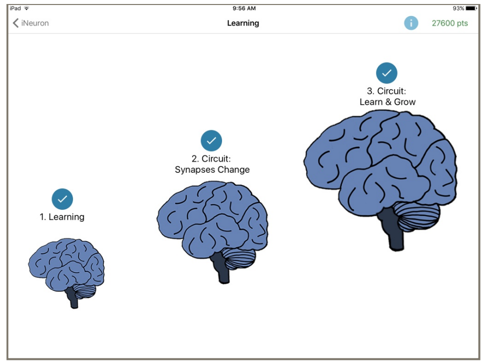


Learning

[Learning](#)

[Synapses Change](#)

[Learn & Grow](#)



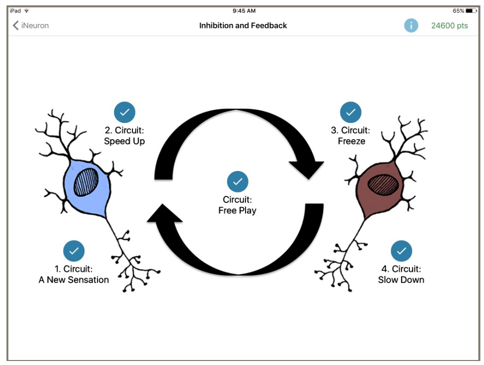
Inhibition & Feedback

[A New Sensation](#)

[Speed Up](#)

[Freeze](#)

[Slow Down](#)



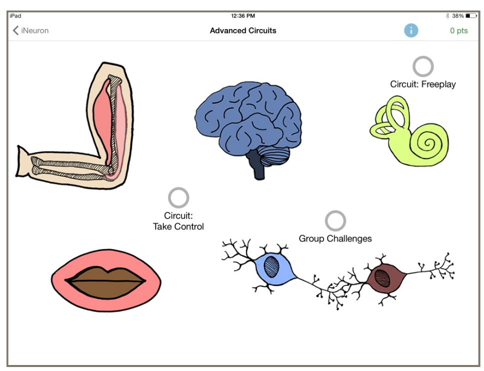
Advanced Challenges

[Take Control](#)

[Brain Anatomy](#)

[Free Play](#)

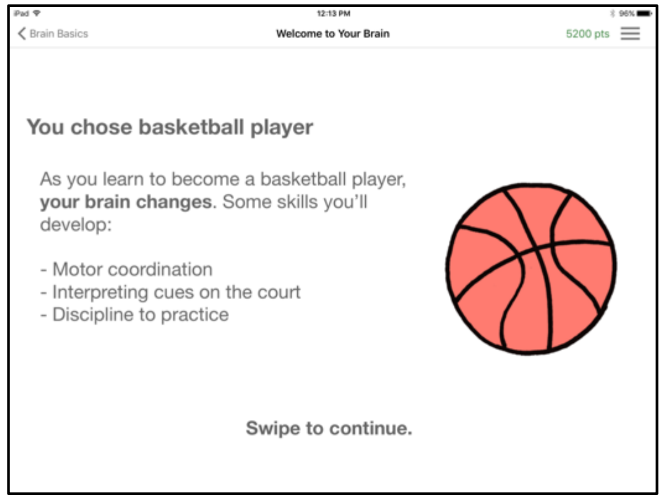
[Group Play](#)



Section 1: Brain Basics

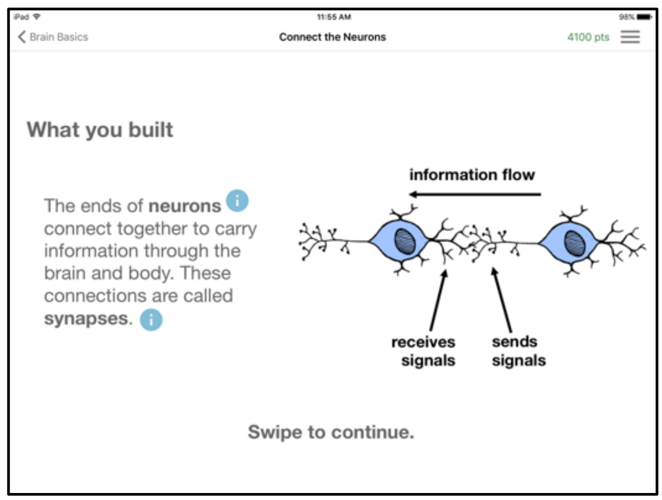
iNeuron™

Challenge:
Welcome to Your Brain



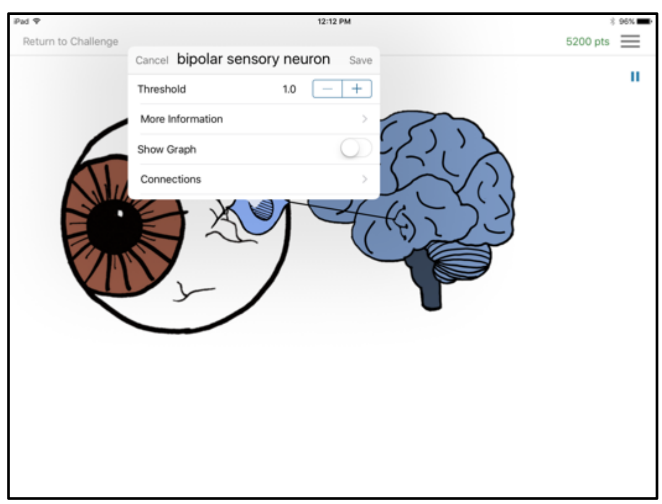
Students choose a role (violinist, basketball player, or chemist) to provide context for the neuroscience concepts they will learn. They are introduced to **synapses**, the term for the connections between brain cells, as well as the many bodily and mental functions the brain controls like sleeping, memory, and vision.

Challenge:
Circuit: Connect the Neurons



Students learn that **neurons** send and receive **signals**, and connect with each other to form **circuits**. They must connect two neurons together by making sure that the correct ends of each neuron are in contact and then tap the plus sign.

Challenge:
Circuit: Break the Circuit



Students view a completed circuit that sends information from the eye to the brain. They must disconnect the circuit by first tapping on the eye, neuron, or brain to bring up its properties menu, then tap "Connections" to delete them.

Section 2: Neurons & Circuits
Challenge: Neurons & Nerves

iNeuron™

Summary
Neurons are cells of the nervous system that carry information throughout the brain and body by sending and receiving signals. The nervous system consists of two parts: the central nervous system and the peripheral nervous system. Each part of a neuron has a specific role in sending and receiving signals. Different types of neurons specialize in relaying certain types of signals such as sensory or motor information.

Key terms

The nervous system
central nervous system (CNS)
peripheral nervous system (PNS)
brain
spinal cord
nerves

Anatomy of a neuron:
dendrites
cell body
axon
axon terminals

Types of neurons:
motor neuron
sensory neuron
interneuron

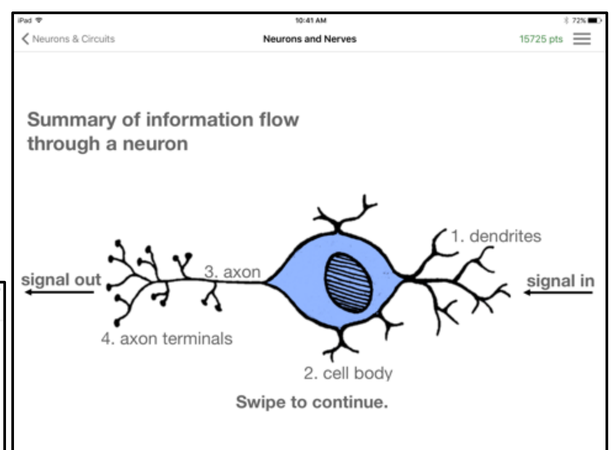
How neurons communicate:
signals
action potential
fire
circuit

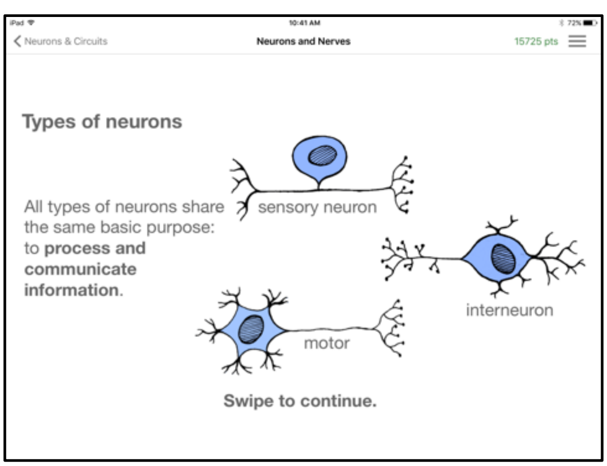
Questions for further inquiry

Describe some similarities and differences between the CNS and PNS. *Answer: the CNS is made up of the brain and spinal cord, while the PNS is made up of nerves in the body. Both the CNS and PNS contain neurons that send and receive signals.*

What direction does information flow through the neuron? *Answer: starting from receiving a signal -dendrites, cell body, axon, axon terminal.*

List the three main types of neurons. What kind of information does each type relay? *Answer: motor (makes muscles contract), sensory (receives signals from sense organs) and inter (connects one neuron to another).*





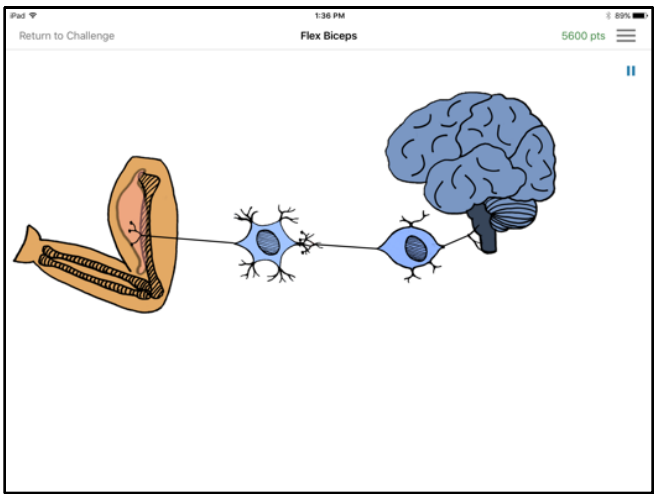
Section 2: Neurons & Circuits
Challenge: Flex Biceps

iNeuron™

Summary

In this challenge, students build a circuit with the goal of making the biceps flex. To solve it they must successfully apply their knowledge of neuron types and neuron anatomy. Specifically, they should be able to identify the difference between the interneuron and the motor neuron, and know that only the motor neuron can connect to a muscle. In addition, they must understand the direction of signal flow through a neuron in order to connect the sending and receiving ends correctly.

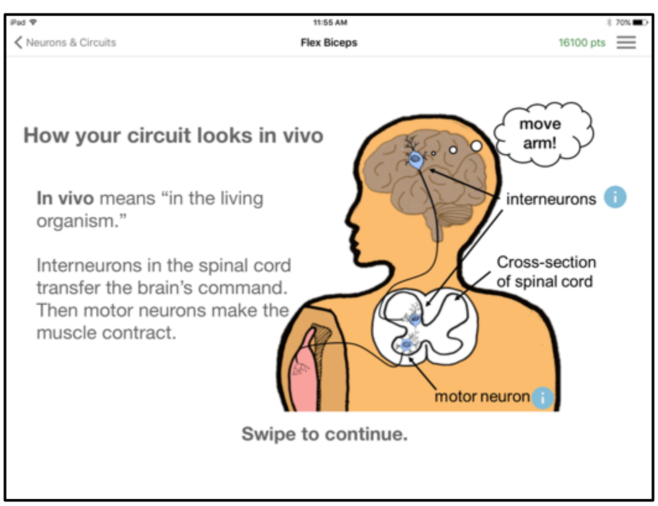
Circuit solution



Student FAQ's

What does "contract" mean? *Answer: contract means the same as "flex", which is to make muscle fibers shorter in order to make movement possible.*

Why do the neurons look so big? *Answer: the challenges in this app are models used for learning – the neurons in your actual body are too small to see with the naked eye.*



Questions for further inquiry

Where does the signal to move your arm begin? *Answer: the brain (frontal lobes).*

Where are the dendrites of the motor neurons that control the movement of the arms located in the body? *Answer: the spinal cord.*

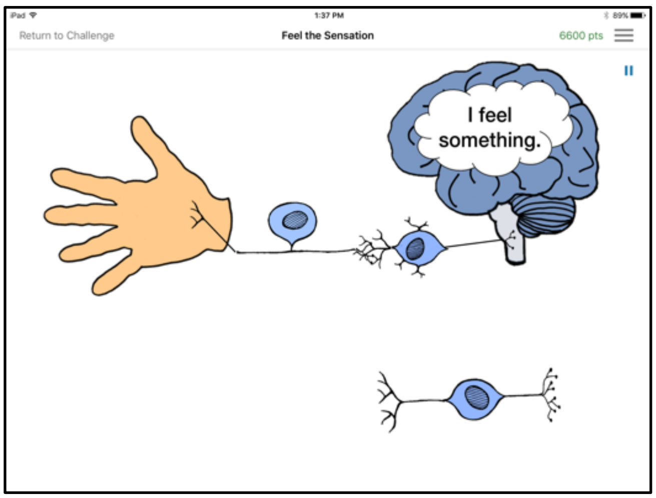
Section 2: Neurons & Circuits
Challenge: Feel the Sensation

iNeuron™

Summary

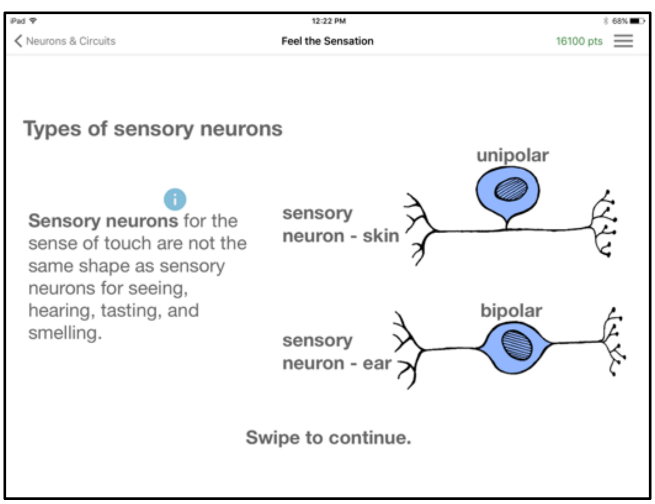
In this challenge, students build a circuit with the goal of sending a sensory signal from the hand (which is being pricked by a pin) to the brain. To solve it they must successfully apply their knowledge of types of sensory neurons. Specifically, they need to identify which of the two sensory neurons is the correct one for this circuit and use the unipolar sensory neuron to connect to the hand.

Circuit solution



Student FAQ's

Students commonly get stuck trying to use all three neurons to build the circuit. Only one of the sensory neurons (unipolar) should be used – the other sensory neuron (bipolar) is only present in other sensory systems like the visual and auditory systems. Have students tap on each neuron to display its type and ask them to identify its role.



Questions for further inquiry

What different kinds of sensations can you feel on your skin? *Answer: pressure, texture, temperature and pain are the main types of sensory information detected by the receptors of sensory neurons in the skin.*

Are sensory neurons in the hand part of the central or peripheral nervous system? *Answer: sensory neurons in the hands bundle together to form nerves that are part of the peripheral nervous system (PNS).*

Section 3: Sound Signals
Challenge: How We Hear

iNeuron™

Summary

The ear is divided into three main structures that contribute to our sense of hearing. Sound waves detected by the outer ear are translated into signals sent to the brain by bipolar sensory neurons in the inner ear. Auditory cortex in the brain interprets these signals so that we can understand and interpret specific sounds like music and speech.

Key terms

Parts of the ear:
outer ear
middle ear
inner ear (cochlea)

Types of neurons:
bipolar sensory neurons
unipolar sensory neurons

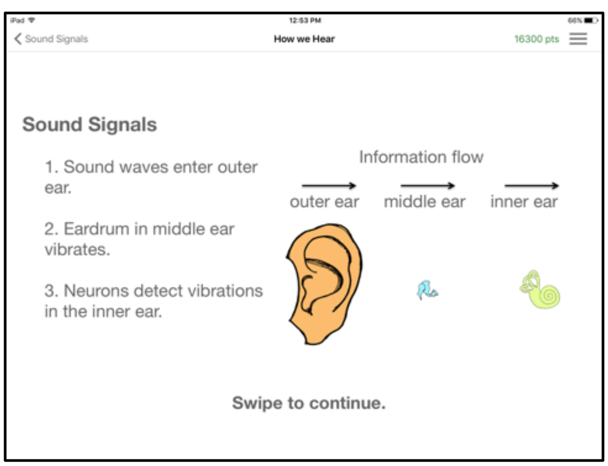
Auditory processing:
sound waves
brain stem
auditory cortex

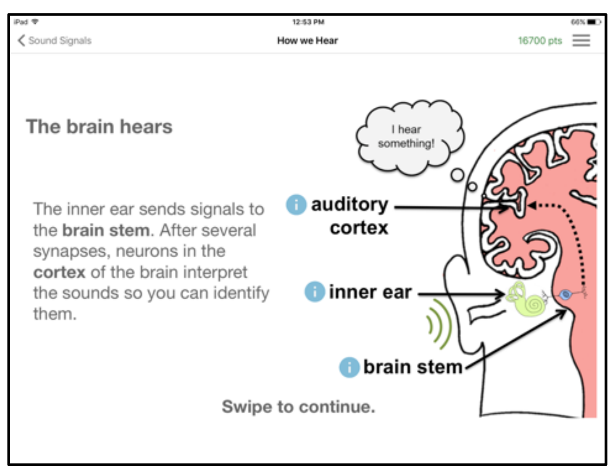
Questions for further inquiry

In what order does information flow through the three parts of the ear? *Answer: outer, middle, inner ear.*

How do sensory neurons of the ear differ from those located in the skin? *Answer: sensory neurons in the ear are bipolar, while sensory neurons in the skin are unipolar.*

Which part of the ear contains neurons responsible for transmitting auditory information to the brain? *Answer: the inner ear contains the receptors of bipolar sensory neurons that connect to the brain stem and send auditory signals to the brain.*



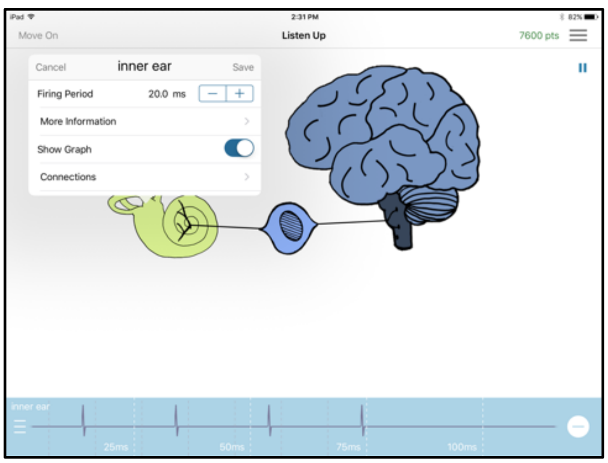


Section 3: Sound Signals
Challenge: Listen Up

iNeuron™

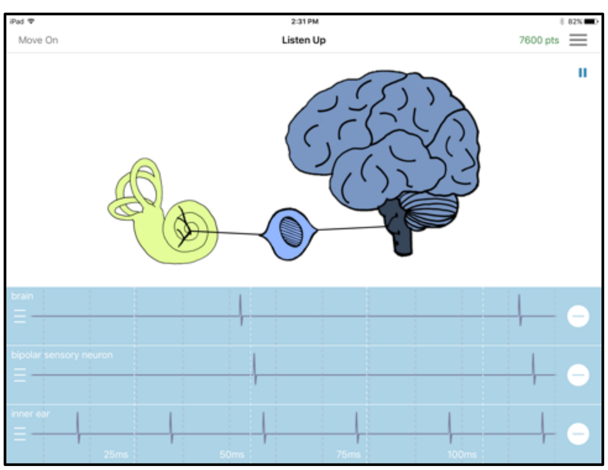
Summary
In this challenge, students observe a completed auditory circuit that sends signals from the inner ear to the brain stem. Their goal is to tap each piece in the circuit to bring up its properties sheet, and turn on its graph. Then they should observe the graphs in order to identify which piece has the highest firing rate.

Circuit solution



1. Turn on graphs.

Student FAQ's
Students may get stuck after they turn on the graphs, waiting for an indication of challenge success. They were instructed to tap Move On in the upper left corner of the screen once they were done observing the graphs. They will then be prompted to indicate which piece in the circuit had the highest firing rate (inner ear).



2. Observe firing rates, then tap Move On.

Questions for further inquiry
How did you know which piece in the circuit had the highest firing rate? *Answer: the graph of the inner ear showed more action potentials within a period of time than the other pieces in the circuit.*

Does a high firing rate mean that part of the circuit is firing quickly or slowly? *Answer: a higher firing rate means that piece in the circuit is firing more quickly.*

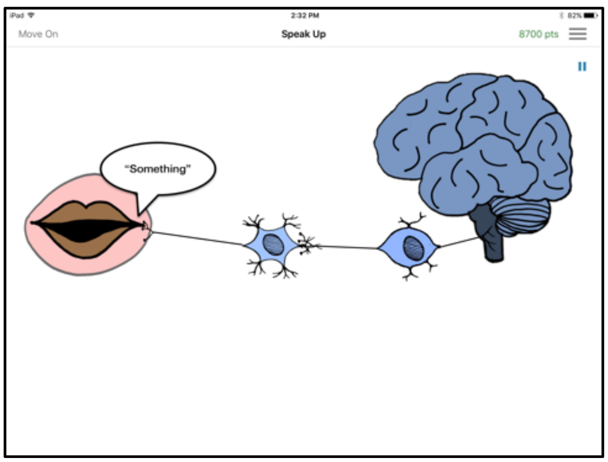
Section 3: Sound Signals
Challenge: Speak Up

iNeuron™

Summary

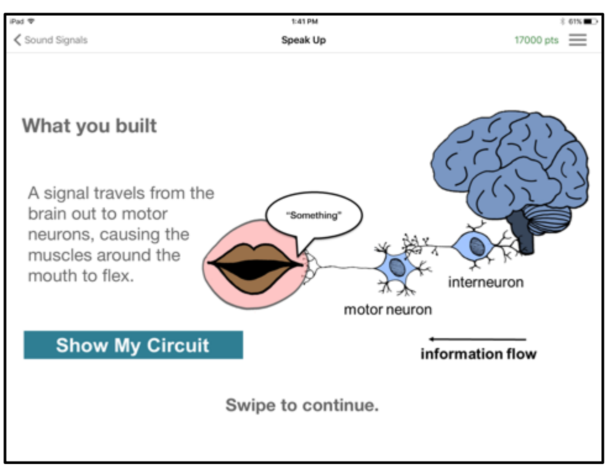
In this challenge, students build a circuit with the goal of making the mouth move. To solve it they must successfully apply their knowledge of neuron types and neuron anatomy. Specifically, they should be able to identify the difference between the interneuron and the motor neuron, and know that only the motor neuron can connect to a muscle. In addition, they must understand the direction of signal flow through a neuron in order to connect the sending and receiving ends correctly.

Circuit solution



Student FAQ’s

This challenge is relatively straightforward and conceptually identical to the Flex Biceps challenge, where the mouth muscle replaces the biceps. Students may need a refresher on which neuron is the motor neuron and which is the interneuron.



Questions for further inquiry

Speaking starts with signals sent from the brain. What kind of neurons in the brain send these signals? *Answer: interneurons. All neurons in the brain are interneurons.*

Your mouth contains a unique sense organ that is also a muscle. What is it? *Answer: the tongue. The tongue contains sensory neurons inside taste buds, as well as motor neurons that make it move when we speak.*

Section 3: Sound Signals
Challenge: Firing Rate & Threshold

iNeuron™

Summary

Neuroscientists use graphs to visualize how neurons fire. Neurons tend to fire many action potentials in a given period of time, and their activity is best described by a firing rate. Neurons fire quickly, and the unit Hertz (Hz) is used to describe how many times a neuron fires per second. The distance between each action potential is called the firing period. Every neuron has a threshold, which is a number that describes the amount of input the neuron needs to receive before it will fire.

Key terms

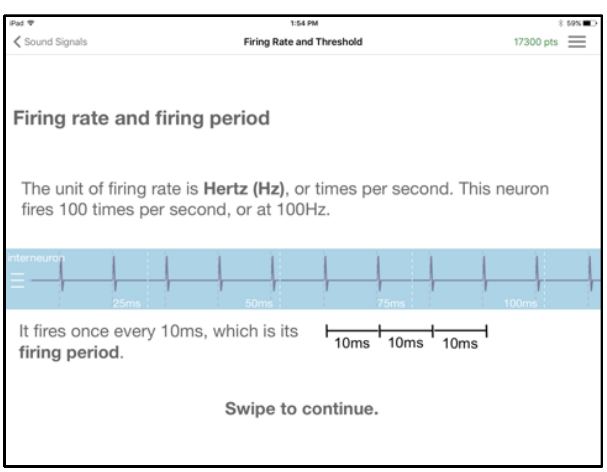
quantitative data
neuroscientist
action potential
fire
voltage
firing period
milliseconds (ms)
firing rate
hertz (Hz)
threshold

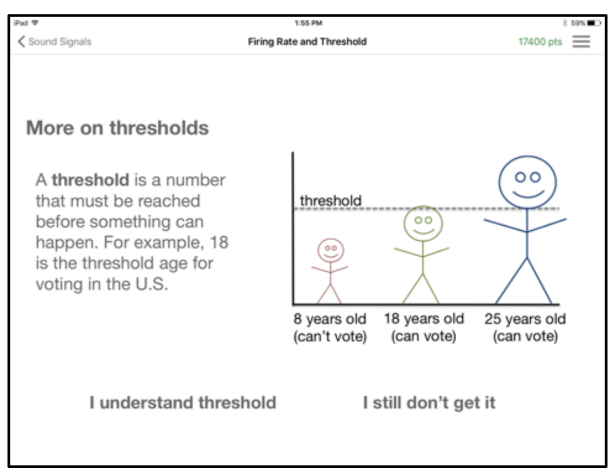
Questions for further inquiry

If a neuron takes about 5 milliseconds (ms) to fire once, how many times could it fire per second? *Answer: there are 1,000 milliseconds in one second, so a neuron can fire up to roughly 200 times per second (1,000/5).*

When a neuron has a high threshold, its firing rate is low. Why? *Answer: a high threshold means that a lot of input/signal is needed to make the neuron fire. Therefore, it fires less frequently.*

What is the difference between firing rate and firing period? *Answer: The firing period is how much time elapses between each action potential, and its units are milliseconds (ms). The firing rate is a measure of how often the neuron fires per second, and its units are Hertz (Hz).*





Section 3: Sound Signals
Challenge: Listen Carefully Part 1

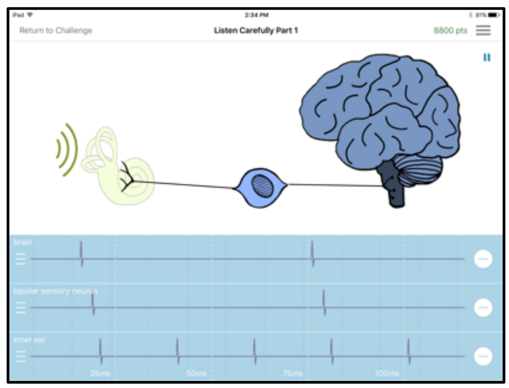
iNeuron™

Summary

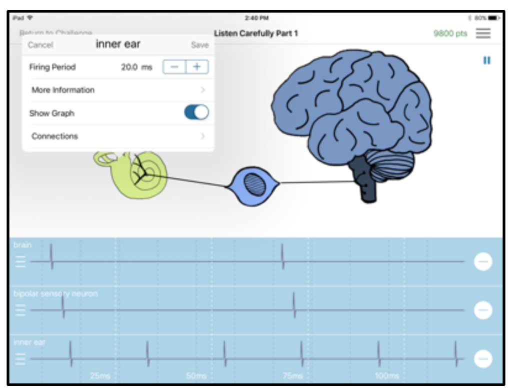
In this challenge, students build an auditory circuit and then adjust its parameters with the goal of making the brain stem fire once every 20 milliseconds. By tapping on the inner ear or sensory neuron to bring up its property sheet they can change the ***firing period*** or ***threshold***. This alters the firing rates of pieces downstream in the circuit. To solve the challenge they must understand how increasing or decreasing the firing period and threshold affects the firing rate of the brain stem. This challenge has multiple solutions.

This challenge can be particularly difficult for students. The following steps will help guide them to a solution:

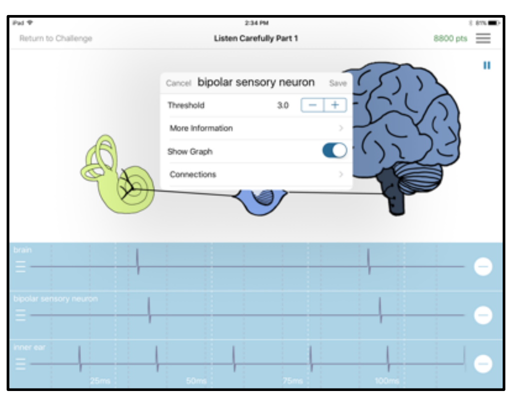
1. Turn on the graphs to see how fast the brain stem is firing initially. Ask the student – is the brain stem firing faster or slower than once every 20 ms? *(it is firing slower)*.



2. Change the firing period of the inner ear, then tap Save. Ask the student to observe what happens when it is increased vs. decreased *(increasing the firing period decreases the frequency of signals sent)*.

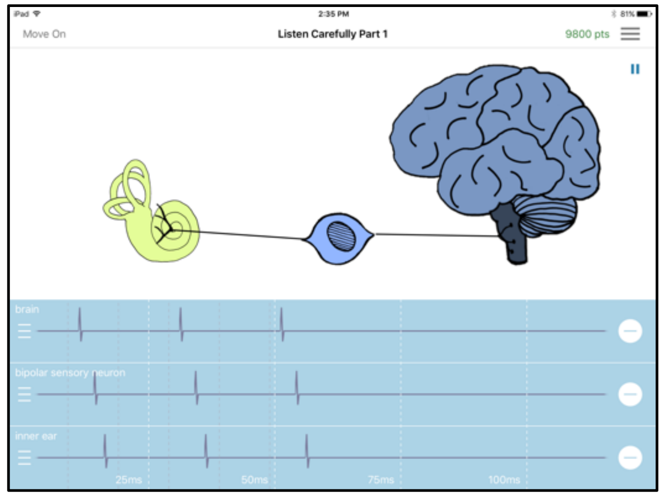


3. Change the threshold of the sensory neuron, then tap Save. Ask the student to observe what happens when it is increased vs. decreased *(increasing the threshold decreases the frequency of signals sent)*.

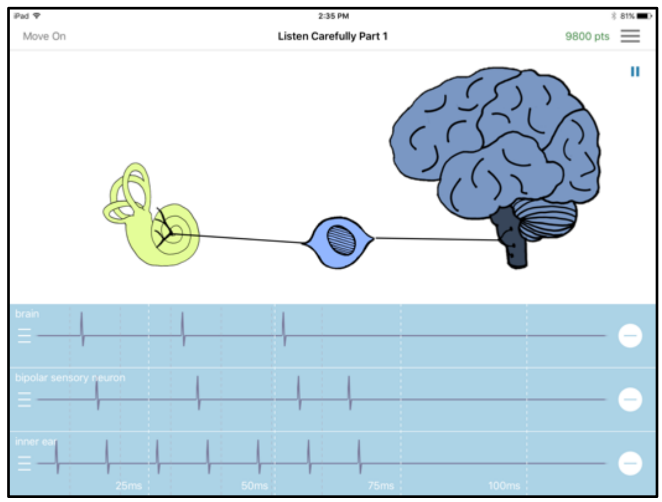


Circuit solutions (see if you can find more!)

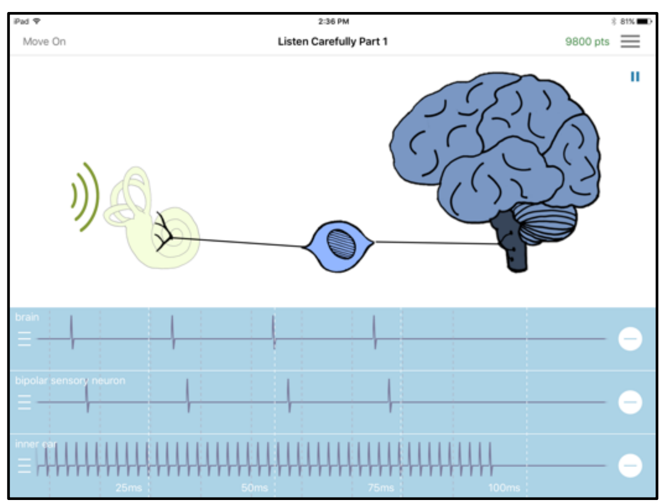
Firing Period = 20ms
Threshold = 1



Firing Period = 10ms
Threshold = 2



Firing Period = 2ms
Threshold = 10



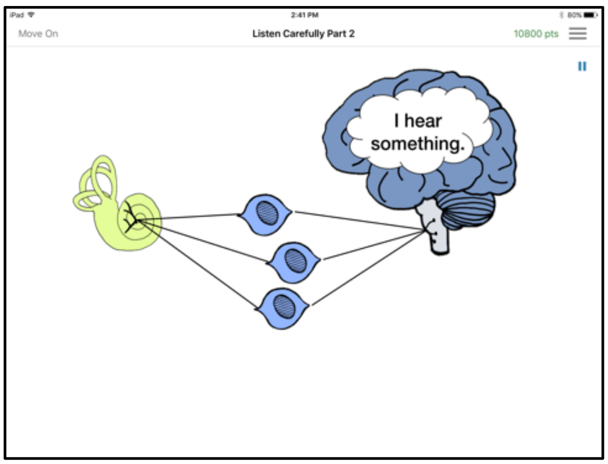
Section 3: Sound Signals
Challenge: Listen Carefully Part 2

iNeuron™

Summary

Just like in Listen Carefully Part 1, the challenge goal is to build an auditory circuit and make the brain stem fire once every 20 milliseconds. However, the goal is accomplished in a different way. Three sensory neurons are provided to make a circuit that carries signals from the inner ear to the brain stem. By connecting each neuron from the inner ear to the brain stem, the signal coming from the inner ear is multiplied and the brain stem will fire more frequently.

Circuit solution



Student FAQ's

Students may attempt to connect the sensory neurons in a chain rather than stacking them as in the solution image shown. Remind them that these sensory neurons can only receive signals from sense organs, not from other neurons.

Students may also try to change thresholds or firing periods, similar to the previous challenge. The instructions reminded them that this would not lead to a successful solution.

Questions for further inquiry

Why did connecting 3 neurons from the inner ear to the brain stem make the brain stem fire faster? *Answer: each neuron sends a signal to the brain stem when it receives a signal from the inner ear. Thus, the brain stem receives 3 times as much signal as it would from just one neuron.*

How is this challenge similar to Listen Carefully Part 1? How is it different? *Answer: the challenges are similar because both circuits made the brain stem fire once every 20 milliseconds. They are different because in Part 1 only one neuron was needed. Increasing the firing period and decreasing threshold increased the signals sent to the brain stem. In Part 2 three neurons were needed to increase the signals sent to the brain stem.*

How many neurons do you think actually connect each inner ear to the brain stem in our bodies? *Answer: Thousands. The axons of these sensory neurons bundle together to form the auditory nerve, which connects the inner ear to the brain stem.*

Section 4: Synapses
Challenge: Synapses

iNeuron™

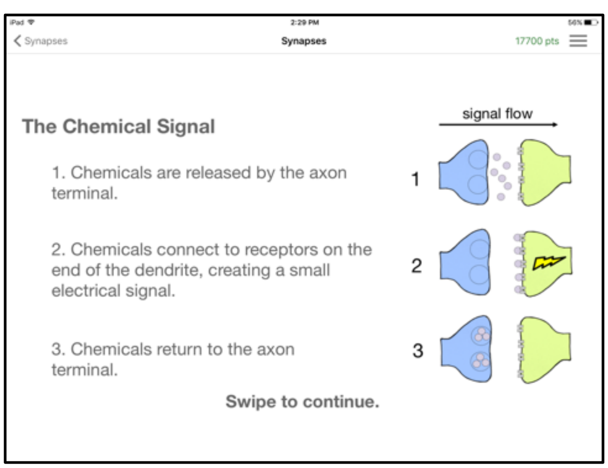
Summary
Communication between two neurons take place at the synapse. Here, an action potential causes the axon terminal to release neurotransmitters, which bind to receptors on the dendrite of the receiving neuron. This creates a small electrical signal inside the receiving neuron, which may cause it to fire as well. Once the action potential is complete, the neurotransmitter molecules are recycled back into the axon terminal.

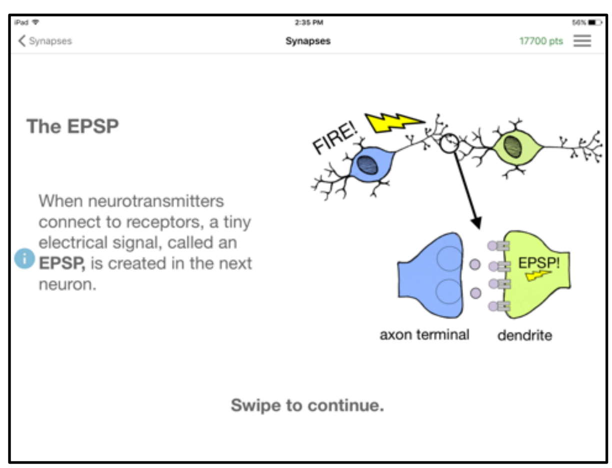
Key Terms
synapse
chemical signal
neurotransmitters
receptors
EPSP
reuptake

Questions for further inquiry
What part of a neuron's signal is electrical, and what part is chemical? *Answer: the action potential that a neuron sends down its axon is electrical, but at the synapse the signal changes to chemical.*

What is an EPSP? *Answer: An EPSP is a tiny electrical change that happens inside a neuron's cell body when it receives a signal from another neuron. If that change is large enough to cross its threshold, the neuron will fire.*

Do neurons normally connect to just one other neuron? *Answer: No. For instance, most neurons in the brain are connected to thousands of other neurons, receiving signals from and sending signals to all of them.*





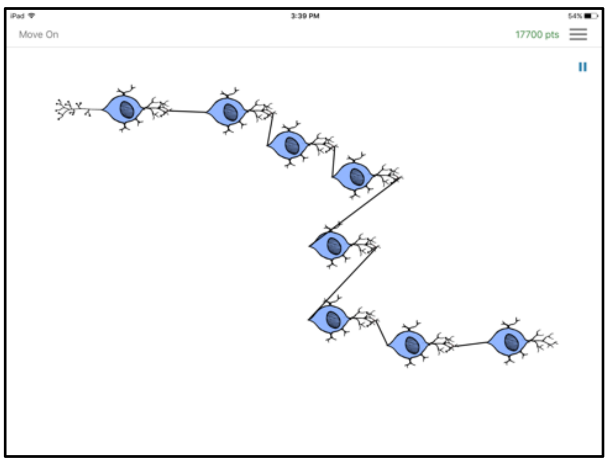
Section 4: Synapses
Challenge: Synapse Race

iNeuron™

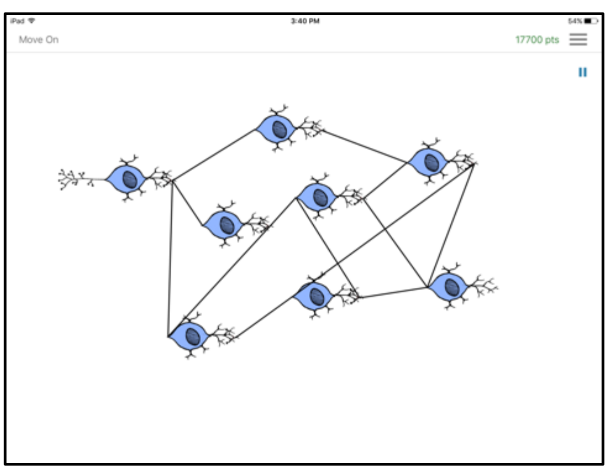
Summary

In this challenge, students create as many synapses as they can in 15 seconds. There are many “solutions” to this challenges. To make as many synapses as possible, students must understand that a connection between one neuron and another is called a synapse, and successfully apply their knowledge of which end of a neuron sends signals and which end receives signals. Students can also make multiple synapses at the same neuron, which models how neurons connect in the brain.

Circuit solutions



neurons in a chain



neurons in a web

Questions for further inquiry

When in a human’s life are new synapses made in the brain? *Answer: Neurons form new synapses with other neurons throughout our lifetimes, based on our experience. We also lose synapses when they stop being used. This is one of the physical bases for learning.*

What strategy could you use to make the most synapses in this challenge? *Answer: by not just connecting the neurons in a chain, but making multiple synapses per neuron. In the brain, neurons are often connected in three-dimensional webs rather than chains.*

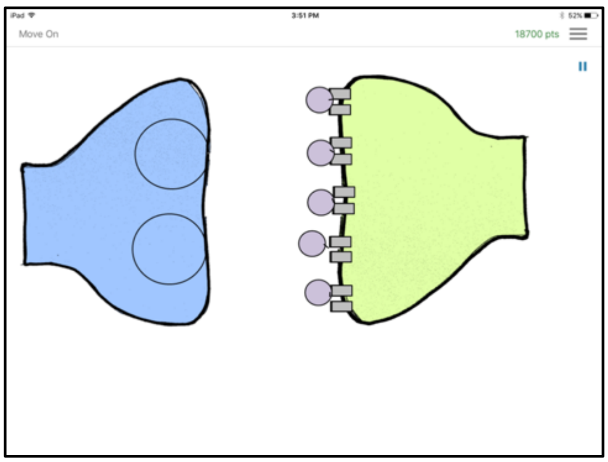
What is a “network”? *Answer: in neuroscience, a network is a chain or web of connected neurons that serves a particular function. Not unlike the internet, which is a network of connected computers.*

Section 4: Synapses
Challenge: Neurotransmitters

iNeuron™

Summary
In this challenge, students start with an image of a synapse – the axon terminal of one neuron communicating with the dendrite of another neuron. To solve this challenge, they must move all of the neurotransmitter molecules out of the axon terminal and connect them to the receptors on the dendrite.

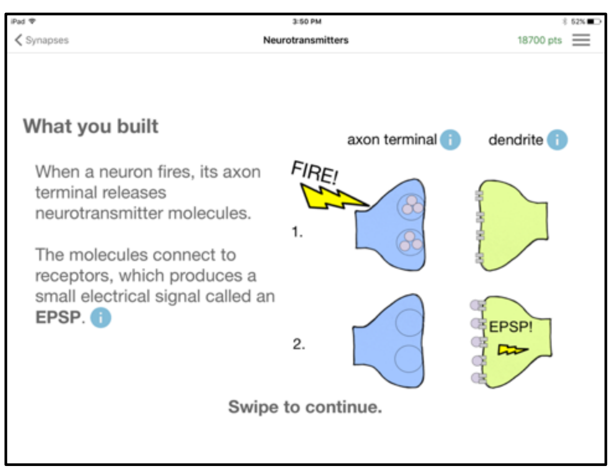
Circuit solution



Questions for further inquiry

In a synapse, does the axon terminal touch the dendrite? *Answer: No. There is a small gap between them, and communication happens when neurotransmitters travel across the gap.*

What causes an axon terminal to release neurotransmitters? *Answer: Neurotransmitters are released every time a neuron fires an action potential.*



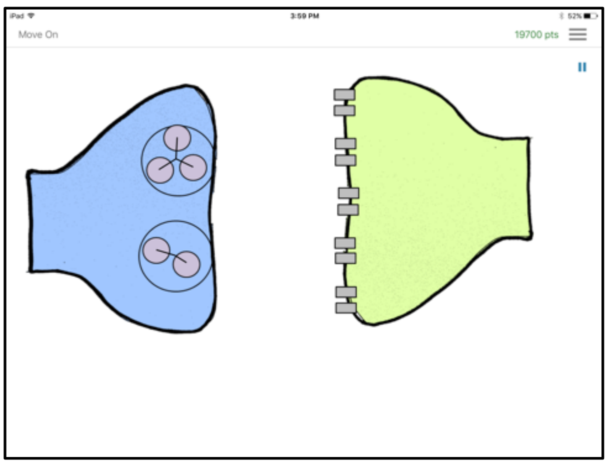
Section 4: Synapses
Challenge: Reuptake

iNeuron™

Summary

In this challenge, students again start with an image of a synapse, but after neurotransmitters have already been connected to receptors on the dendrite. To solve this challenge, they must move all of the neurotransmitter molecules back from the dendrite to the axon terminal. This process is called ***reuptake***, and is how neurotransmitters get recycled after an action potential is complete.

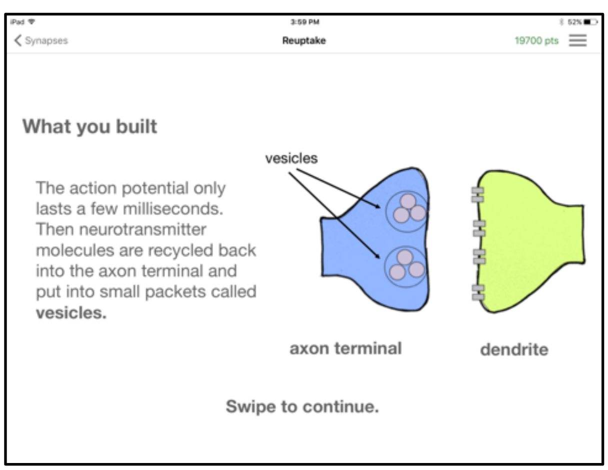
Circuit solution



Questions for further inquiry

Do neurotransmitters travel inside the dendrite?
Answer: No. Neurotransmitter molecules connect to receptors on the outside of the dendrite and cause chemical changes to occur.

What are the circles shown in the axon terminal that the neurotransmitter molecules go into?
Answer: The circles represent vesicles, which are packets inside the axon terminal that hold molecules of neurotransmitter.



Section 5: Learning
Challenge: Learning

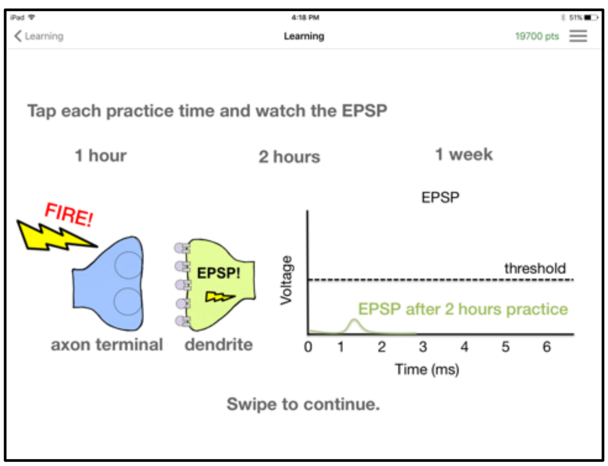
iNeuron™

Summary

We experience learning as changes in our knowledge and behavior, but learning actually happens because of changes in our nervous system. When we practice knowledge or skills, the circuits in our brain and body gradually change to communicate signals more efficiently. This is called ***synaptic plasticity***. Eventually, practice will also cause new synapses to grow.

Key terms

Synaptic plasticity
EPSP (excitatory post-synaptic potential)

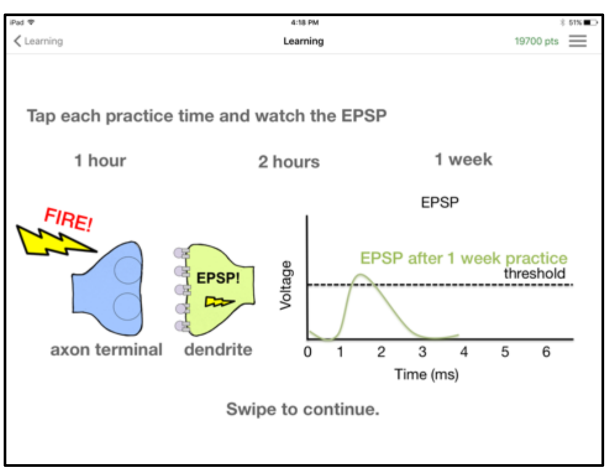


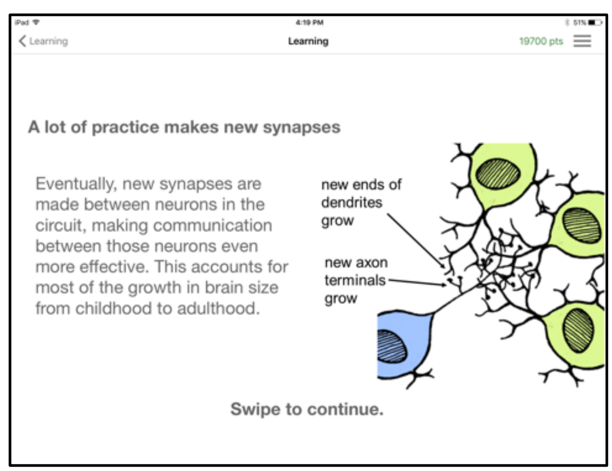
Questions for further inquiry

How does practice change the size of the EPSP? *Answer: after a lot of practice, the EPSP caused by an action potential gets larger. This makes circuits run more efficiently.*

How does practice change the number of synapses in the brain? *Answer: Circuits that get activated a lot because of practice grow new synapses. Circuits that stop getting activated because of a lack of practice lose synapses.*

What kinds of practice cause synapses to get stronger and new synapses to grow? *Answer: any kind of practice! Practice playing video games and your circuits for playing video games will get stronger. Practice math and your math circuits will get stronger. Our brains change based on what we do with our time.*





Section 5: Learning
Challenge: Synapses Change

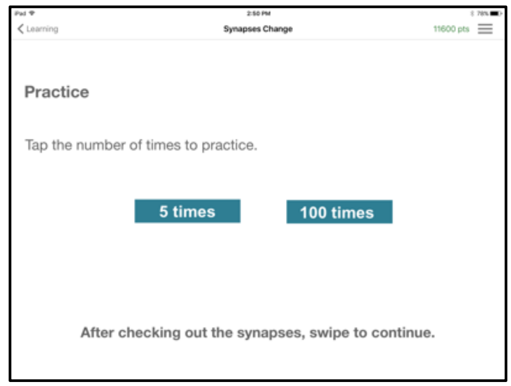
iNeuron™

Summary

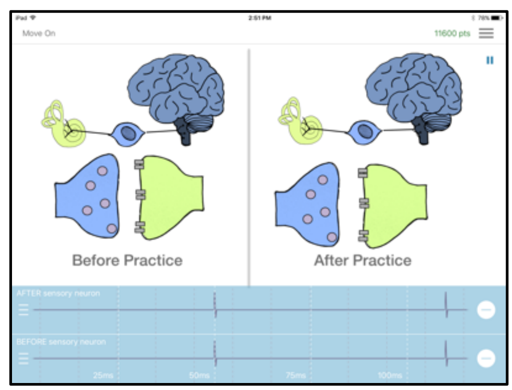
When any skill or piece of knowledge is practiced, a corresponding circuit in the brain/body is activated. In this challenge, students learn how practice changes a circuit and a synapse. To solve it, they must carefully observe how the circuit and synapse change (or do not change) after a skill is practiced 5 times and then 100 times.

This challenge is structured differently from many of the other challenges – rather than build a circuit, the students must make observations and analyze.

1. Tap either "5 times" or "100 times" to view the circuit and synapse (you'll have a chance to view both options).

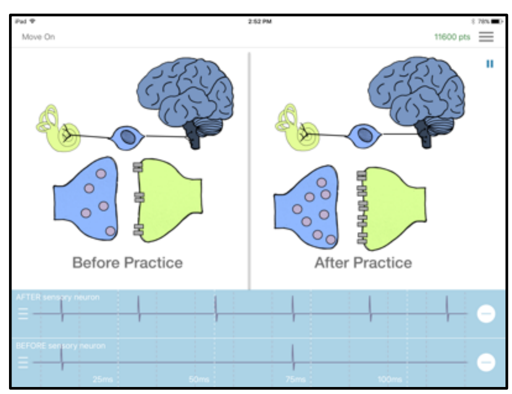


2. Observe any differences between the two circuits and synapses, one shown before practice, and the other after practice. When done observing, tap "Move On".

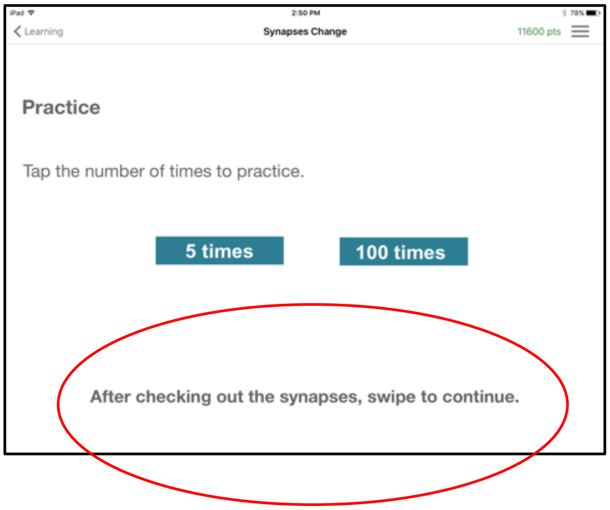


5 times

3. Tap the option for the other amount of practice. When done observing any differences, tap "Move On".

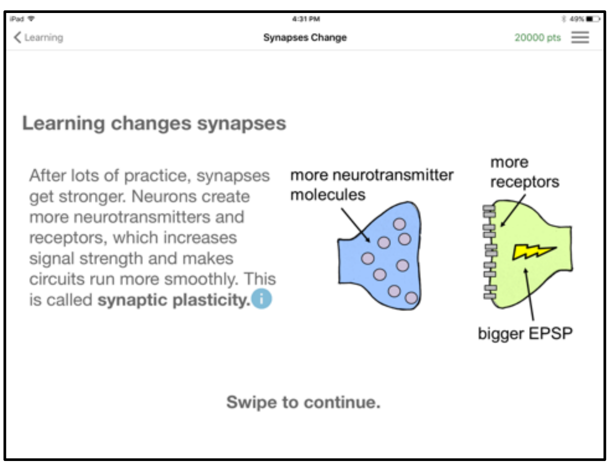


100 times



Student FAQ's

Students sometimes get stuck because they do not realize they need to tap Move On when they are done making observations. They may also get stuck at the screen where they choose the amount of practice after they have viewed both options – they should swipe to continue, which will take them to some multiple-choice questions to answer.



Questions for further inquiry

What happened to the circuit after practicing 5 times? *Answer: nothing. Changes to circuits (usually) require a little more effort than that.*

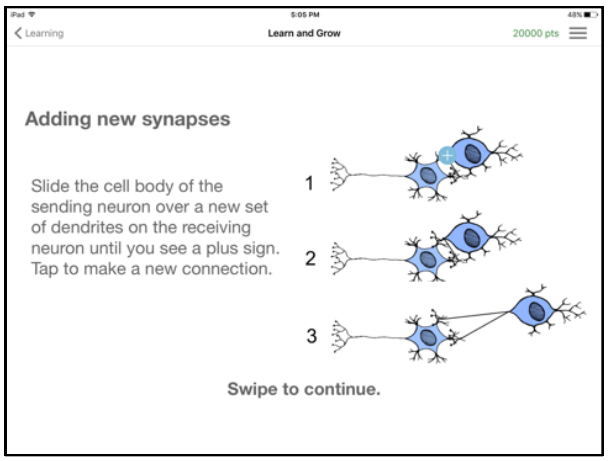
What happened to the circuit after practicing 100 times? *Answer: more neurotransmitter molecules were released at the synapse, more receptors appeared at the dendrite, and the EPSP was larger. All these changes led to the circuit running faster. In the nervous system, these changes are why we experience a skill or piece of knowledge that is well-learned as easier to do or remember than something we just learned yesterday.*

The circuits in our brains and bodies change with experience, but the most important thing to know is that learning takes time and effort.

Section 5: Learning
Challenge: Learn & Grow

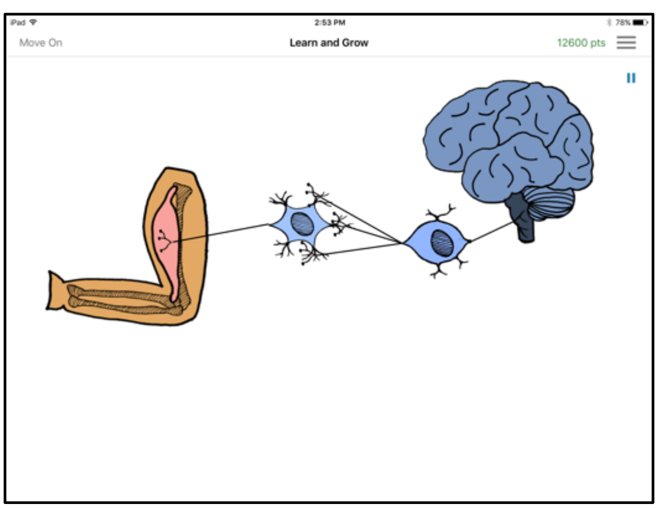
iNeuron™

Summary
In this challenge, students again build a circuit with the goal of making the biceps flex, but they must also add two new synapses to make the circuit run faster. To solve it they must remember how to make a simple motor circuit, and follow the given instructions for making new synapses.



Student FAQ's
Students may get stuck after they have made the motor circuit, likely because they did not read the instructions for how to make a new synapse (shown at left). Remind them that they need to add two new synapses between the interneuron and motor neuron.

Circuit solution



Questions for further inquiry
Why did adding synapses make the circuit run faster? *Answer: with 3 synapses between the interneuron and motor neuron, the amount of signal being sent is tripled. This causes the motor neuron to fire more frequently and the biceps to flex more often.*

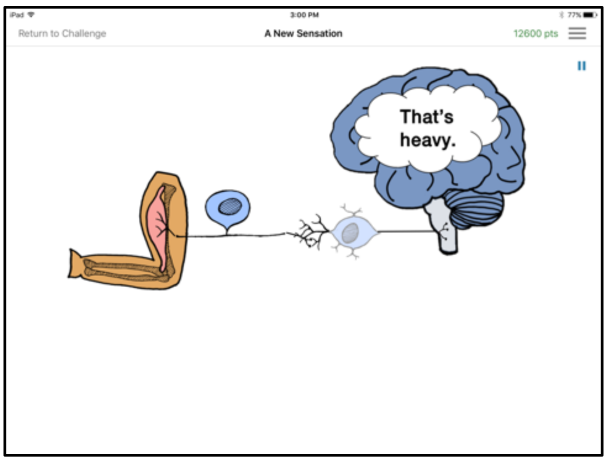
Section 6: Inhibition & Feedback
Challenge: A New Sensation

iNeuron™

Summary

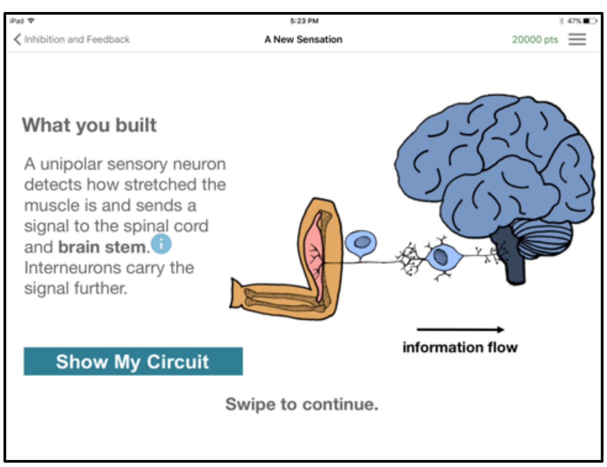
In this challenge, students build a circuit with the goal of sending sensory information from the biceps muscle to the brain. To solve it they must successfully apply their knowledge of neuron types, and understand the new concept of ***proprioception***, which is the sense of the position of different parts of the body and how the body is moving in space.

Circuit solution



Student FAQ's

This challenge is relatively straightforward and conceptually identical to the Feel the Sensation challenge. However, the sensory neuron must connect to the muscle rather than the skin, since this is where proprioceptive information comes from. Students may also need a refresher on which neuron is the sensory neuron and which is the interneuron.



Questions for further inquiry

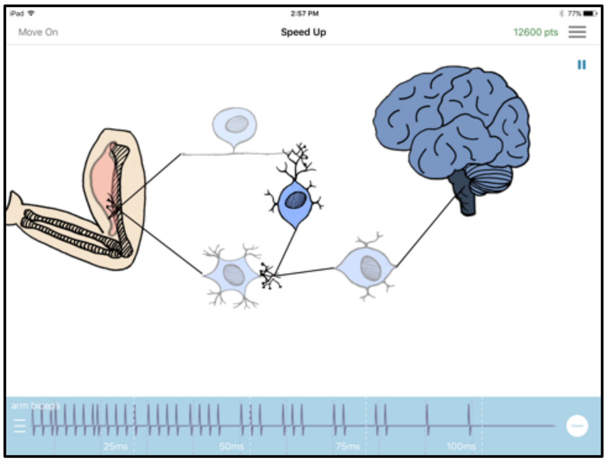
Is the feeling of hunger an example of proprioception? *Answer: no. Proprioception is specific to muscles, and tells us about how our bodies are positioned in space and how flexed or stretched our muscles are. Hunger is an example of **interoception**, which is sensory information coming from our internal organs.*

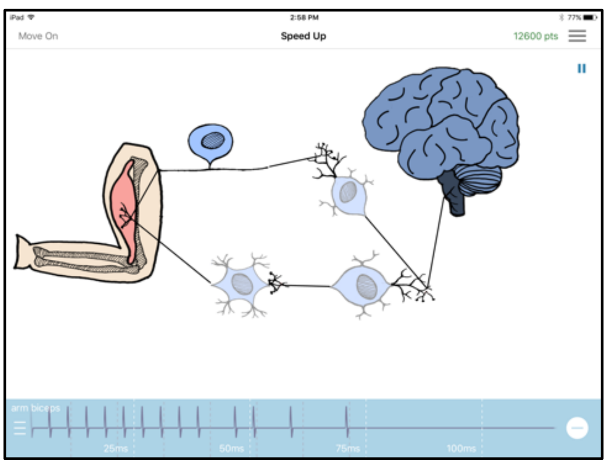
Section 6: Inhibition & Feedback
Challenge: Speed Up

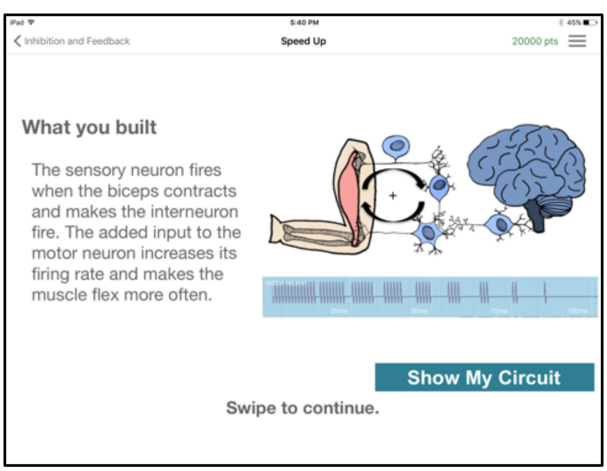
iNeuron™

Summary
In this challenge, students build a circuit that contains a positive feedback loop. To solve it, they must combine what they have learned about building motor circuits with what they have learned about building sensory circuits. This challenge has two possible solutions.

Circuit solutions







Student FAQ's
This challenge can be difficult for students, as there are several components. Have them start by building a simple motor circuit that makes the biceps flex, then add the sensory input and complete the feedback loop with the remaining interneuron. Showing the graph will help the student see how the loop speeds up the circuit over time.

Questions for further inquiry
Why is this called a "positive" feedback loop? *Answer: because the loop increases the amount of input that comes into the circuit.*

Why does the circuit run faster after the feedback loop is completed? *Answer: each time the biceps flexes, the sensory neuron fires. The sensory neuron sends a signal back to an interneuron that connects to the original motor circuit and increases the signal going to it. Each time the circuit runs, the additional input causes it to accelerate further.*

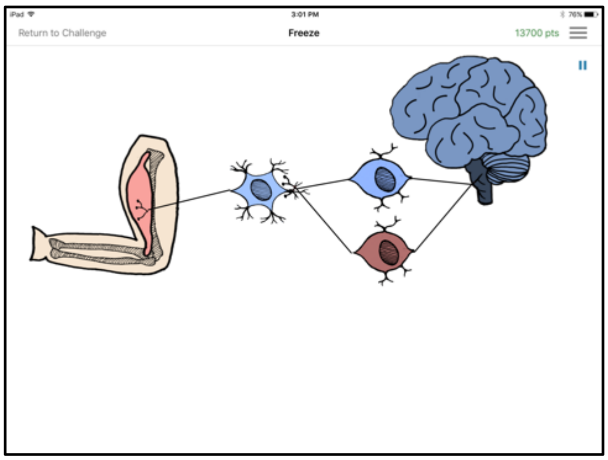
Section 6: Inhibition & Feedback
Challenge: Freeze

iNeuron™

Summary

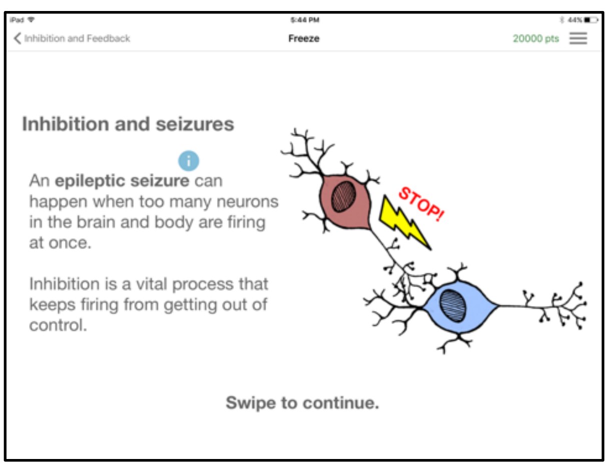
In this challenge, students start with a complete motor circuit that makes the biceps flex. To solve it, they must add an ***inhibitory*** interneuron to the circuit to make it stop. An inhibitory neuron sends "negative" signals when it fires, making the neuron it sends signals to less likely to fire.

Circuit solution



Student FAQ's

Some students may try to disconnect the circuit and insert the inhibitory neuron in it. Instead, they should add the inhibitory neuron to the existing circuit – it may be helpful to remind them that a neuron can have more than one synapse and connect to multiple neurons at once.



Questions for further inquiry

Does inhibition increase or decrease the activity of neurons? *Answer: decrease.*

How does inhibition help people with epilepsy? *Answer: Epilepsy is a condition in which people have seizures, which are episodes of too much electrical activity in the brain and body (i.e., too many neurons firing). Some drugs that treat epilepsy increase the activity of inhibitory neurons in the brain, helping to reduce the frequency and severity of seizures.*

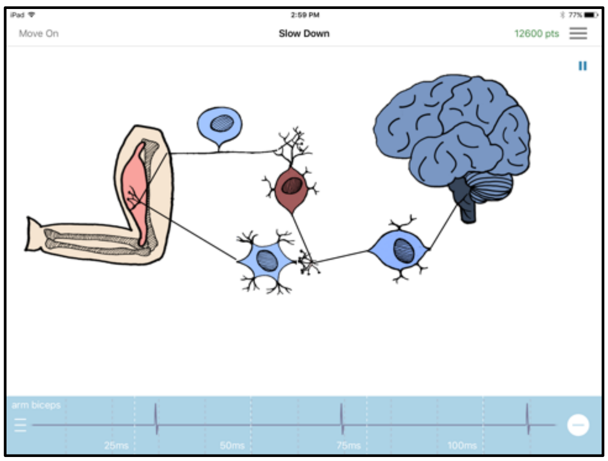
Section 6: Inhibition & Feedback
Challenge: Slow Down

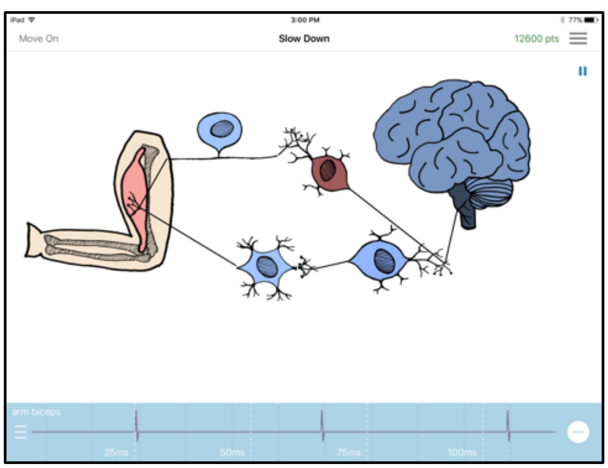
iNeuron™

Summary

This challenge is a complement to Speed Up. Students must build a circuit that contains a negative feedback loop. To solve it, they must combine what they have learned about building motor circuits with what they have learned about building sensory circuits and inhibition. This challenge has two possible solutions.

Circuit solutions





Student FAQ's

This challenge can be difficult for students, as there are several components. Have them start by building a simple motor circuit that makes the biceps flex, then add the sensory input and complete the feedback loop with the remaining interneuron. Showing the graph will help the student see how the loop slows down the circuit over time.

Questions for further inquiry

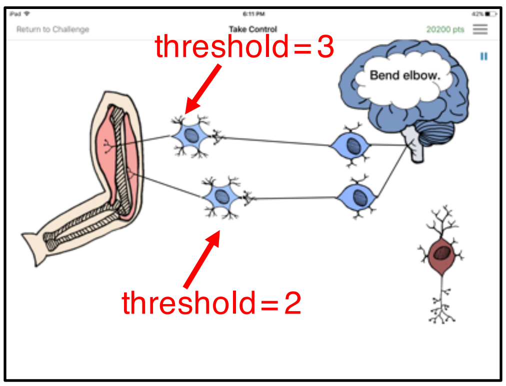
Why is this called a "negative" feedback loop? *Answer: because the loop decreases the amount of input that comes into the circuit.*

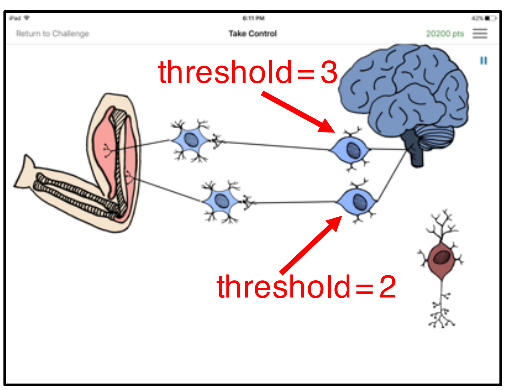
Why does the circuit run slower after the feedback loop is completed? *Answer: each time the biceps flexes, the sensory neuron fires. The sensory neuron sends a signal back to an inhibitory interneuron that connects to the original motor circuit and decreases the signal going to it. Each time the circuit runs, the additional input causes it to decelerate further.*

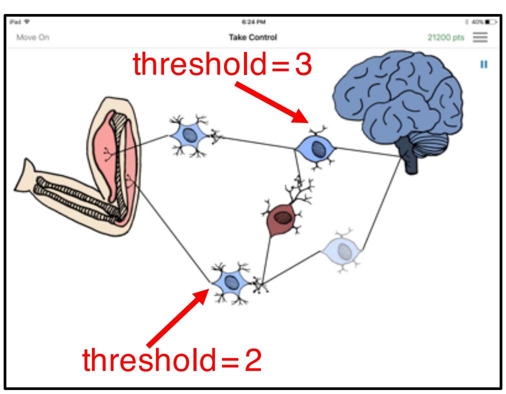
Section 7: Advanced Challenges
Challenge: Take Control

Summary
In this advanced challenge, students build two motor circuits, one to make the biceps flex and one to make the triceps flex. They must coordinate the timing of each circuit so that the elbow bends and extends – i.e., the biceps flexes while the triceps is relaxed, then the triceps flexes while the biceps is relaxed. Solving this challenge requires students to integrate concepts such as threshold and inhibition, and there are several possible solutions.

Circuit solutions







Student FAQ's
This challenge can be difficult! Start by guiding students to build two simple motor circuits using the available neurons, one to the biceps muscle and one to the triceps muscle. They key to making the elbow bend and extend is to alter the timing of the two circuits so the muscles don't contract at the same time. The following tips will help guide students to a solution:

- The extra inhibitory interneuron may be used to send inhibition from one circuit to the other to alter the timing, but it is not used at all in some solutions.
- Changing the speed of each motor circuit so their timings are offset can be accomplished by changing thresholds of the neurons in each circuit.
- The arm has to bend and extend twice to solve the challenge, so be patient when observing your circuit to see if you have found a solution.
- The solutions shown at left are just a few of the many possibilities. Challenge your students who excel at building circuits to find additional solutions.

Section 7: Advanced Challenges
Challenge: Brain Anatomy

iNeuron™

Summary
Students are introduced to the global organization of the brain into the right and left hemispheres, four cortical lobes, and the deeper sub-cortical structures. Functions of different parts of the brain are described, with an emphasis on how most complex bodily and mental functions require the coordination of many parts of the brain at once.

Key Terms
cerebrum
brain stem
cerebellum
anterior
posterior

Cerebral cortex
right hemisphere
left hemisphere
frontal lobe
parietal lobe
temporal lobe
occipital lobe

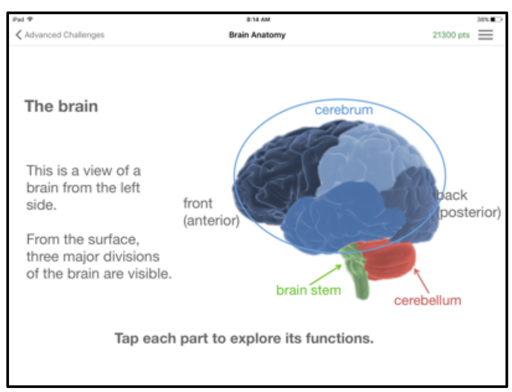
Forebrain
midbrain
hindbrain

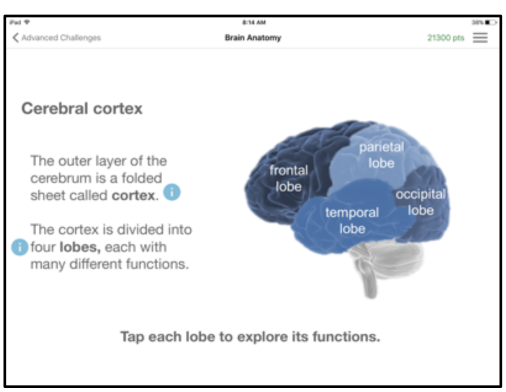
Sub-cortical structures
amygdala
corpus callosum
thalmus
hypothalamus
hippocampus

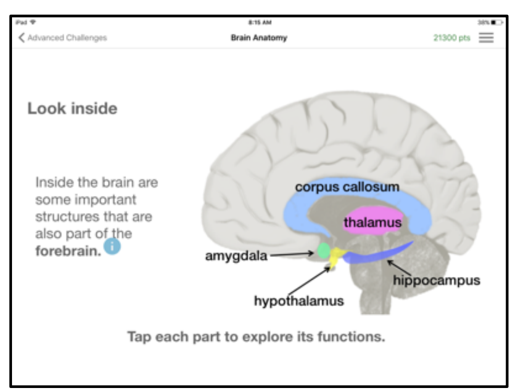
Questions for further inquiry
Is it true that you only use 10% of your brain? *Answer: Absolutely not! That's a myth that's been floating around for a long time. Every part of your brain will be active at one point or another.*

Are some people "right-brained" and others "left-brained? *Answer: Not really. The right and left hemispheres work together. Some functions are slightly more specialized to one hemisphere – e.g., language processing in the left. But everyone needs both hemispheres to think, feel, and act.*

How many neurons are in the brain? *Answer: the current estimate is around 86 billion. That's a lot of brain power. If you tried to count from 1 to 86 billion, it would take you over 30 years!*







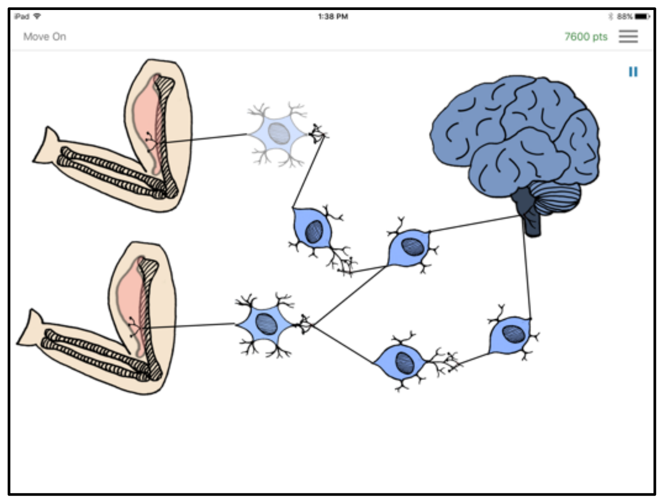
Free Play

iNeuron™

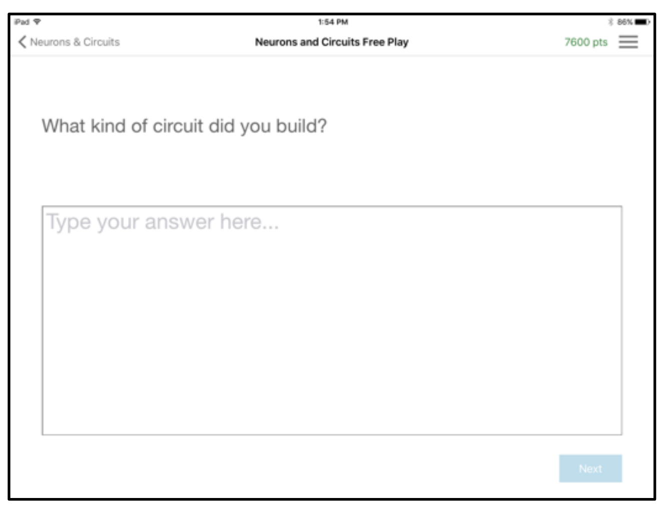
Summary

Free Play or open-ended challenges are available in every section beginning with Neurons & Circuits. There is no goal to achieve in Free Play; instead, students are encouraged to set their own goals to build and explore different kinds of circuits using the pieces provided. When students are done exploring they should tap "Move On" in the upper left corner of the screen. They will then be prompted to provide a brief short-answer description of their circuit.

Tap "Move On" to continue



Type a description of what you did in Free Play



Group Play

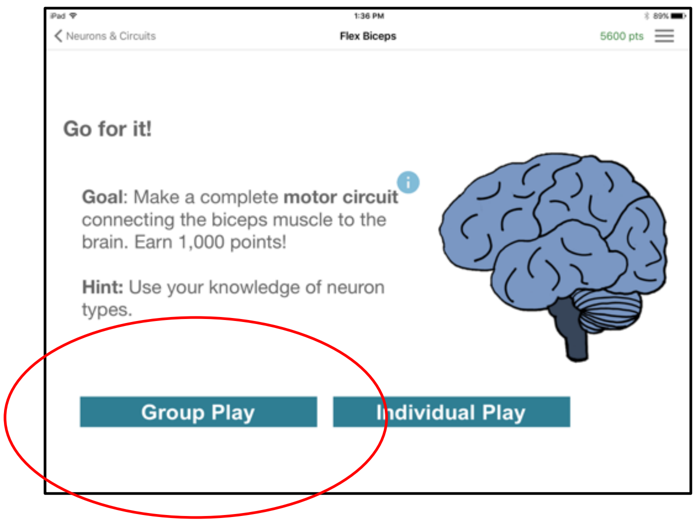
iNeuron™

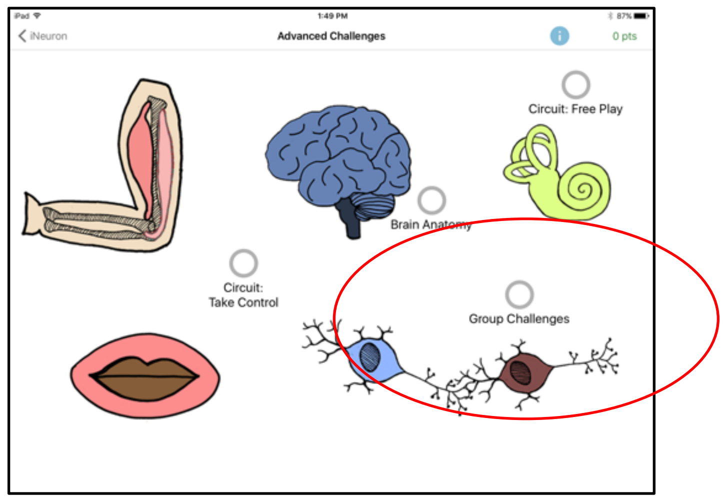
Summary

Most circuit-building challenges in iNeuron may be played either individually or in groups. In group play, students communicate across their devices using Wi-Fi or Bluetooth to collaboratively solve a challenge. Because most challenges contain 3-4 pieces that can be manipulated, groups of 2-4 students are optimal.

Accessing Group Play

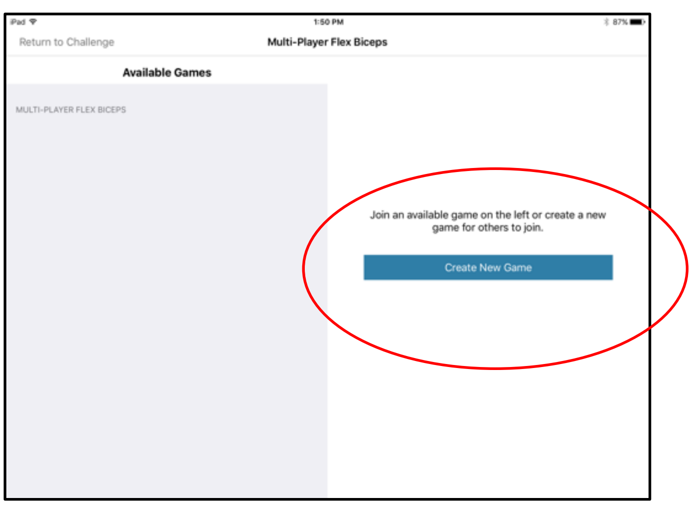
From within a single challenge, students can select either "Group Play" or "Individual Play" before they begin. To access all of the Group Play challenges at once, students go to the section Advanced Challenges and then Group Challenges.

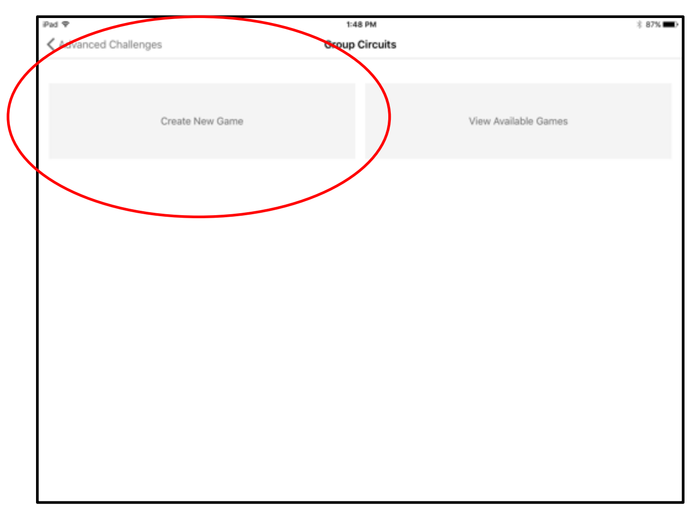




Starting a Game

The group chooses one student to be the game creator. That student taps the "Create New Game" button. If starting a game from the Advanced Challenges section, the game creator will then select the desired challenge from a list. When all users have joined the game the game creator taps the "Start Game" button on his or her device.

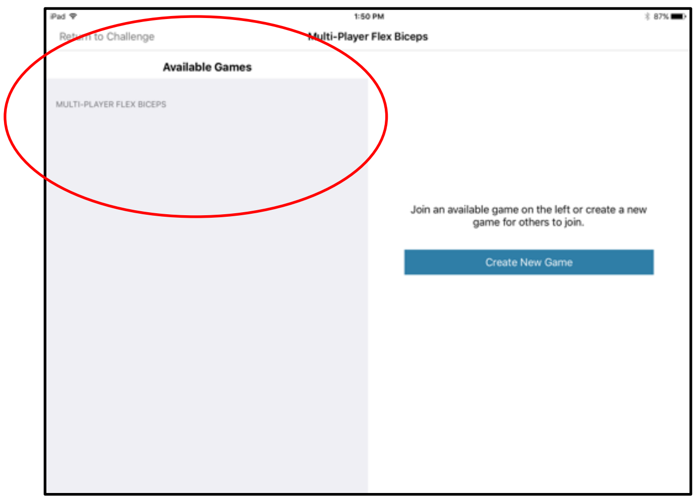


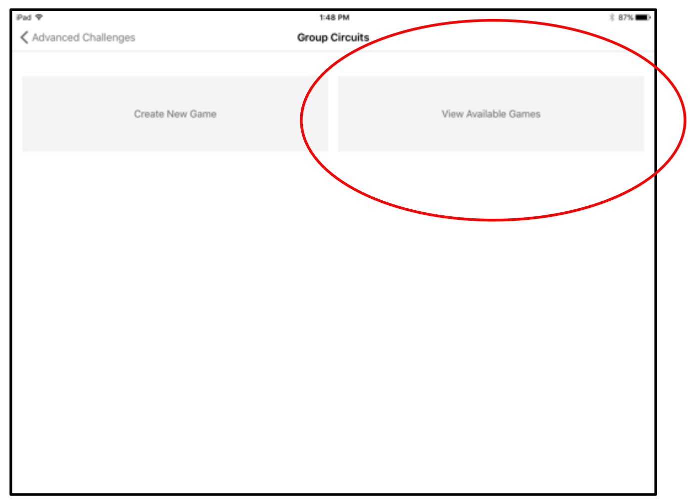


Group Play

iNeuron™

Joining a Game:
Other students in the group will see the game creator's user name appear under the list of Available Games within the challenge, or by tapping the "View Available Games" button from the Advanced Challenges section. They should tap that student's user name to join the game. They must wait until the game creator sees all users appear on his or her device and then taps "Start Game".





Making Connections
Once the game is started each piece will be randomly assigned to students in the group. A student may be assigned more than one piece. A student may only move and control the pieces that are assigned to him or her.

To connect two pieces, slide the pieces together until the plus sign appears. A student who controls one of the pieces must tap the plus sign and then the student who controls the other piece must also tap the plus sign on his or her device within 3 seconds. A countdown timer appears over the plus sign to indicate when a connection is being attempted with a student's piece. A notification will pop up when pieces have been successfully connected.

Solving a Challenge
The challenge goal is the same whether it is played individually or in group play. Students in group play will see a notification pop up on their devices when the challenge's goal has been met.