

# Explore Brains & Neurons: The Teenage Brain

## OVERVIEW

Students will investigate how the brain works by exploring the characteristics of neurons, how neurons communicate, and the plasticity of the brain. Students will also explore what we know about the teenage brain and how substances such as drugs (e.g. caffeine, alcohol) affect our brain and its functions.

### NYS Science Core Curriculum

**LE 5.3a:** Dynamic equilibrium results from detection of and response to stimuli. Organisms detect and respond to change in a variety of ways both at the cellular level and at the organismal level.

## BACKGROUND FOR EDUCATOR

Our brain has sensing, emotional, thinking, and memory functions. All these functions ultimately depend on how neurons work. During adolescence neurons branch and form new connections. The more we use certain neuronal paths, the stronger they become. And unused connections weaken and fade away. The adolescent brain is still strengthening connections between its reasoning and emotion-related regions. In addition, the reward center of the brain is more active during adolescence than in adulthood. These findings would explain why teenagers have weak cognitive control over high-risk behaviors such as drug and alcohol use, and why their brains are affected differently than adult brains.

## BEFORE YOUR VISIT

### Class Discussion: Explore Our Brain

Use the following true/false statements to surface misconceptions and to stimulate a class discussion. Ask students what surprised them. Refer to the last page for more information on why these statements are false.

- Your brain stops developing once you've reached adulthood. (*False*)
- New neurons can't be created. (*False*)
- Touching the brain would hurt. (*False*)
- When we're asleep our brains are at rest. (*False*)
- People with larger brains are smarter than people with smaller brains. (*False*)
- Thinking is separate from emotions. (*False*)
- Memories are stored in the brain like a computer. (*False*)
- Things like language and memory reside in specific targeted areas of the brain. (*False*)

**Plan how your students will explore *Brain: The Inside Story* using the four different student worksheets.** Jigsaw is a collaborative learning strategy that includes "home groups" and "expert groups". Before coming to the Museum, set up the jigsaw by forming home groups (groups of four students). Within each home group, each student chooses to become an expert in one of four areas: "1: Your Sensing Brain", "2: Your Emotional Brain", "3: Your Thinking Brain", and "4: Your Changing Brain". Distribute the corresponding worksheets to the expert groups. You may want to review the worksheets and the map of the exhibition with them to make sure they understand what they are to do.

**Write on the board:** "Your Sensing Brain", "Your Emotional Brain", "Your Thinking Brain", and "Your Changing Brain". Divide students into groups of three and have them come up with examples of how they use each of these "parts" of their brain.

*(Sample answer: When I meet with my friend, I use my thinking brain to decide what transportation I'll take; my sensing brain when I use my vision to look at my friend and my hearing when I listen to what he/she says; my emotional brain when I'm afraid he/she will be mad at me because I'm late; and my changing brain when the experience of seeing my friend again strengthens the neural connections in my brain.)*

**Have each group come up with three to five questions** that they have about the brain. You may wish to have them look for answers to these questions as they explore the *Brain* exhibition.

## DURING YOUR VISIT

### **Brain: The Inside Story Exhibition**

#### **3rd floor (45 minutes)**

Have the four expert groups investigate the exhibition using the corresponding student worksheets: “1: Your Sensing Brain”, “2: Your Emotional Brain”, “3: Your Thinking Brain”, and “4: Your Changing Brain”. While all students will explore how neurons work and communicate in the Your Sensing Brain section, each expert group will investigate in-depth a specific section of the exhibition. You may wish to have students work in pairs to keep the exploration manageable and focused.

### **Spitzer Hall of Human Origins**

#### **1st floor (20 minutes)**

Have students explore the third section of the exhibit “What Makes Us Human?” and take notes of the different abilities that seem to be unique to humans. Using the information gathered during the visit to the *Brain* exhibit, have students identify the regions of the brain that would be more related to those abilities that seem unique to humans.

## BACK IN THE CLASSROOM

### **Activity: Our Sensing, Emotional, Thinking, and Changing Brain**

To complete the jigsaw, have experts return to their home groups to share what they learned about their in-depth section. Encourage them to help each other develop a deeper understanding of the brain and how it works.

### **Activity: The Teenage Brain**

#### **Inside the Teenage Brain: [sciencebulletins.amnh.org/?sid=h.s.teen\\_brain.20100614](http://sciencebulletins.amnh.org/?sid=h.s.teen_brain.20100614)**

Have students explore this Human Bulletins Snapshot, which shows how neuroscientists’ findings on the development of the brain in adolescence would explain the weak cognitive control over high-risk behaviors in adolescence. Divide students in groups and have them compare this Human Bulletin with their student worksheets. Ask students to review what they learned about functions and regions of the brain in the exhibition and apply this knowledge by completing the chart below.

<b>BRAIN FUNCTIONS AFFECTED BY ALCOHOL</b>	<b>REGION OF THE BRAIN THAT PARTICIPATE IN THOSE FUNCTIONS</b>
<b>1. Sensory perception such as vision, hearing</b>	<i>(Answer: visual cortex and auditory cortex)</i>
<b>2. Ability to speak</b>	<i>(Answer: language cortex)</i>
<b>3. Judgment</b>	<i>(Answer: prefrontal cortex)</i>
<b>4. Body automatic functions like breathing and heartbeat</b>	<i>(Answer: brain stem)</i>
<b>5. Motor skills, coordination, and reaction time</b>	<i>(Answer: motor cortex, cerebellum)</i>
<b>6. Balance</b>	<i>(Answer: cerebellum)</i>

### ONLINE RESOURCES

#### **Science Bulletins (Human Bulletins)**

[amnh.org/sciencebulletins](http://amnh.org/sciencebulletins)

#### ***Nature Neuroscience: A Unique Adolescent Response to Reward Prediction Errors***

[nature.com/neuro/journal/v13/n6/full/nn.2558.html](http://nature.com/neuro/journal/v13/n6/full/nn.2558.html)

#### ***Discovery News: Teen Brain Wired to Take Risks***

[news.discovery.com/human/teenager-brain-risky-behavior.html](http://news.discovery.com/human/teenager-brain-risky-behavior.html)

#### **PBS Frontline: Inside the Teenage Brain**

[pbs.org/wgbh/pages/frontline/shows/teenbrain/](http://pbs.org/wgbh/pages/frontline/shows/teenbrain/)

#### **Teenager Growth**

[teengrowth.com/index.cfm?action=info\\_article&ID\\_article=1372](http://teengrowth.com/index.cfm?action=info_article&ID_article=1372)

#### **SNF Brain Briefings: Adolescent Brain**

[sfn.org/index.aspx?pagename=brainBriefings\\_Adolescent\\_brain](http://sfn.org/index.aspx?pagename=brainBriefings_Adolescent_brain)

**Brain Quiz Answers**

- **Your brain stops developing once you've reached adulthood.** (False)

*Your brain began forming before you were born, building the intricate network of neurons that help you survive in the world. Once developed, the basic structures for sensing, feeling and thinking last for a lifetime—yet your brain continues to change. The neural connections keep making adjustments with every experience and everything that you learn.*

- **New neurons can't be created.** (False)

*Scientists once assumed that after early childhood, the number of neurons in the brain was fixed, and no new ones could ever form. But recent research has shown that new neurons form throughout life in at least two areas of the brain: the hippocampus, which helps memories form, and the olfactory bulb, which processes smell.*

- **Touching the brain would hurt.** (False)

*The brain doesn't have pain receptors, thus it can't hurt. When we have headaches, the pain is caused by disturbance of the pain-sensitive structures around the brain. Several areas of the head and neck have these pain-sensitive structures: (a) within the cranium (e.g. blood vessels, meninges, and cranial nerves) and (b) outside the cranium (the periosteum of the skull, muscles, nerves, arteries and veins, subcutaneous tissues, eyes, ears, sinuses and mucous membranes).*

- **When we're asleep our brains are at rest.** (False)

*Sleep can be described by reduced or lack of consciousness, relatively suspended sensory and non-motor activity, and inactivity of nearly all voluntary muscles. However, the brain is far from being at rest when we sleep. Scientists described the sleep cycle having five stages through the night: 1, 2, 3, 5 and REM (rapid eye movement) sleep.*

- **People with larger brains are smarter than people with smaller brains.** (False)

*Although this was a belief commonly held and debated in the 19th and early 20th centuries, brain size among individuals does not vary significantly. The brains of people who were widely considered to be smarter than most, turned out to be average-sized.*

- **Thinking is separate from emotions.** (False)

*Emotions tell you how important things are to you, whether your needs are being met and what you want to do about it. Your rational brain this input is "crippled." In the same way, your thinking brain or cognitive part works regulating your emotional responses and impulses.*

- **Memories are stored in the brain like a computer.** (False)

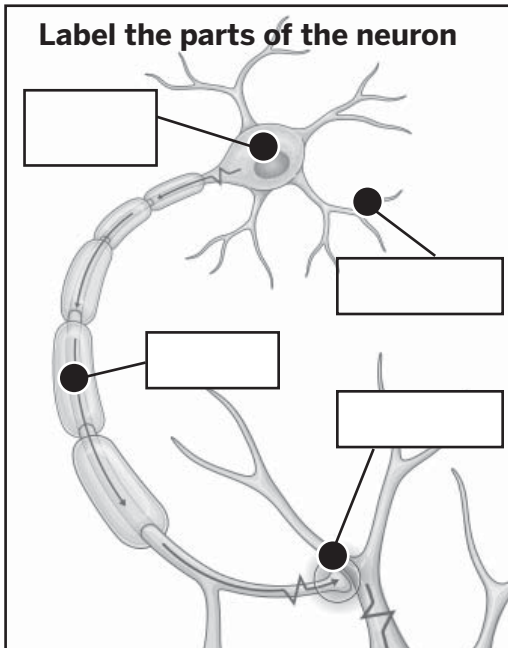
*Although the computer analogy is useful to visualize the interconnectedness of the neuronal network in the brain, memory in the brain is much more complex. While computers work based on bits of information, it seems that the brain stores information by enhancing neuronal connections, therefore, enhancing the synthesis of proteins for the formation of new dendrites and neurotransmitters, which will be involved in the connections and transmission of information. In addition, our brains have an emotional memory, which helps (and some hinders) our behaviors.*

- **Things like language and memory reside in specific targeted areas of the brain.** (False)

*Although we can identify specific areas related to language (language cortex) and memory (hippocampus for long-term memory; basal ganglia for procedural memory; amygdala for emotional memory; and prefrontal cortex, for short-term memory), they never work in isolation.*

**1 Investigate Neurons**

Record your answers to the following questions on a separate page.



At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”

- **What are neurons and why are they important?**
- **What happens when two neurons connect at the synapse?**

Next, go back and find the homunculus model and the panel “Feeling With Your Brain”.

- **Describe or illustrate the process in which neurons relay touch signals from your finger to your brain.**

**2 Investigate Your Sensing Brain**

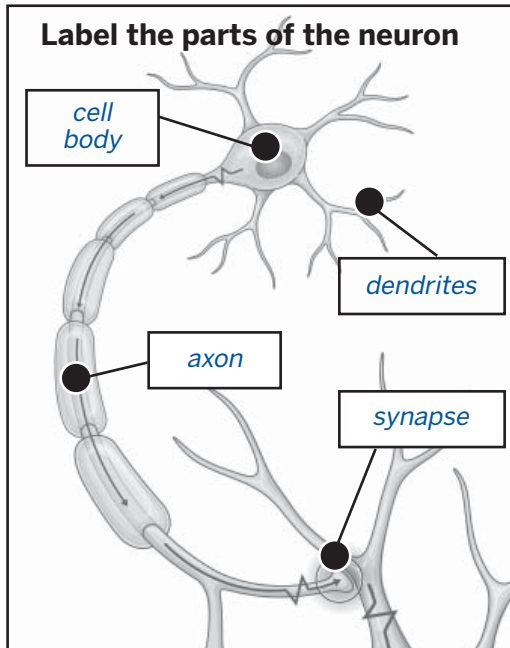
Explore the rest of this section. **Use illustrations and models of the brain to fill out this chart.**

<b>Which part of your brain is triggered when you are...</b>	<b>Main Brain Part(s)</b>	<b>Think of another real-life example that uses these parts</b>
Eating a bowl of hot soup		
Listening to your favorite song		
Reading news online		
Climbing the rope in gym class		

**ANSWER KEY**

**1 Investigate Neurons**

At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”



**• What are neurons and why are they important?**

*(Answer: Neurons are cells specialized for communication of information. They form an interconnected network that is the basis for all brain function, allowing us to connect with the outside world, make thinking possible, and allow us to survive.)*

**• What happens when two neurons connect at the synapse?**

*(Answer: There is a transmission of signals via chemical messengers called neurotransmitters. This is how neurons communicate information.)*

Next, go back and find the homunculus model and the panel “Feeling With Your Brain”.

**• Describe or illustrate the process in which neurons relay touch signals from your finger to your brain.**

*(Answers may include: 1. Nerve endings in my skin transfer pressure, texture, heat, and pain into electrical signals. 2. Signals travel up my spinal cord to the thalamus, a kind of relay station that sends sensory information to different parts of the brain. 3. A long, narrow region called the somatosensory cortex takes in the signals. Different parts of this touch region process signals from different parts of the body.)*

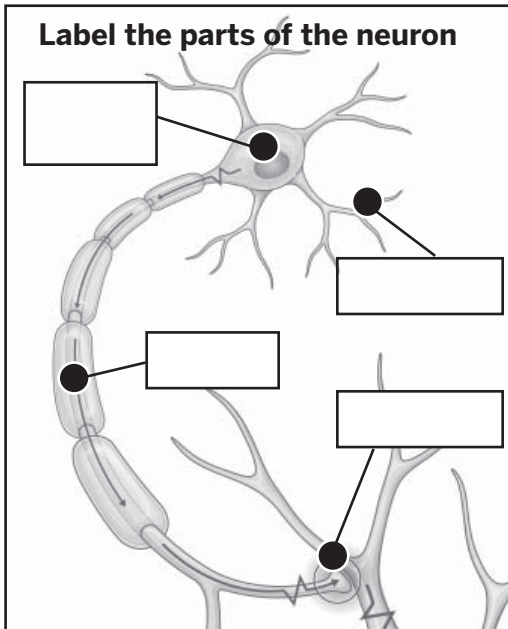
**2 Investigate Your Sensing Brain**

Explore the rest of this section. **Use illustrations and models of the brain to fill out this chart.**

Which part of your brain is triggered when you are...	Main Brain Part(s)	Think of another real-life example that uses these parts
Eating a bowl of hot soup	<i>(Answers may include: gustatory cortex, olfactory cortex, somatosensory cortex)</i>	<i>(Sample answer: tasting cereal)</i>
Listening to your favorite song	<i>(Answers may include: auditory cortex, hippocampus [long-term memory], limbic system (emotion), Wernicke's area [understanding language])</i>	<i>(Sample answer: listening to the teacher)</i>
Reading news online	<i>(Answers may include: visual cortex, the Wernicke's area [understanding language])</i>	<i>(Sample answer: reading a book)</i>
Climbing the rope in gym class	<i>(Answers may include: motor cortex, visual cortex, somatosensory cortex, cerebellum, brainstem)</i>	<i>(Sample answer: playing handball)</i>

**1 Investigate Neurons**

Record your answers to the following questions on a separate page.



At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”

- **What are neurons and why are they important?**
- **What happens when two neurons connect at the synapse?**

Next, go to the *Your Emotional Brain* section and explore the “How Do You Feel?” interactive.

- **Did you choose to take the cookie or to please your mom? How did the decisions you make affect the levels of brain chemicals in your brain?**

Go to the “Drugs” panel. Compare the effects of caffeine versus cocaine and heroine.

- **How do their effects differ at the neuronal level?**

**2 Investigate Your Emotional Brain**

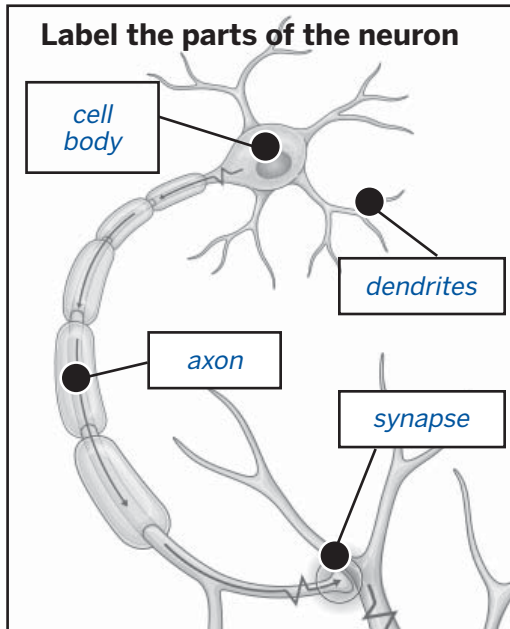
Explore the rest of this section. **Use illustrations and models of the brain to fill out this chart.**

<b>Which part of your brain is triggered when you are...</b>	<b>Main Brain Part(s)</b>	<b>Think of another real-life example that uses these parts</b>
Climbing the rope in gym class		
Recalling the fun summer trip		
Catching your breath after running for the bus		
Getting anxious about an exam		

**ANSWER KEY**

**1 Investigate Neurons**

At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”



**• What are neurons and why are they important?**

*(Answer: Neurons are cells specialized for communication of information. They form an interconnected network that is the basis for all brain function, allowing us to connect with the outside world, make thinking possible, and allow us to survive.)*

**• What happens when two neurons connect at the synapse?**

*(Answer: There is a transmission of signals via chemical messengers called neurotransmitters. This is how neurons communicate information.)*

Next, go to the *Your Emotional Brain* section and explore the “How Do You Feel?” interactive.

**• Did you choose to take the cookie or to please your mom? How did the decisions you make affect the levels of brain chemicals in your brain?**

*(Sample answer: If I choose to take the cookie, the level of dopamine rises, but soon the memory of my Mom makes the level of stress hormones rise. Now if I turn the cookie back, the level of dopamine and stress hormones drop; but if I go ahead and eat the cookie, the feeling of dangers makes stress hormones go up. If I choose to obey my Mom, the level of dopamine in my brain drops. Frustrated, I decide to take a ride on my bike, and the exercise increases the level of endorphins. I later chose to ask my Mom for a cookie, which increases the levels of dopamine and oxytocin.)*

Go to the “Drugs” panel. Compare the effects of caffeine versus cocaine and heroine. **• How do their effects differ at the neuronal level?**

*(Answer: Caffeine keeps us awake by blocking the neurotransmitter adenosine, which normally triggers receptors that make us sleepy. Drugs such as cocaine and heroine replicate the feeling of reward or pleasure, such as eating chocolate or being “in the zone” when running. However, drugs take a shortcut, producing the feeling of pleasure without the useful behavior, which can lead to addiction)*

**2 Investigate Your Emotional Brain**

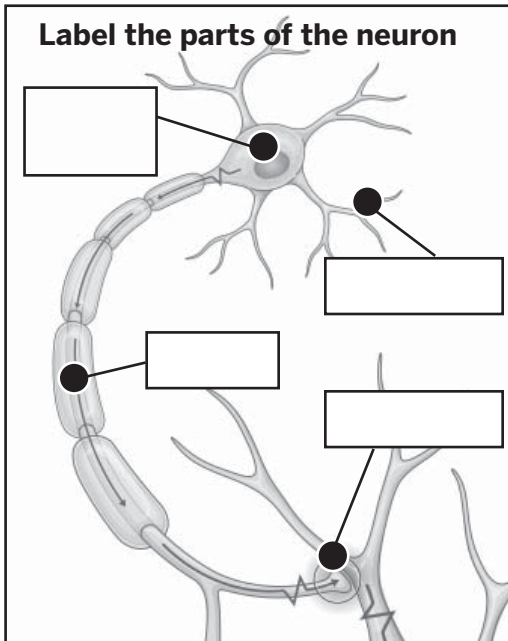
Explore the rest of this section. **Use illustrations and models of the brain to fill out this chart.**

Which part of your brain is triggered when you are...	Main Brain Part(s)	Think of another real-life example that uses these parts
Climbing the rope in gym class	<i>(Answers may include: motor cortex, visual cortex, somatosensory cortex, cerebellum, brainstem)</i>	<i>(Sample answer: playing handball)</i>
Recalling the fun summer trip	<i>(Answers may include: hippocampus [long-term memory], amygdala [emotional memory])</i>	<i>(Sample answer: remembering the plot of a movie I watched when I was 10 years old)</i>
Catching your breath after running for the bus	<i>(Answers may include: brainstem (regulation of breathing and heartbeat)</i>	<i>(Sample answer: my heart beats faster when I’m very nervous)</i>
Getting anxious about an exam	<i>(Answers may include: amygdala [emotions and emotional memory], hippocampus [long-term memory], hypothalamus [regulation of body changes related to emotions])</i>	<i>(Sample answer: worrying about my parent’s health)</i>



**1 Investigate Neurons**

Record your answers to the following questions on a separate page.



At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”

- **What are neurons and why are they important?**
- **What happens when two neurons connect at the synapse?**

Next, go to the *Your Thinking Brain* section. On the panels circling the large model of the brain stem and limbic system, examine DSI images of the brain.

- **What do the DSI scans reveal about how the brain works?**

**2 Investigate Your Thinking Brain**

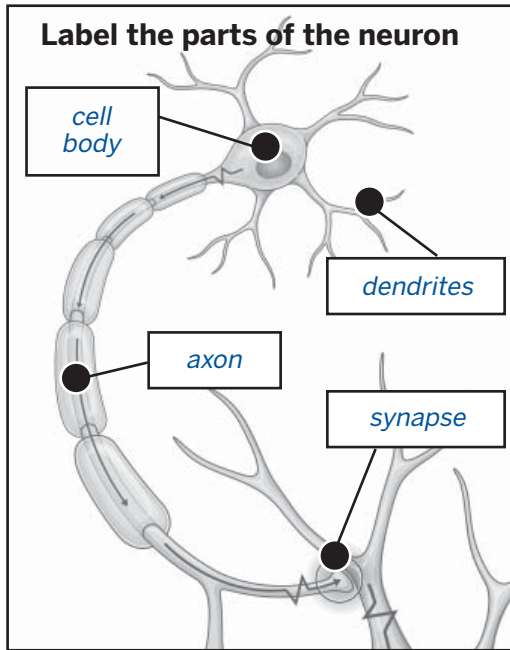
Explore the rest of this section. **Use illustrations and models of the brain to fill out this chart.**

<b>Which part of your brain is triggered when you are...</b>	<b>Main Brain Part(s)</b>	<b>Think of another real-life example that uses these parts</b>
Listening to your favorite song		
Reading news online		
Deciding what’s the best route to get to the next class		
Paying attention to what the teacher is saying		

**ANSWER KEY**

**1 Investigate Neurons**

At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”



**• What are neurons and why are they important?**

*(Answer: Neurons are cells specialized for communication of information. They form an interconnected network that is the basis for all brain function, allowing us to connect with the outside world, make thinking possible, and allow us to survive.)*

**• What happens when two neurons connect at the synapse?**

*(Answer: There is a transmission of signals via chemical messengers called neurotransmitters. This is how neurons communicate information.)*

Next, go to the *Your Thinking Brain* section. On the panels circling the large model of the brain stem and limbic system, examine DSI images of the brain.

**• What do the DSI scans reveal about how the brain works?**

*(Answers may include: DSI scans reveal the countless neural connections between various brain parts in three dimensions. The images show how various regions of the brain work together, and the importance of the connections between them.)*

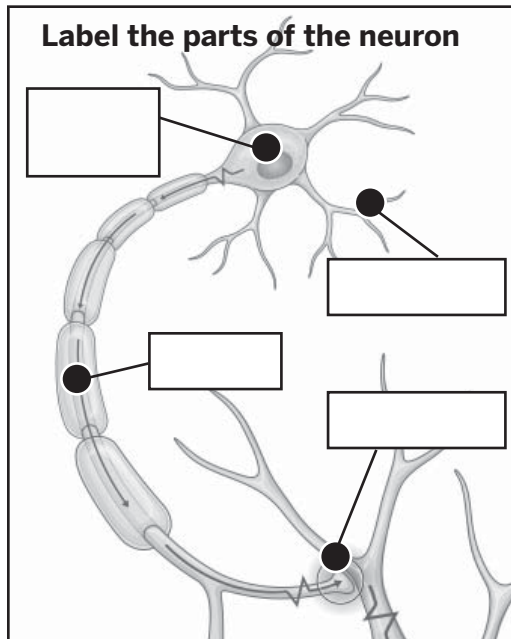
**2 Investigate Your Thinking Brain**

Explore the rest of this section. **Use illustrations and models of the brain to fill out this chart.**

Which part of your brain is triggered when you are...	Main Brain Part(s)	Think of another real-life example that uses these parts
Listening to your favorite song	<i>(Answers may include: auditory cortex, hippocampus [for memory], limbic system [emotion], Wernicke's area [understanding language])</i>	<i>(Sample answer: listening to the teacher)</i>
Reading news online	<i>(Answers may include: visual cortex, Wernicke's area [understanding language])</i>	<i>(Sample answer: reading a book)</i>
Deciding what's the best route to get to the next class	<i>(Answers may include: prefrontal cortex [planning], hippocampus [long-term memory])</i>	<i>(Sample answer: playing video games, thinking about my future)</i>
Paying attention to what the teacher is saying	<i>(Answers may include: prefrontal lobe, visual cortex, auditory cortex, hippocampus [long-term memory], Wernicke's area [understanding language])</i>	<i>(Sample answer: paying attention to the dialogue in my favorite TV show)</i>

**1 Investigate Neurons**

Record your answers to the following questions on a separate page.



At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”

- **What are neurons and why are they important?**
- **What happens when two neurons connect at the synapse?**

Next, go to the *Your Changing Brain* section and explore the Growing, Living, and Aging panel.

- **What’s happening in your brain as you repeat an experience or memory?**
- **Why are teens more vulnerable to addiction?**

**2 Investigate Your Changing Brain**

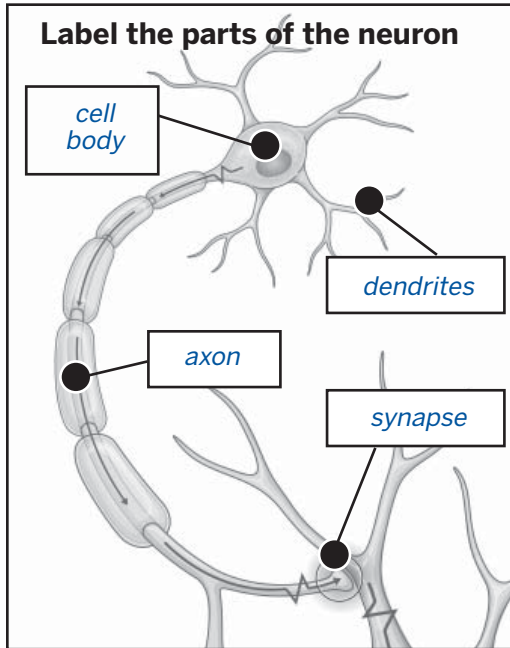
Explore the rest of this section and **fill out this chart**.

<b>Which part of the brain is triggered when...</b>	<b>Main Brain Part(s)</b>	<b>Think of another real-life example that uses these parts</b>
A baby learns to see		
A teenager practices the piano everyday		
New neurons form		
A blind person reads Braille		

**ANSWER KEY**

**1 Investigate Neurons**

At the end of the *Your Sensing Brain* section, look for the panel “What is a neuron?”



**• What are neurons and why are they important?**

*(Answer: Neurons are cells specialized for communication of information. They form an interconnected network that is the basis for all brain function, allowing us to connect with the outside world, make thinking possible, and allow us to survive.)*

**• What happens when two neurons connect at the synapse?**

*(Answer: There is a transmission of signals via chemical messengers called neurotransmitters. This is how neurons communicate information.)*

Next, go to the *Your Changing Brain* section and explore the Growing, Living, and Aging panel.

**• What’s happening in your brain as you repeat an experience or memory?**

*(Answer: the neuronal circuit or pathway involved in that experience or memory is reinforced by the addition of new connection between neurons. This changes the brain, which scientists call plasticity of the brain.)*

**• Why are teens more vulnerable to addiction?**

*(Answers may include: A teenager’s brain is supple and open to change, and skills learned at this age are likely to last a lifetime. For the same reasons, risky habits picked up during the teenage years, such as alcohol and drug abuse, are especially hard to shake. Scientists have found that the adolescent brain is still strengthening connections between its reasoning and emotion-related regions. In addition, the reward center of the brain is more active during adolescence than in adulthood. These findings would explain the weak cognitive control over high-risk behaviors, such as drug use in adolescence.)*

**2 Investigate Your Changing Brain**

Explore the rest of this section and **fill out this chart.**

Which part of the brain is triggered when...	Main Brain Part(s)	Think of another real-life example that uses these parts
A baby learns to see	<i>(Answers may include: visual cortex)</i>	<i>(Sample answer: reading a book)</i>
A teenager practices the piano everyday	<i>(Answers may include: prefrontal cortex, motor cortex, auditory cortex, basal ganglia [procedural memory], hippocampus [long-term memory])</i>	<i>(Sample answer: solving math equations)</i>
An adult brain forms new neurons	<i>(Answers may include: hippocampus, olfactory bulb)</i>	<i>(Sample answer: forming memories, smelling food)</i>
A blind person reads Braille	<i>(Answers may include: visual cortex, somatosensory cortex)</i>	<i>(Sample answer: writing Braille)</i>