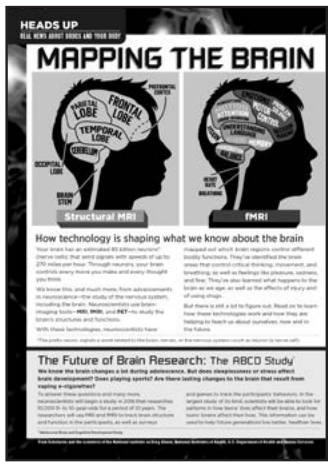


SUBJECT

- Science Literacy
- English/Language Arts
- Health/Life Skills

COMMON CORE STATE STANDARDS

- RST.9 Analyze structure of relationships among concepts in a text
- W.9 Draw evidence to support analysis and reflection

NEXT GENERATION SCIENCE STANDARDS

- LS1.A Structure and Function
- LS1.D Information Processing

NATIONAL SCIENCE EDUCATION STANDARDS

- Structure and Function in Living Things
- Personal and Community Health

Additional Teaching Resources:

- **headsup.scholastic.com/teachers**
- **teens.drugabuse.gov**

MAPPING THE BRAIN

NIH National Institute on Drug Abuse

The brain is the body's most complex organ, controlling everything from our heartbeat to how we make important decisions. Through research and the use of brain-imaging tools, neuroscientists are learning just how critical the teen years are for brain development. This article explains for students how brain-imaging techniques work, how they apply to their lives, and also highlights some of the things neuroscientists have learned about drug use. It may also inspire them to want to learn more about neuroscience!

Critical-Thinking Questions:

1. How does the fMRI tool help show how teens think about risks and rewards? *(The fMRI can show more brain activity for teens in the area that processes motivation and pleasure than that used for decision making. This shows that teens may focus more on rewards and less on risks when making decisions.)*

2. Describe how each tool highlighted in the article teaches something different about the relationship between the brain and using drugs. *(Structural MRI scans can show changes in a person's brain structure as a result of using drugs. Functional MRIs [fMRI] show that teens may focus more on rewards and less on risks when making decisions—which can increase risks for using drugs. PET scans have shown that heavy drug use can reduce the number of dopamine receptors.)*

3. How might brain research, such as the ABCD Study, help doctors in their jobs? *(Doctors can use brain research to better understand how the teen brain works and how teen behavior impacts it. This information can help future generations.)*

Writing Prompts:

- What are two ways using drugs may affect the brain?
- Describe one of these three brain imaging technologies: structural MRI, fMRI, and PET.
- How might changes in the brain caused by using drugs make it more difficult for a person to stop using drugs?

Paired Reading, Writing Prompts:

- "Wiring Your Brain," **headsup.scholastic.com/students/wiring-your-brain**

  Writing Prompt: Evaluate the statement: "Using drugs can affect brain development."

- "The Awesomely Evolved Human Brain," **headsup.scholastic.com/students/awesomely-evolved-human-brain**

  Writing Prompt: Explain the role of dopamine in the brain and how it might affect behavior.

Tiered Vocabulary Tools:

Visit **scholastic.com/headsup/brain-imaging-tools** for vocabulary printables that support the student article and lesson.

Video Extension:

"The Human Brain: Major Structures and Functions," **https://teens.drugabuse.gov/videos**

After reading the article, watch this short video with your students and ask them what new information about the brain they learned. Discuss how brain imaging may have helped scientists to learn facts explained in the video. Have students write down at least one question they still have about the brain after reading the article and watching the video. Ask them to conduct additional research, and write a 3–4 paragraph report on their findings.

Student Work Sheet: "Can You Think Like a Neuroscientist?"

The skills sheet on the reverse side has students imagine they are neuroscientists studying the brain.

Answer Key:

1) a. Structural MRI; structure. **b.** Starting from write-in box, upper right, clockwise: frontal lobe; prefrontal cortex; brain stem; cerebellum; occipital lobe; temporal lobe; parietal lobe

2) fMRI; function

3) a. PET scan; the cellular level **b.** The scans show that using drugs contributes to a decrease in dopamine activity.

4) Structural MRI would be used to track changes in the size of the prefrontal cortex because this tool produces pictures showing the size and shape of brain areas.

5) fMRI imaging could show which areas of the brain are involved in making risky decisions. This tool shows which areas of the brain are most active during certain behaviors and functions.

[Continue to work sheet on next page.]

Supplement to Scholastic magazines. Scholastic and associated logos are trademarks and/or registered trademarks of Scholastic Inc. All rights reserved.
NIDA 16–17; Insert 1—Act.

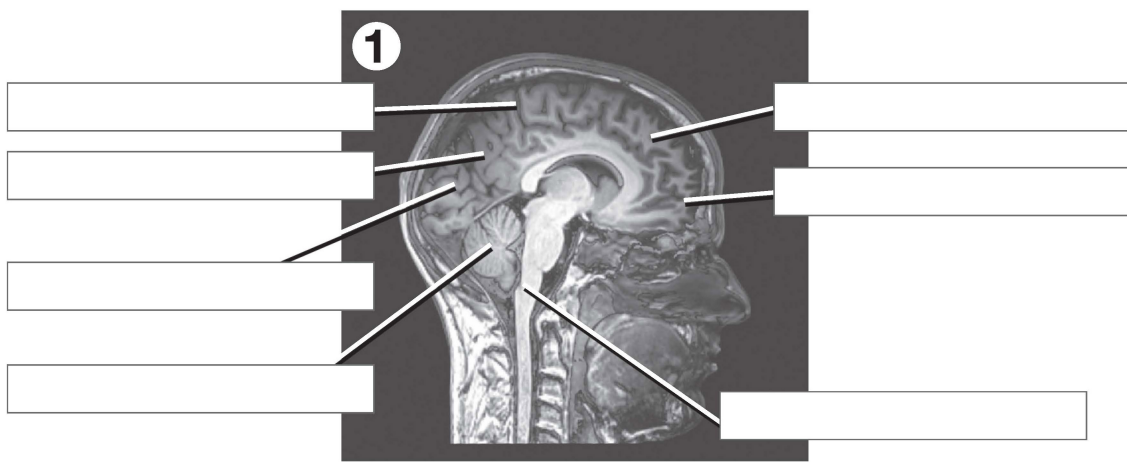
STUDENT WORK SHEET

Can You Think Like a Neuroscientist?

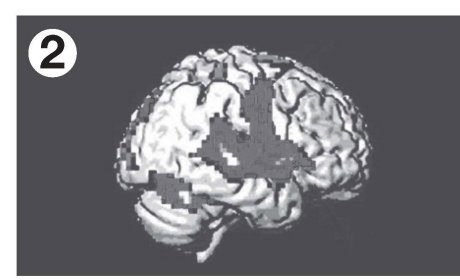
Use the information from "Mapping the Brain" and the real brain scans below to answer the questions. Record your responses on a separate sheet of paper if necessary.

1. a. The image below shows regions of the brain. Compare it with the scan in the article. What kind of information about the brain does it provide (structure, function, or cellular)?

b. Label the highlighted regions of the brain.

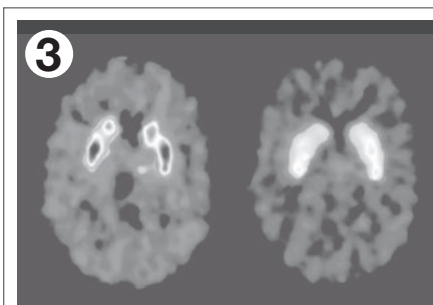


2. The image at right shows brain activity levels while a person is laughing. What type of scan is shown? What kind of information does it provide?



3. a. These images (below right) were created using radiotracers that attached to cells in the brain. What type of scan is shown? What kind of information does it provide?

b. Dopamine is the brain chemical that helps us feel pleasure. Dopamine levels are higher in the brain on the left. What does this show about how using drugs affects the brain?



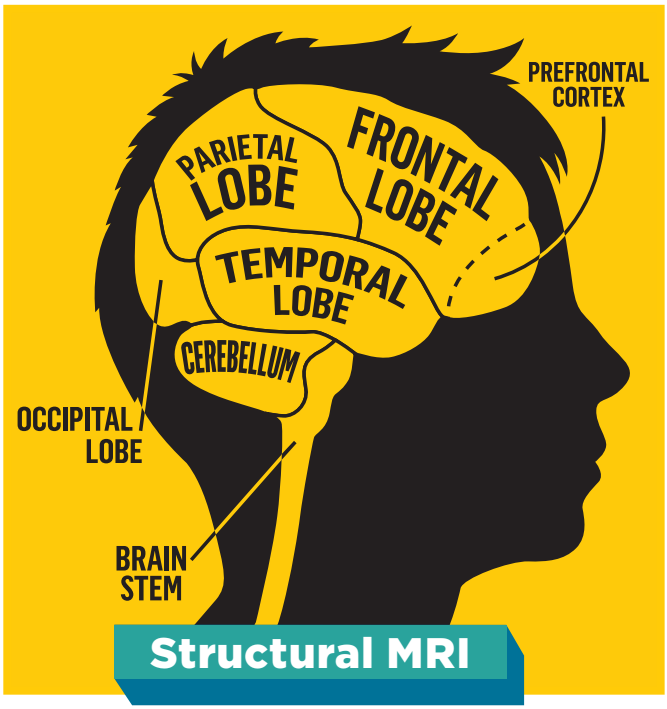
4. Which imaging tool would you use to learn about how the size of the prefrontal cortex changes as kids grow into adulthood? Explain your answer.

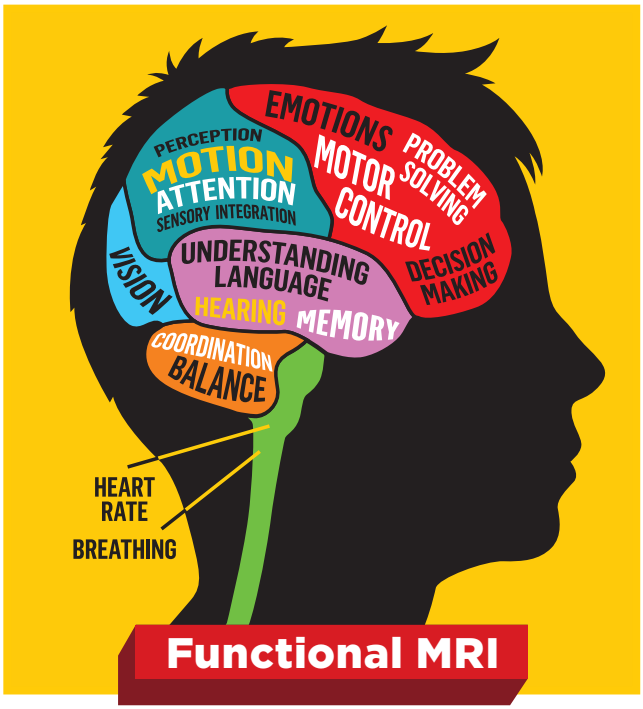
5. What type of imaging technique would you use to find out which areas of the brain are active when a person considers a risky decision? Explain your answer.

Images: from top, © deradrian/Flickr; © 2013, Oxford University Press; Brookhaven National Laboratory.

HEADS UP
REAL NEWS ABOUT DRUGS AND YOUR BODY

MAPPING THE BRAIN





How technology is shaping what we know about the brain

Fact: Through 85 billion neurons* (nerve cells) traveling up to 270 miles per hour, your brain controls every move you make and every thought you think.

How do we know this? The answer is found through neuroscience, the study of the nervous system, including the brain. Scientists study the brain with three very complex tools: **MRI**, **fMRI**, and **PET**.

Using these tools, neuroscientists have learned which areas of the brain control thoughts, movements, and feelings. Every day they learn more about what can hurt the brain, like injury or using harmful drugs. They also learn what can protect the brain, like physical activity and learning new skills.

Read on to learn more about how these tools work and what they are teaching us about ourselves.

*The prefix neuro- shows that a word is related to the brain, nerves, or the nervous system—such as neuron (a nerve cell).

The Future of Brain Research: The ABCD Study[1]

In 2016, neuroscientists will begin the ABCD Study, a landmark study of teen brain development. Neuroscientists with the ABCD Study will use MRI and fMRI to map the brains of 10,000 9–10-year-olds for 10 years. They will also use surveys and games to measure behaviors, like sleep, sports activity, stress, and using drugs. The scientists will look at how teens' lives affect their brains and how teens' brains affect their lives. This is information that can help future generations live better, healthier lives.

[1] Adolescent Brain and Cognitive Development Study

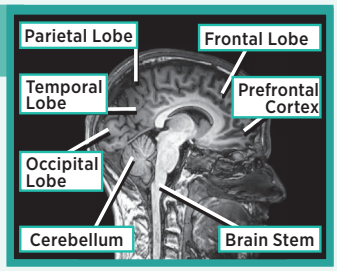
From Scholastic and the scientists of the National Institute on Drug Abuse, National Institutes of Health, U.S. Department of Health and Human Services

Structural MRI
Structural Magnetic Resonance Imaging

WHAT IT SHOWS

Gives a detailed picture of the size and shape of tissues, organs, and bones. It also shows if there is injury or disease.

HOW IT WORKS



A person lies in an MRI machine which surrounds them in a magnetic field while sending out radio waves. Because hydrogen atoms in water are magnetic, this causes differences in how the different areas of the body respond based on the amount of water in organs, muscle, and bones. A computer measures the release of energy from the radio waves and then creates a picture.

SOMETHING WE'VE LEARNED

MRI scans show that people who have used harmful drugs for a long time have a smaller prefrontal cortex than non-drug users. This is the brain area that controls decision making.

Functional MRI (fMRI)
Functional Magnetic Resonance Imaging

WHAT IT SHOWS

Shows the brain areas being used when a person is doing something.

HOW IT WORKS

The color areas in the fMRI above show active brain regions.

A person lies in an MRI machine while doing something, like laughing, looking at an image, or solving a puzzle. Oxygen levels increase in the areas of the brain a person is using. A computer analyzes oxygen changes to map brain function.

SOMETHING WE'VE LEARNED

Scientists have done studies of teens playing games to earn rewards. They report there is higher activity in the areas of the brain that control motivation and pleasure compared with those that control thoughtful decision making. This shows that teens may focus more on the rewards and less on drawbacks of decisions. Thinking like this could increase a person's risk for using drugs.

PET Positron Emission Tomography

WHAT IT SHOWS

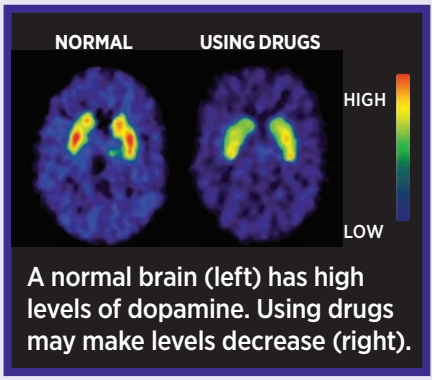
Shows the brain and body at the cellular level.

HOW IT WORKS

Radioactive chemicals, called radiotracers, are injected into the body. Each radiotracer is designed to go to different parts of the body. The PET machine uses color to show the location of the radiotracers.

SOMETHING WE'VE LEARNED

When the brain chemical dopamine locks into its brain receptors, a person feels pleasure. PET scans have shown that heavy use of harmful drugs can reduce the number of dopamine receptors. Fewer receptors means less dopamine activity. This finding helps explain why people addicted to drugs experience less pleasure from everyday activities and crave drugs to feel normal.



A normal brain (left) has high levels of dopamine. Using drugs may make levels decrease (right).

More Info: For additional facts about the brain, visit **scholastic.com/headsup** and **teens.drugabuse.gov**.

Images: clockwise from top left, © deradrian/Flickr; © 2013, Oxford University Press; Brookhaven National Laboratory; background: Sebastian Kaulitzki/Shutterstock.

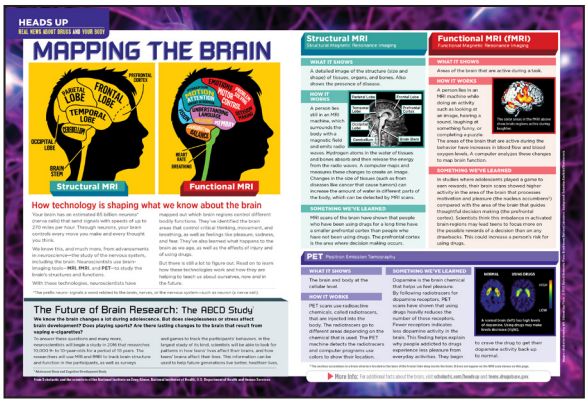
VOCABULARY LIST

GRADES 6–12

Dear Teacher,

The vocabulary list on the following pages is drawn from the "Mapping the Brain" student article and work sheet.

This vocabulary can be previewed with students prior to reading or reinforced with students afterward. Encourage students to incorporate these words into their writing and discussion of the "Mapping the Brain" student article and the "How to Think Like a Neuroscientist" work sheet.



Supplement to "Mapping the Brain"

- Student Article: **scholastic.com /headsup/mappingthebrain**
- Teacher's Guide (includes work sheet): **scholastic.com/headsup/teachers /mappingthebrain**

The vocabulary list integrates two different tiers of vocabulary: words that would be used across several content areas, such as *advancement*, *motivation*, or *process*, and domain-specific words such as *cellular*, *cerebral*, and *chemicals*.

Some suggestions for students to help their understanding include:

- organizing concept maps that include word parts, synonyms, antonyms, and examples;
- composing memory aids that explain the words or use them in a meaningful context;
- employing the words to create newspaper articles, stories, or poems.

Sources: Unless otherwise noted, definitions below are sourced or adapted from:

- Grades 6–8: *The American Education Publishing Children's Dictionary*
- Grades 9–12: *Merriam-Webster Collegiate Dictionary*

[Continue to vocabulary sheet on next page.]

VOCABULARY LIST FROM "MAPPING THE BRAIN"

- **absorb** *(verb)*: to take in or draw in
- **activated** (*adjective)*: to be set into motion; to be made active
- **addicted** *(adjective)*: to be dependent on something and not able to give it up, such as a drug
- **adolescence** *(noun)*: the period of life when a child develops into an adult
- **advancement** *(noun)*: the act, process, or result of moving forward; progress
- **analyze** *(verb)*: to study closely and carefully
- **atom** *(noun)*: the smallest component of an element that can exist by itself, consisting of protons, neutrons, and electrons
- **brain stem** *(noun)*: the lower part of the brain that connects to the spinal cord and controls certain automatic functions, such as breathing
- **cellular** *(adjective)*: of, related to, or made of cells from a living thing
- **cerebellum** *(noun)*: the area of the brain located between the brain stem and the cerebrum that controls voluntary muscle coordination and balance
- **cerebral** *(adjective)*: relating to or involving the cerebrum
- **cerebrum** *(noun)*: the upper part of the brain that is split into two hemispheres. These two hemispheres are referred to as cerebral hemispheres.
- **chemical** *(noun)*: a substance, such as an element or a mix of elements (compound), that is made by a chemical process
- **complex** *(adjective)*: having a complicated structure; not simple
- **crave** *(verb)*: to have a strong desire for something
- **critical thinking** *(noun)*: thought process characterized by clear and rational thinking that relies on facts and evidence
- **development** *(noun)*: the act or process of growing or causing something to become larger or more advanced
- **dopamine** *(noun)*: a neurotransmitter chemical that helps transmit signals in the brain and is associated with feelings of pleasure
- **drawback** *(noun)*: something that causes problems or creates a disadvantage
- **emit** *(verb)*: to send out
- **frontal lobe** *(noun)*: the front part of each cerebral hemisphere of the brain in which emotions, problem solving, motor control, and decision-making processes are controlled
- **function** *(noun)*: the purpose or activity for which a thing exists or is used
- **functional MRI** (fMRI) *(noun)*: a brain imaging tool that shows areas of the brain that are active during a behavior
- **generation** *(noun)*: a group of people born and living during the same time
- **hemisphere** *(noun)*: as in brain hemisphere; either of the two halves of the upper part of the brain in humans and other animals
- **hydrogen** (*noun)*: a chemical element that has no color or smell and that is the simplest, lightest, and most common element. A single molecule of water contains two hydrogen atoms and one oxygen atom.
- **imaging** *(noun)*: the act of creating a medical or scientific image that shows a picture of the inside of a body
- **imbalance** *(noun)*: a state or condition when different things do not occur in equal or proper amounts
- **inject** *(verb)*: to force a liquid into something, such as with a needle
- **integration** *(noun)*: the act or process of combining different things
- **lasting** *(adjective)*: existing or continuing for a long time
- **lobe** *(noun)*: a somewhat rounded part of a body organ or division of a body organ
- **magnetic** *(adjective)*: relating to a magnet or magnetism

- **magnetic field** *(noun)*: a region of space near a magnetic body where magnetic forces can be detected
- **motivation** *(noun)*: the condition of being eager to act or work
- **nervous system** *(noun)*: the system of nerves in your body that sends messages for controlling movement and feelings, for example
- **neuron** (*noun)*: a nerve cell that carries messages between the brain and other parts of the body and is a basic part of the nervous system
- **neuroscience** (*noun)*: the area of science related to the nervous system, including the nerves, brain, and spinal cord
- **neuroscientist** *(noun)*: a scientist who studies the nervous system, including the nerves, brain, and spinal cord
- **nucleus accumbens** *(noun)*: the area of the brain that processes motivation and pleasure
- **occipital lobe** *(noun)*: the lobe of each cerebral hemisphere located at the back of the brain that contains the visual-processing area
- **organ** *(noun)*: a structure in a plant or animal that performs a specific function, such as the brain or the heart
- **parietal lobe** *(noun)*: the rear part of each hemisphere in the upper part of the brain that contains an area concerned with sensory perception and integration, motion, and attention
- **participant** *(noun)*: a person who is involved in an activity, event, or study
- **perception** *(noun)*: the ability to notice or understand something using one of your senses
- **positron emission tomography** (PET) *(noun)*: a tool that produces images of activity inside the body by detecting energy given off by radioactive substances that have been injected into the body
- **prefrontal cortex** *(noun)*: the front part of the frontal lobe area of the brain that is involved in complex decision making and thinking
- **process** *(noun)*: a series of actions that produce something to lead to a certain result
- **radio wave** *(noun)*: an electromagnetic wave that is used for sending signals through the air without using wires
- **radioactive** *(adjective)*: emitting energy or high-energy particles (radiation) as a result of the decay of unstable atoms
- **radiotracer** *(noun)*: a radioactive substance injected into the body that is used to track and study processes in the body
- **receptor** *(noun*): a cell or group of cells that receives signals and has an attraction for specific chemicals
- **reduce** *(verb)*: to make smaller in size, amount, or number
- **region** *(noun*): a particular area of something
- **release** *(verb)*: to set free, or to allow a substance to enter the air, water, bloodstream, etc.
- **scan** *(noun)*: a medical or scientific image that shows a picture of the inside of a body
- **sensory** *(adjective)*: of or related to your physical senses (touch, taste, smell, sight, and hearing)
- **structural MRI** *(noun)*: a brain imaging tool that shows a detailed image of the structure of tissues, organs, and bones in the body
- **technology** (*noun)*: a machine or method that is created or invented by scientists to solve problems
- **temporal lobe** *(noun)*: the large lobe of each cerebral hemisphere that is situated in front of the occipital lobe and contains a sensory area associated with hearing, understanding language, and memory
- **tissue** *(noun*): the group of cells that forms the parts and organs in a plant or animal
- **tumor** *(noun)*: a mass of tissue that is made up of abnormal cells
- **vaping** *(verb)*: inhaling and exhaling vapor from an electronic cigarette