

Exploring The New Science of Addiction

Abstract

Students explore *The New Science of Addiction: Genetics and the Brain* interactive module on our website to complete a web quest.

Logistics

Time Required

▶ **Class Time:**
80 minutes

▶ **Prep Time:**
10 minutes to copy student pages

Materials

Student handouts, computers with internet access

Prior Knowledge Needed

None

Appropriate For:

Primary Intermediate Secondary College

Learning Objectives

- ▶ Drug addiction is a chronic disease characterized by changes in the brain.
- ▶ A network of neurons in the brain known as the reward pathway is responsible for driving our feelings of motivation, reward and behavior.
- ▶ Neurons, such as those that comprise the reward pathway, communicate at the synapse using neurotransmitters.
- ▶ Drugs of abuse alter the brain's reward pathway by disrupting the action at the synapse.
- ▶ There is a genetic component to addiction.
- ▶ The adolescent brain is particularly susceptible to developing a lifetime addiction.
- ▶ Changing opinions about drugs and drug abuse present challenges and issues that society must consider.

Exploring The New Science of Addiction

Classroom Implementation

Activity instructions:

- Have students log on to *The New Science of Addiction: Genetics and the Brain* module at <http://gslc.genetics.utah.edu/units/addiction>
- Instruct students to navigate their way through the module to complete the web quest (pages S-1 – S-11).

Note: Questions marked **Learn More** explore a greater level of depth. You may choose to omit all, or some of these questions based on your needs.

Quantities

Per Student _____

▼ One copy of pages S-1– S-11

Standards

U.S. National Science Education Standards

Grades 5-8:

Content Standard C: Life Science

- Structure and Function in Living Systems
 - » Every cell is covered by a membrane that controls what can enter and leave the cell.
- Reproduction and Heredity
 - » The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

Content Standard F: Science in Personal and Social Perspectives

- Personal Health
 - » Alcohol and other drugs are often abused substances. Such drugs change how the body functions and can lead to addiction.
- Science and Technology in Society
 - » Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment.
 - » Societal challenges often inspire questions for scientific research.

Exploring The New Science of Addiction

Grades 9-12:

Content Standard C: Life Science

- The Cell
 - » Cells have particular structures that underlie their functions.
- The Behavior of Organisms
 - » Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules.

Content Standard F: Science in Personal and Social Perspectives

- Personal and Community Health
 - » An individual's mood and behavior may be modified by substances. The modification may be beneficial or detrimental depending on the motives, type of substance, duration of use, pattern of use, level of influence, and short- and long-term effects. Students should understand that drugs can result in physical dependence and can increase the risk of injury, accidents, and death.
- Science and Technology in Local, National and Global Challenges
 - » Progress in science and technology can be affected by social issues and challenges.

B. AAAS Benchmarks for Science Literacy:

Grades 6-8

The Human Organism

- Physical Health
 - » Toxic substances, some dietary habits, and some personal behavior may be bad for one's health.

Grades 9-12

The Human Organism

- Basic Functions
 - » The nervous system works by electrochemical signals in the nerves and from one nerve to the next.
 - » Along nerve cells, electrical impulses carry information much more rapidly than is possible by diffusion or blood flow. Some drugs mimic or block the molecules involved in transmitting nerve or hormone signals and therefore disturb normal operations of the brain and body.

Human Society

- Cultural Effects on Behavior

Why Log-In On Our Website?

Logging in as a teacher on the Genetic Science Learning Center website has its benefits. You'll get exclusive access to great resources just for you!

- Get links to resources for this and other Print-and-Gos™.
- Access extra media materials for this module.
- Download classroom-ready presentations and graphics.
- Tips for using Print-and-Gos™ with online materials.

and much more!

Exploring The New Science of Addiction

- » Heredity, culture, and personal experience interact in shaping human behavior. Their relative importance in most circumstances is not clear.

The Designed World

- Health Technologies

- » Knowledge of genetics is opening whole new fields of health care.

Credits

Molly Malone, Genetic Science Learning Center

Harmony Starr, Genetic Science Learning Center (illustrations)

Sheila Avery, Genetic Science Learning Center (illustrations)

Pete Anderson, Genetic Science Learning Center (illustrations)

Funding

Funding for this module was provided by a Science Education Drug Abuse Partnership Award (SEDAPA) from the National Institute on Drug Abuse, a component of the National Institutes of Health, Department of Health and Human Services.

NIDA NATIONAL INSTITUTE
ON DRUG ABUSE

Exploring The New Science of Addiction

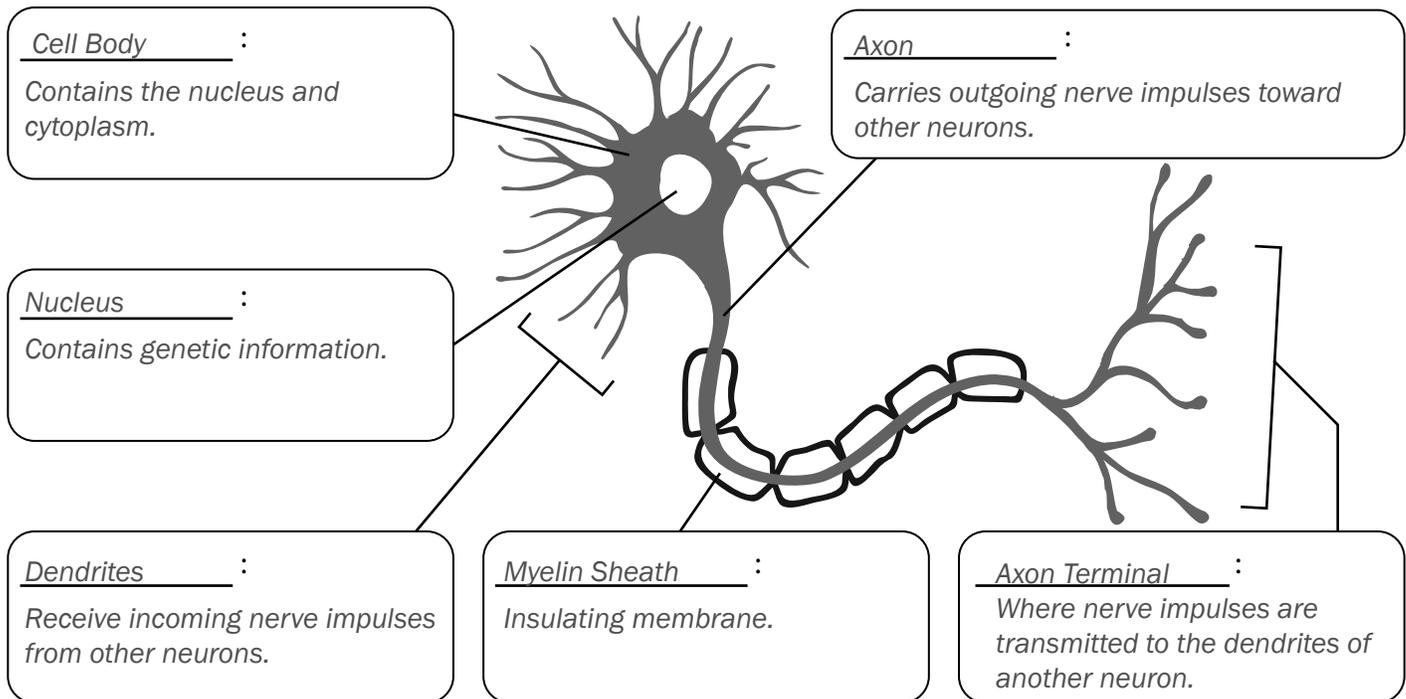
Answer Key

Log on to: <http://gslc.genetics.utah.edu/units/addiction> and explore this module to find the answers to the questions below.

Hint: the Search feature on this website may or may not help you find what you are looking for; it is best to go through the module to find the answers.

Natural Reward Pathways Exist in the Brain

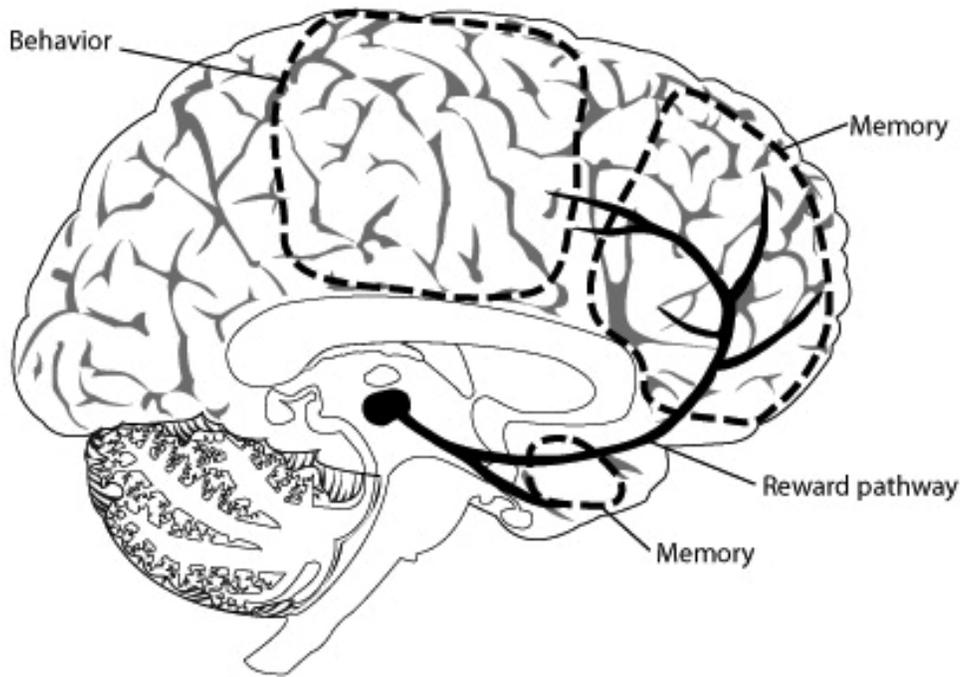
1. *Make a Mad, Mad, Mad Neuron*, label each part on the neuron below and give a brief description of each part's function.



Exploring The New Science of Addiction

Answer Key

2. On the brain below, roughly sketch in and label: A) the Reward Pathway, B) the area of the brain responsible for behavior and C) the area of the brain responsible for memory.



The components of the Reward Pathway are:

Neurons, dopamine, and regions of the brain that control memory and behavior.

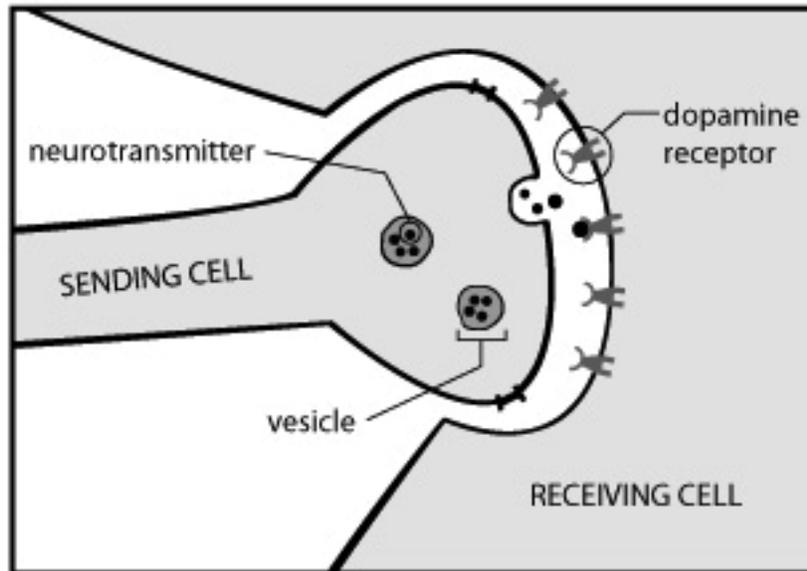
The Reward Pathway is responsible for:

Driving feelings of reward, motivation and behavior. Making us feel good when we engage in behaviors necessary for survival.

Exploring The New Science of Addiction

Answer Key

3. *Crossing the Divide: How Neurons Talk to Each Other* (view the movie to answer the questions below).



Describe what is happening in the diagram above.

(Answers will vary)

Dopamine-containing vesicles in the axon terminal of the sending cell are dumping their contents into the synapse. The released dopamine is locking into the dopamine receptors on the surface of the receiving cell.

Assuming the sending cell started at rest, list the events that had to happen in order to get it to this stage?

An electrical impulse has traveled down the sending cell and stimulated the vesicles to release their contents.

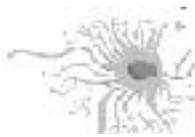
What events will transpire next in order to complete the message?

When the dopamine locks into the receptors, a second messenger molecule (in the receiving cell) will create an impulse that will travel down the receiving cell. The dopamine will release from the receptors and travel back to the sending cell through reuptake transporters.

Exploring The New Science of Addiction

Answer Key

Learn More: The Other Brain Cells

Glial Cell Type	Diagram	Function
Oligodendrocytes		wrap tightly around axons to form the myelin sheath thus speeding up the action potential
Microglia		eat foreign invaders (bacteria and viruses), then display the chewed up parts on their cell surface to signal for help
Astrocytes		hold neurons in place, get nutrients to them, and digest parts of dead neurons

Drugs Alter the Brain's Reward Pathway

4. Categorize the *Drugs of Abuse*

Stimulant	Depressant	Other
Cocaine	Alcohol	Steroids
MDMA	GHB	Dissociative Drugs
Methamphetamine	Rohypnol	Hallucinogens
Nicotine	Marijuana	Heroin
	Nicotine	Inhalants

5. Observe the mice at the *Mouse Party*.

Where is the action of each drug taking place?

In the brain, at the synapses between neurons.

All of the drugs affect the natural balance of neurotransmitters in the brain.

(T)

F

Learn More: Drug Delivery Methods

Name two reasons why the method of drug delivery is an important factor in addiction.

Users seek a delivery method that gets them higher faster

Rapidly delivered drugs affect brain regions that influence addiction

Exploring The New Science of Addiction

Answer Key

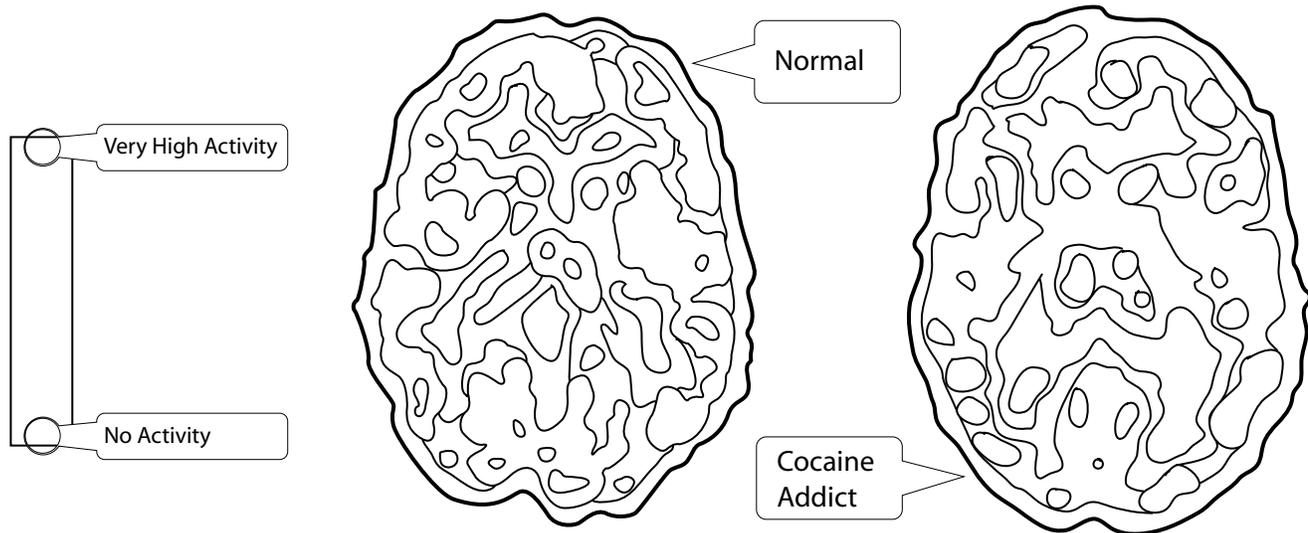
6. Play *Cerebral Commando* until you win. What was the most effective strategy?

The most effective strategy is to remove dopamine receptors to prevent over-stimulation.

7. Color in the PET scan images of the normal-functioning brain and the brain of a cocaine addict below:

[Answers will show decreased brain activity (red and yellow areas) in the brain of the cocaine addict]

PET Images Showing Brain Activity:



Learn More: Brain Imaging Technologies

A PET scan involves the following steps:

Step one:

The patient is given a safe dose of a radioactive compound such as FDG (flourodeoxyglucose).

Step two:

The PET scanner measures energy that is released when particles (positrons) from the radioactive substance collide with electrons in the patient's brain.

Step three:

A computer turns the PET scanner's measurements into multi-colored images.

Exploring The New Science of Addiction

Answer Key

Learn More: *Brain Imaging Technologies (cont'd.)*

Compare:	PET	MRI
Measures	<i>Energy that is released when positrons and electrons collide.</i>	<i>Waves of energy emitted by hydrogen atoms in blood as they pass through a magnetic field.</i>
Electromagnetic Wave Detected	<i>Gamma Rays</i>	<i>Radio Waves</i>

Learn More: *Beyond the Reward Pathway*

Aside from memory, motivation and reward, what other functions controlled by the brain would you expect drugs that interfere with dopamine to affect?

Motor control

Hormonal Regulation

Maternal Behavior

Pregnancy

Sensory Processes

List the main role(s) for each neurotransmitter below:

Dopamine:

"feel good" response

Serotonin:

regulation of body temperature, sleep, mood, appetite and pain

GABA:

inhibitory

Glutamate:

excitatory

Exploring The New Science of Addiction

Answer Key

Learn More: *How Drugs Can Kill*

Complete the table below:

Class of Drug:	How it Kills
Polydrug Cocktails (Ex. Alcohol and Heroin)	<i>Breathing is suppressed</i>
Heroin and other Opiates	<i>Respiratory failure</i>
Alcohol	<i>Causes unconsciousness and breathing to slow or cease. If a person vomits while unconscious, they may inhale the vomit and drown.</i>
Nicotine	<i>Muscles that control breathing are paralysed, or it causes a heart attack.</i>
Stimulants: Cocaine	<i>Heart attack, overheating and brain damage</i>
Methamphetamine	<i>Heart attack, overheating and brain damage</i>

Exploring The New Science of Addiction

Genetics is an Important Factor in Addiction

Answer Key

8. There is one addiction gene that has been identified by researchers. T (F)
9. Become the *Pedigree Investigator* and complete the pedigree for the Marshall family. Does the pedigree indicate a possible genetic component to nicotine addiction?
yes
10. List the risk factors for nicotine addiction present in the Marshall family.
ADHD, compulsive and risky behavior, depression, friends who smoke

Learn More: *Discovering Addiction Genes Using the Candidate Gene Approach*

Briefly explain why the CHRNA4 gene might be a likely candidate gene for nicotine addiction.

Nicotinic acetylcholine receptors in the brain that are built of alpha-4 and beta-2 subunits are important for dopamine release in the reward pathway. Past genetic studies have found a link between the gene that codes for the alpha-4 subunit (CHRNA4) and nicotine addiction.

Learn More: *Mice Are Good Model Organisms for Addiction Research*

Reasons why mice are a good model organism for addiction research:

- The reward pathway in the brains of mice is similar to the reward pathway in humans.*
- Mice are genetically similar to humans (85%).*
- Scientists can conduct experiments on mice and other animals that they could not conduct on humans.*

Exploring The New Science of Addiction

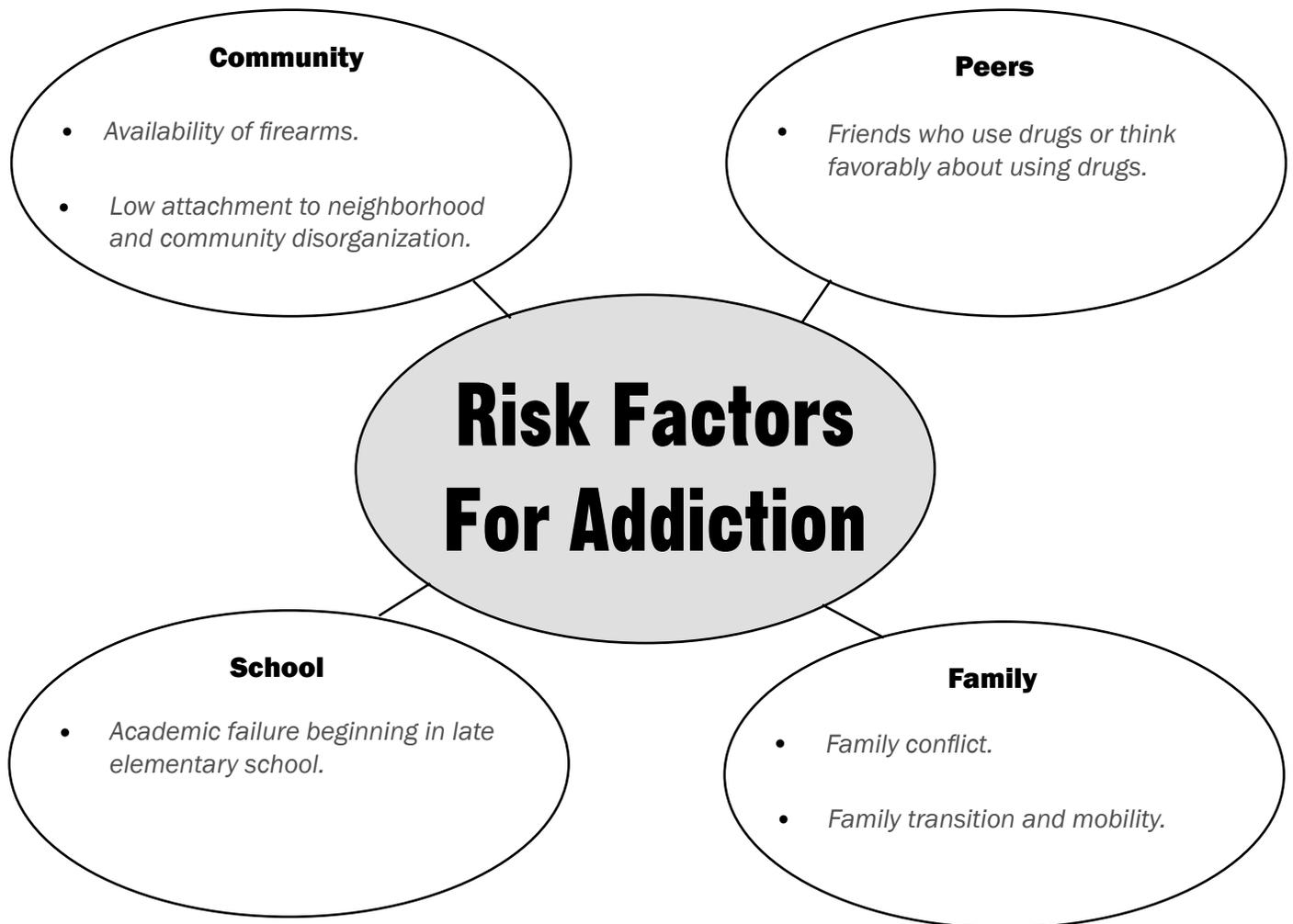
Timing and Circumstances Influence Addiction

Answer Key

11. Name two reasons why the adolescent brain is particularly susceptible to developing a lifetime drug addiction.
- The adolescent brain is still developing, any changes drugs cause during this period are more likely to “stick” and become hard-wired as the brain completes its development.*
 - The part of the brain that is responsible for reasoning and decision-making (prefrontal cortex) shuts down during adolescence, increasing impulsive, risk-taking behavior.*

Learn More: Environmental Risk Factors for Addiction

Fill in the circles below with the appropriate risk factors



Exploring The New Science of Addiction

Answer Key

Challenges and Issues in Addiction

12. Which challenge/issue discussed on this page do you find most compelling? Why?

[Answers will vary]

Exploring The New Science of Addiction

Answer Key

13. Summary

Fill in the boxes below to explain how each contributes to our new understanding of addiction:

Natural Reward Pathways Exist in the Brain

*Example Answer:
Pathways exist in the brain that drive feelings of reward, motivation and behavior.*

Drugs Alter the Reward Pathway

*Example Answer:
Addictive drugs manipulate the reward pathways in the brain. Drugs can cause long-term changes to the reward pathways as well as other areas of the brain resulting in addiction. The changes to the brain can last long after drug use has stopped.*

The New Science of Addiction: Genetics and the Brain

Timing and Circumstances Influence Addiction

*Example Answer:
The adolescent brain is more vulnerable to developing lifetime addiction.

The social environment and factors in the community, family, peer and school domains also influence addiction.*

Genetics is an Important Factor in Addiction

*Example Answer:
Genetic differences exist that may make some people more vulnerable to addiction than others. Genes might influence the physiologic effect of a drug or the physical effects of stopping drug use.

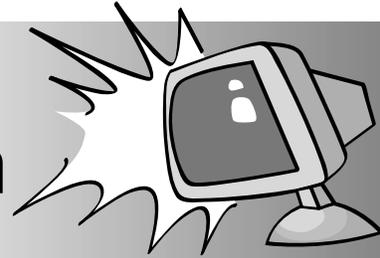
Addiction is the result of the interaction of many genes, behavior and environment.*

Name _____

Date _____



Exploring The New Science of Addiction

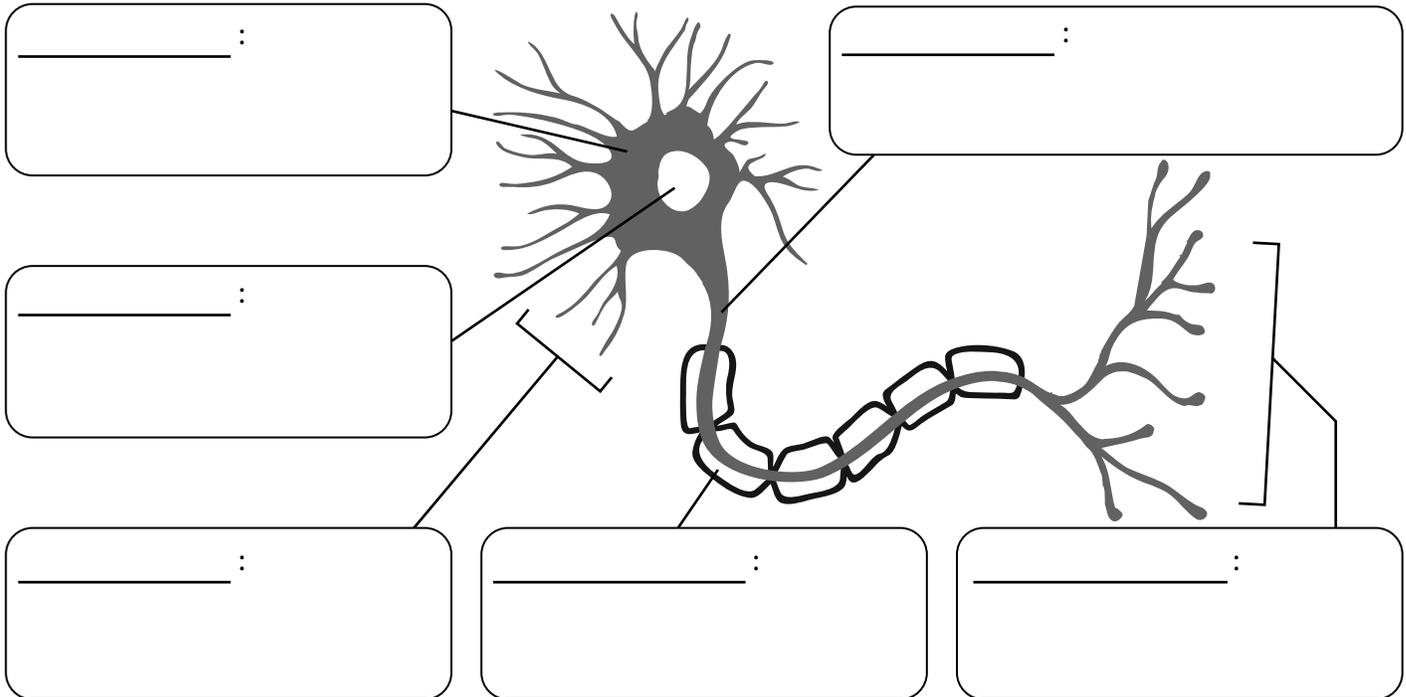


Log on to: <http://gslc.genetics.utah.edu/units/addiction> and explore this module to find the answers to the questions below.

Hint: the Search feature on this website may or may not help you find what you are looking for; it is best to go through the module to find the answers.

Natural Reward Pathways Exist in the Brain

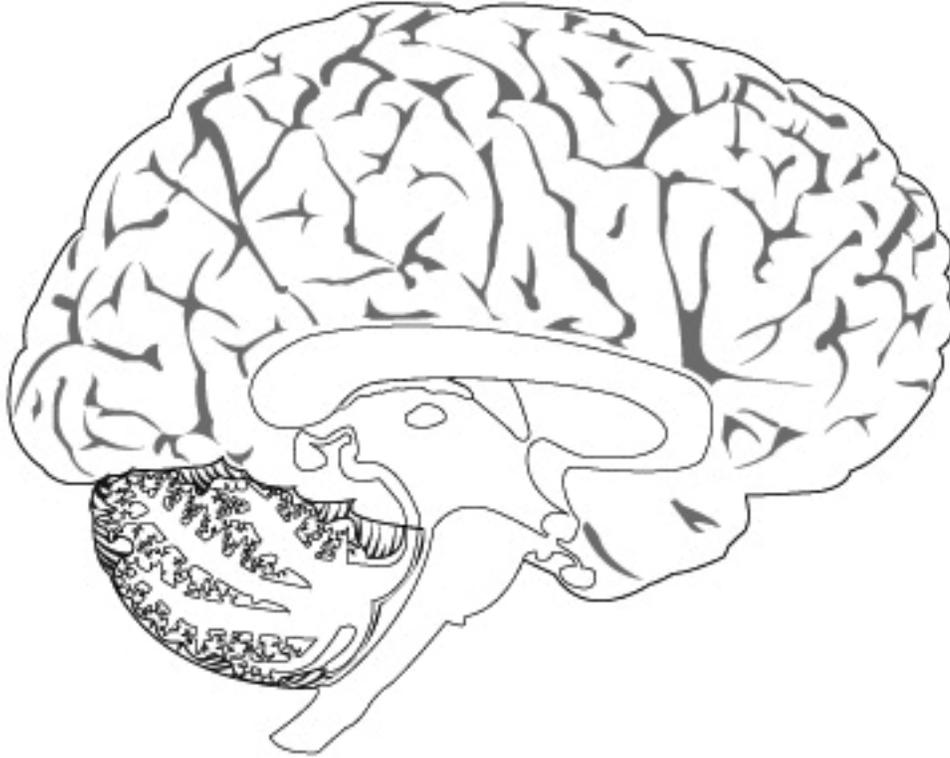
1. *Make a Mad, Mad, Mad Neuron*, label each part on the neuron below and give a brief description of each part's function.



Name _____

Date _____

2. On the brain below, roughly sketch in and label: A) the Reward Pathway, B) the area of the brain responsible for behavior and C) the area of the brain responsible for memory.



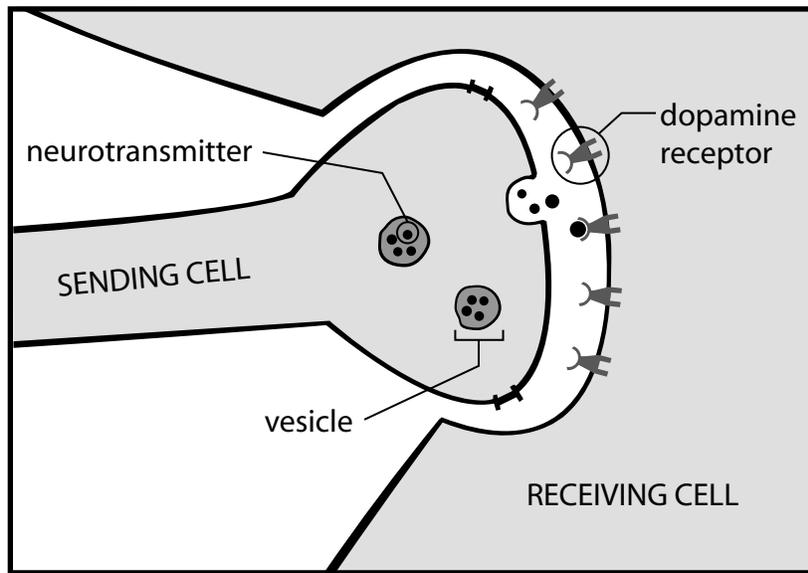
The components of the Reward Pathway are:

The Reward Pathway is responsible for:

Name _____

Date _____

3. *Crossing the Divide: How Neurons Talk to Each Other* (view the movie to answer the questions below).



Describe what is happening in the diagram above.

Assuming the sending cell started at rest, list the events that had to happen in order to get it to this stage.

What events will transpire next in order to complete the message?

Name _____

Date _____

Learn More: *The Other Brain Cells*

Glial Cell Type	Diagram	Function
Oligodendrocytes		
Microglia		
Astrocytes		

Drugs Alter the Brain's Reward Pathway

4. Categorize the *Drugs of Abuse*

Stimulant

Depressant

Other

5. Observe the mice at the *Mouse Party*.

Where is the action of each drug taking place?

All of the drugs affect the natural balance of neurotransmitters in the brain. T F

Learn More: *Drug Delivery Methods*

Name two reasons why the method of drug delivery is an important factor in addiction.

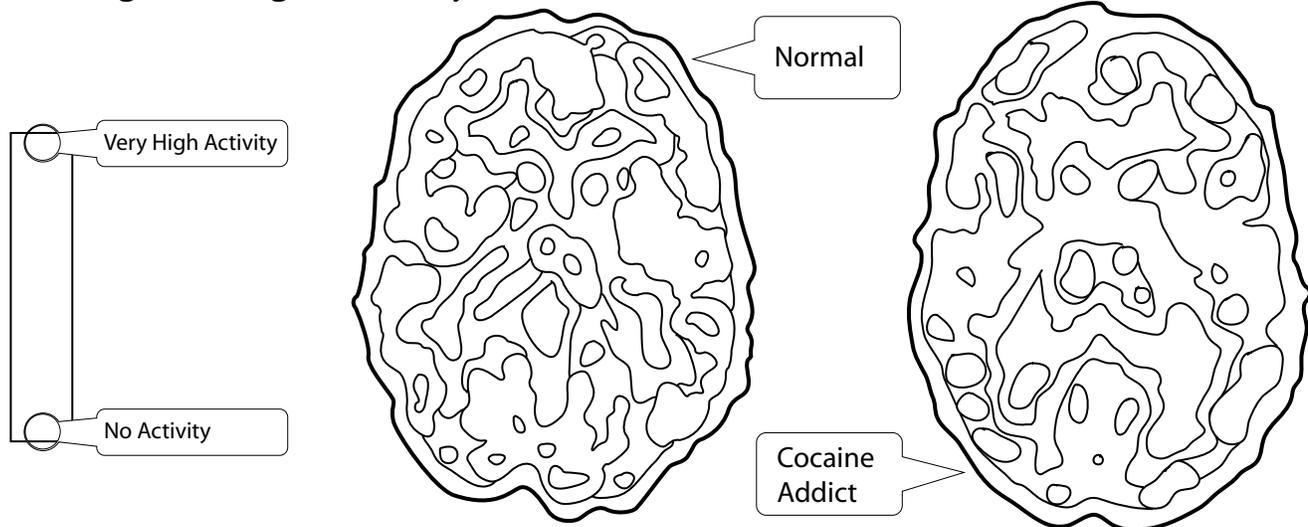
Name _____

Date _____

6. Play *Cerebral Commando* until you win. What was the most effective strategy?

7. Color in the PET scan images of the normal-functioning brain and the brain of a cocaine addict below:

PET Images Showing Brain Activity:



Learn More: *Brain Imaging Technologies*

A PET scan involves the following steps:

Step one:

Step two:

Step three:

Name _____

Date _____

Learn More: *Brain Imaging Technologies (cont'd.)*

Compare:	PET	MRI
Measures		
Electromagnetic Wave Detected		

Learn More: *Beyond the Reward Pathway*

Aside from memory, motivation and reward, what other functions controlled by the brain would you expect drugs that interfere with dopamine to affect?

List the main role(s) for each neurotransmitter below:

Dopamine:

Serotonin:

GABA:

Glutamate:

Name _____

Date _____

Learn More: *How Drugs Can Kill*

Complete the table below:

Class of Drug:	How it Kills
Polydrug Cocktails (ex. Alcohol and Heroin)	
Heroin and other Opiates	
Alcohol	
Nicotine	
Stimulants: Cocaine	
Methamphetamine	

Name _____

Date _____

Genetics is an Important Factor in Addiction

8. There is one addiction gene that has been identified by researchers. T F
9. Become the *Pedigree Investigator* and complete the pedigree for the Marshall family. Does the pedigree indicate a possible genetic component to nicotine addiction?
10. List the risk factors for nicotine addiction present in the Marshall family.

Learn More: *Discovering Addiction Genes Using the Candidate Gene Approach*

Briefly explain why the CHRNA4 gene might be a likely candidate gene for nicotine addiction.

Learn More: *Mice Are Good Model Organisms for Addiction Research*

Reasons why mice are a good model organism for addiction research:

1.

2.

3.

Name _____

Date _____

Timing and Circumstances Influence Addiction

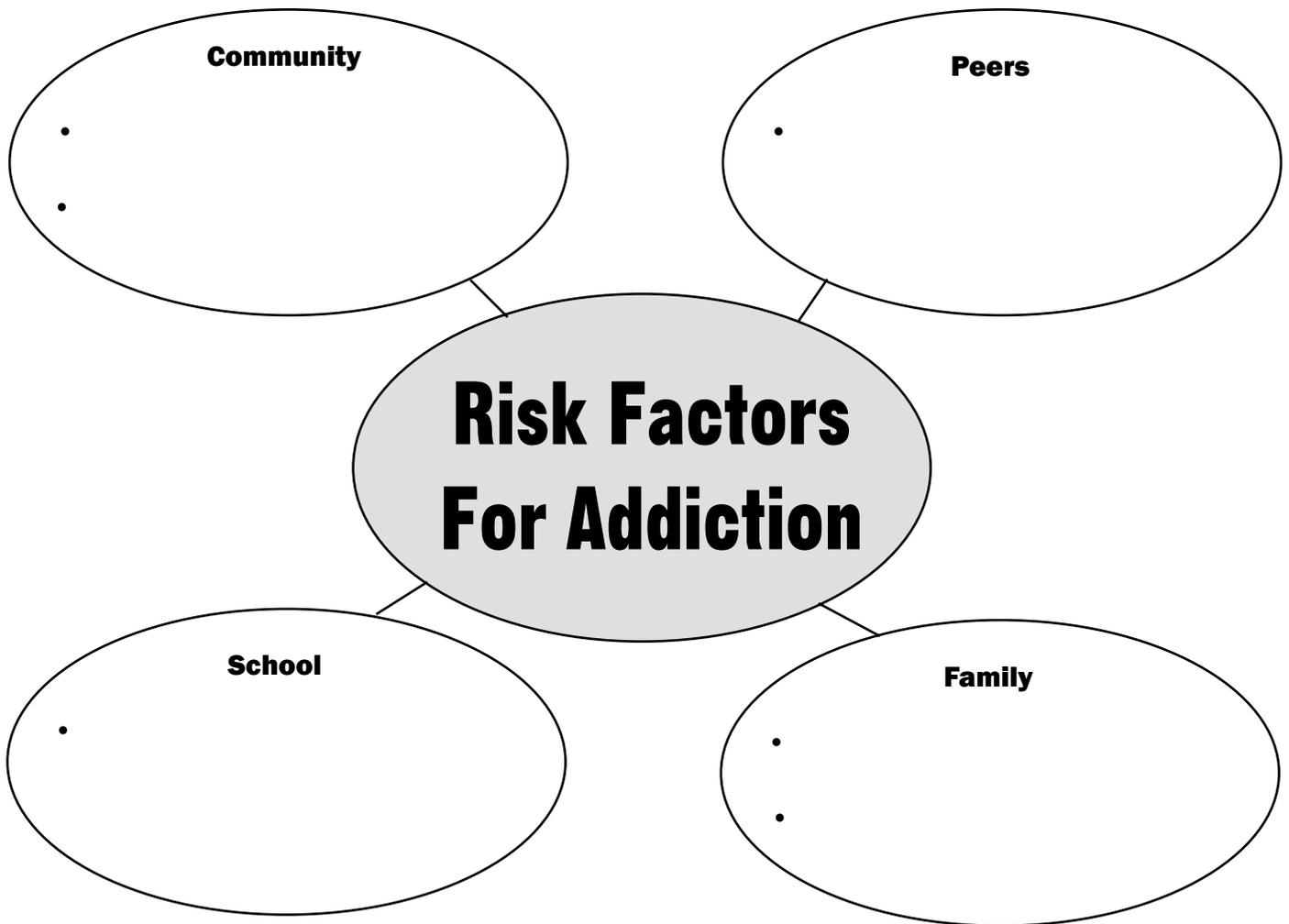
11. Name two reasons why the adolescent brain is particularly susceptible to developing a lifetime drug addiction.

1.

2.

Learn More: *Environmental Risk Factors for Addiction*

Fill in the circles below with the appropriate risk factors



Name _____

Date _____

Challenges and Issues in Addiction

12. Which challenge/issue discussed on this page do you find most compelling? Why?

Name _____

Date _____

13. *Summary*

Fill in the boxes below to explain how each contributes to our new understanding of addiction:

