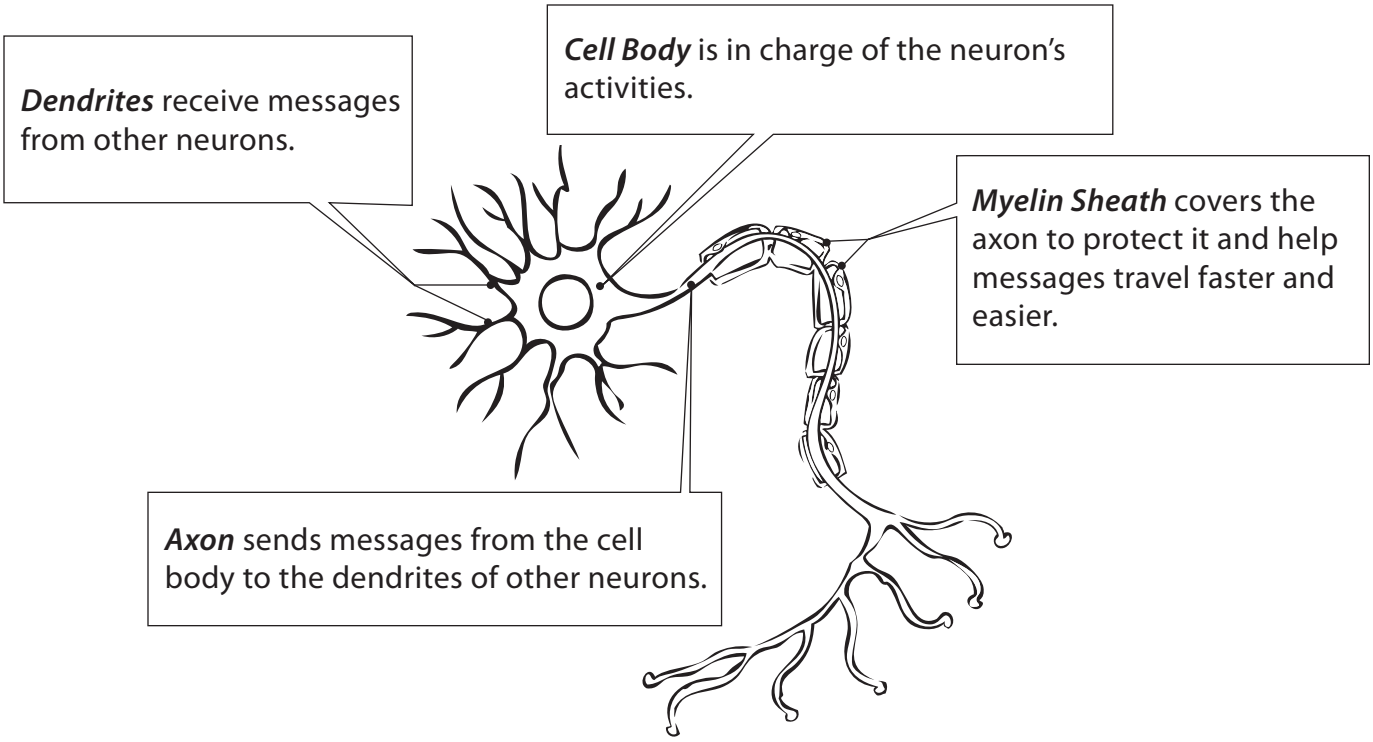
Neurotransmission Fact Sheet

The brain and nervous system are made of billions of nerve cells, called neurons. Neurons have three main parts: cell body, dendrites, and axon. The axon is covered by the myelin sheath.



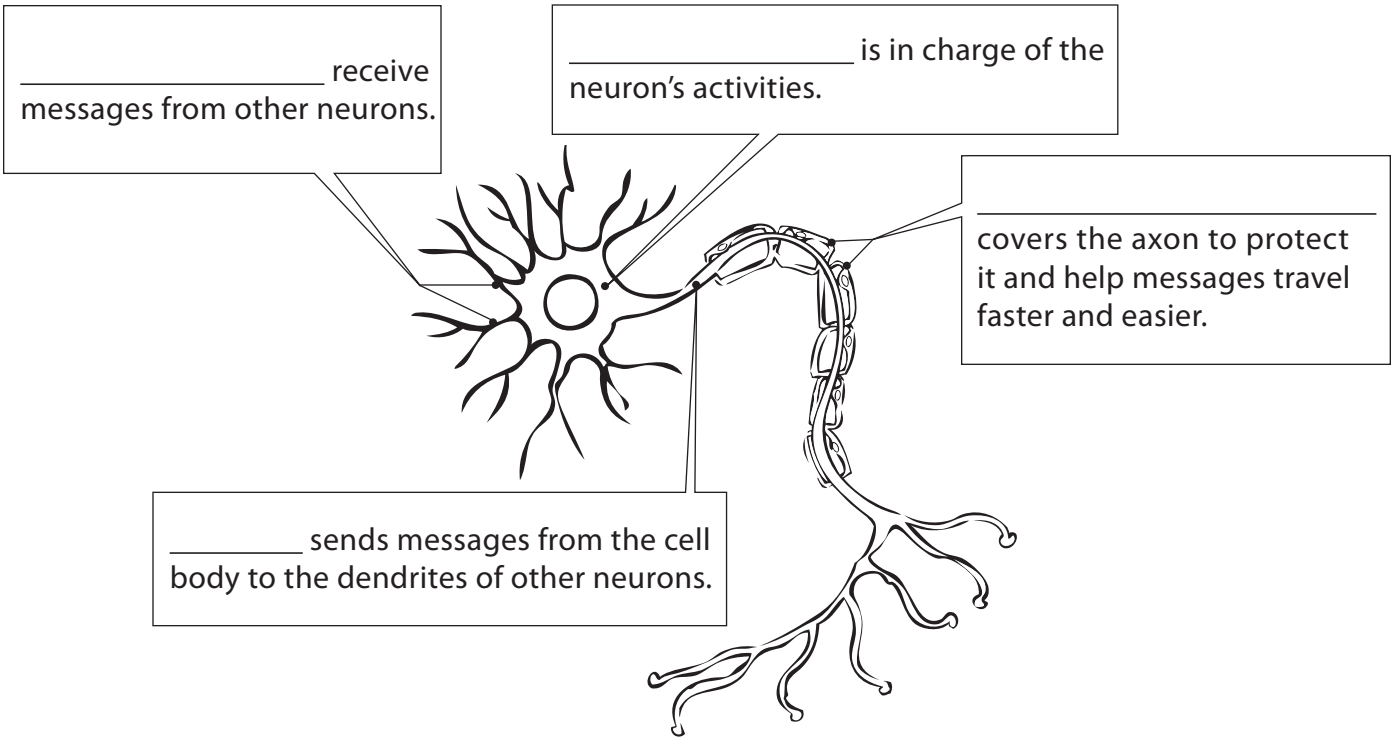
The transfer of information between neurons is called *neurotransmission.*

This is how neurotransmission works:

1. A message travels from the dendrites through the cell body and to the end of the axon.
2. The message causes the chemicals, called neurotransmitters, to be released from the end of the axon into the synapse. The neurotransmitters carry the message with them into the synapse. The synapse is the space between the axon of one neuron and the dendrites of another neuron.
3. The neurotransmitters then travel across the synapse to special places on the dendrites of the next neuron, called receptors. The neurotransmitters fit into the receptors like keys in locks.
4. Once the neurotransmitter has attached to the receptors of the second neuron, the message is passed on.
5. The neurotransmitters are released from the receptors and are either broken down or go back into the axon of the first neuron.

Neurotransmission Fact Sheet

The brain and nervous system are made of billions of nerve cells, called neurons. Neurons have three main parts: cell body, dendrites, and axon. The axon is covered by the myelin sheath.



The transfer of information between neurons is called *neurotransmission.*

This is how neurotransmission works:

1. A message travels from the dendrites through the cell body and to the end of the axon.
2. The message causes the chemicals, called neurotransmitters, to be released from the end of the axon into the synapse. The neurotransmitters carry the message with them into the synapse. The synapse is the space between the axon of one neuron and the dendrites of another neuron.
3. The neurotransmitters then travel across the synapse to special places on the dendrites of the next neuron, called receptors. The neurotransmitters fit into the receptors like keys in locks.
4. Once the neurotransmitter has attached to the receptors of the second neuron, the message is passed on.
5. The neurotransmitters are released from the receptors and are either broken down or go back into the axon of the first neuron.

Answer Key

1. The number of neurons in the brain is about 100 billion.

2. The parts of neurons that send messages are the axons, and the parts of neurons that receive messages are the dendrites.

3. The space between the dendrites of one neuron and the axon of another neuron is called the synapse.

4. The nucleus of a neuron is where genetic material is stored.

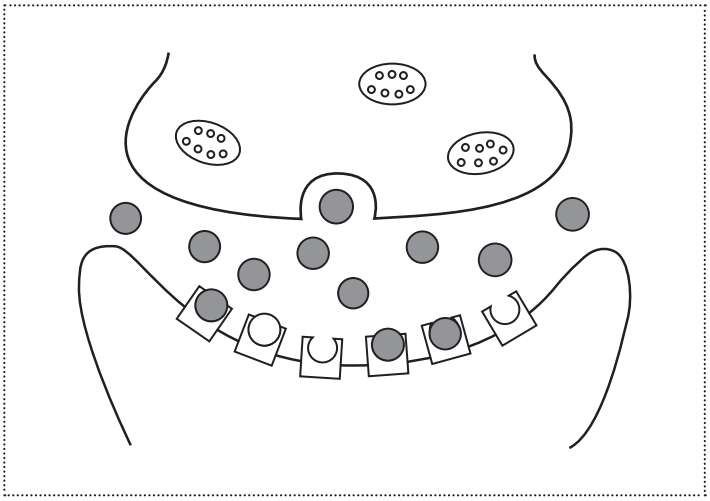
5. Neurons that send information from sensory organs, such as the skin or eyes, to the central nervous system are called sensory (or afferent) neurons.

6. Neurons that send information from the central nervous system to muscles or glands are called motor (or efferent) neurons.

7. Poisons that affect neurotransmission are called neurotoxins.

8. In the year 1921, a man named Otto Loewi first discovered neurotransmitters during an experiment with two frog hearts.

9. Glial cells are brain cells that do many important things that help neurons, including bringing nutrients to neurons, insulating parts of neurons, and digesting parts of dead neurons.



Neurotransmission Scavenger Hunt

Work as quickly as you can to fill in all the blanks!

1. The number of neurons in the brain is about _____ .

2. The parts of neurons that send messages are the _____, and the parts of neurons that receive messages are the _____.

3. The space between the dendrites of one neuron and the axon of another neuron is called the _____.

4. The _____ of a neuron is where genetic material is stored.

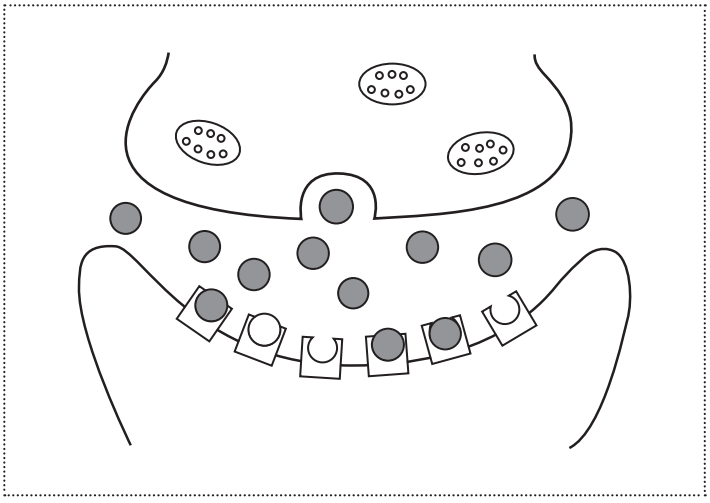
5. Neurons that send information from sensory organs, such as the skin or eyes, to the central nervous system are called _____neurons.

6. Neurons that send information from the central nervous system to muscles or glands are called _____ neurons.

7. Poisons that affect neurotransmission are called _____.

8. In the year _____, a man named _____ _____ first discovered neurotransmitters during an experiment with two frog hearts.

9. _____ cells are brain cells that do many important things that help neurons, including bringing nutrients to neurons, insulating parts of neurons, and digesting parts of dead neurons.

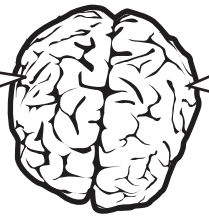


Brain Parts Fact Sheet

Cerebral Cortex:
- Largest part of the brain
- Most highly developed part of the brain
- Controls thinking, perceiving, and understanding language
- Corpus callosum connects the two hemispheres

Hemispheres of the cerebral cortex:

Left Hemisphere
- Controls the right side of the body
- Responsible for mathematical ability, problem solving, language, and decision-making



Right Hemisphere
- Controls the left side of the body
- Responsible for artistic expression and understanding relationships in space

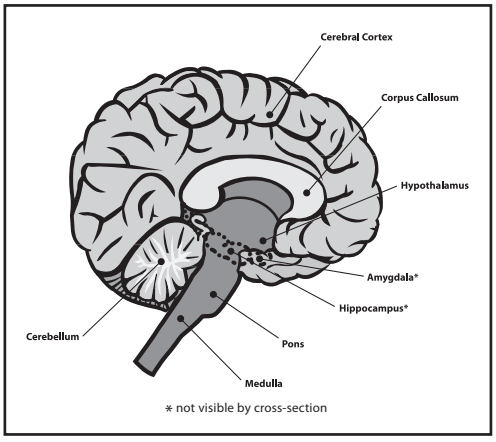
Lobes of the cerebral cortex:

Parietal Lobe
- Located below the crown of the head
- Processes sensory information from the whole body (information about pain, touch, and pressure)

Frontal Lobe
- Located right behind the forehead
- Responsible for initiating and coordinating motor movements and higher cognitive skills like problem solving and thinking

Occipital Lobe
- Located in the back of the brain, against the skull
- Processes all the visual information coming into the brain

Temporal Lobe
- Located behind the temples and just above the ears
- In charge of making sense of the information you hear
- Integrates information from various senses, such as smell and vision



Hypothalamus:
- Controls body temperature, hunger, and thirst

Cerebellum:
- Controls posture, movement, and the sense of balance

Brain Stem:
- Brain's most primitive part
- Controls simple reflexes, such as coughing, sneezing, and digestion
- Two main parts—pons and medulla
  - **Pons** contains the fibers that connect the cerebral cortex with the cerebellum and spinal cord; also controls sleeping, awakening, and dreaming
  - **Medulla** controls heart rate, respiration, and blood pressure; connects the brain to the spinal cord

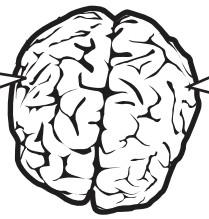
Limbic System: two main parts—hippocampus and amygdala
- **Hippocampus** controls learning and memory
- **Amygdala** plays an important role in emotional behavior

Brain Parts Fact Sheet

Cerebral Cortex:
- Largest part of the brain
- Most highly developed part of the brain
- Controls thinking, perceiving, and understanding language
- Corpus callosum connects the two hemispheres

Hemispheres of the cerebral cortex:

_____
- Controls the right side of the body
- Responsible for mathematical ability, problem solving, language, and decision-making



_____
- Controls the left side of the body
- Responsible for artistic expression and understanding relationships in space

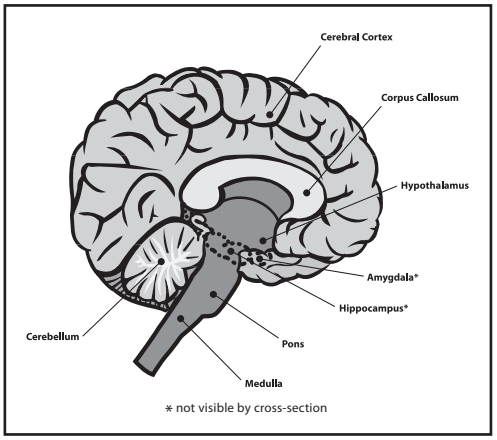
Lobes of the cerebral cortex:

_____
- Located below the crown of the head
- Processes sensory information from the whole body (information about pain, touch, and pressure)

_____
- Located right behind the forehead
- Responsible for initiating and coordinating motor movements and higher cognitive skills like problem solving and thinking

_____
- Located in the back of the brain, against the skull
- Processes all the visual information coming into the brain

_____
- Located behind the temples and just above the ears
- In charge of making sense of the information you hear
- Integrates information from various senses, such as smell and vision



Hypothalamus:
- Controls body temperature, hunger, and thirst

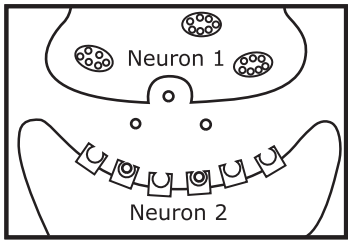
Cerebellum:
- Controls posture, movement, and the sense of balance

Brain Stem:
- Brain's most primitive part
- Controls simple reflexes, such as coughing, sneezing, and digestion
- Two main parts—pons and medulla
  - **Pons** contains the fibers that connect the cerebral cortex with the cerebellum and spinal cord; also controls sleeping, awakening, and dreaming
  - **Medulla** controls heart rate, respiration, and blood pressure; connects the brain to the spinal cord

Limbic System: two main parts—hippocampus and amygdala
- **Hippocampus** controls learning and memory
- **Amygdala** plays an important role in emotional behavior

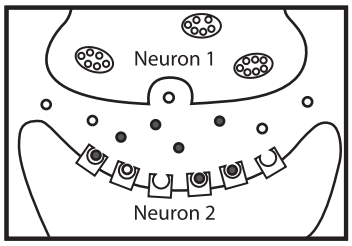
Key	
○	Acetylcholine
●	Nicotine
∪	Receptor

Nonsmoker: Normal acetylcholine and receptors



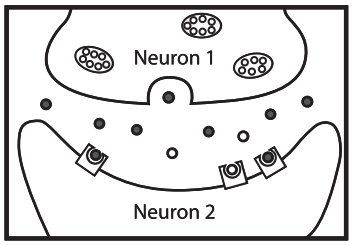
Acetylcholine receptors help with respiration, heart rate, memory, alertness, muscle movement, pleasure, and well-being. In a synapse of a nonsmoker, there is a normal amount of acetylcholine and receptors, so the neuron is working just like it should.

New Smoker: Too many chemicals in the synapse



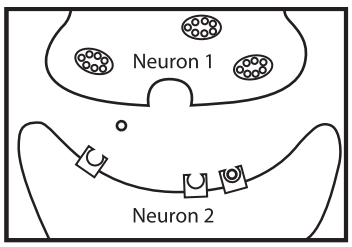
Nicotine is a similar shape to acetylcholine, so it fits into the same receptors. This makes neuron 1 send messages much more often than it should.

Addicted Smoker: Less acetylcholine and fewer receptors



After a person has been smoking for a while, the brain decreases the amount of acetylcholine and the number of receptors. The brain does this to stop the neuron from sending too many messages.

Quitting "cold turkey": Not enough acetylcholine and receptors

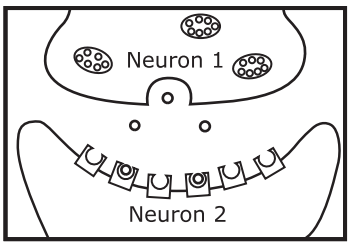


When nicotine use stops, the neuron is unable to send many messages because there is no longer enough acetylcholine. There are also fewer acetylcholine receptors. The user feels uncomfortable and has withdrawal symptoms.

Nicotine and the Brain

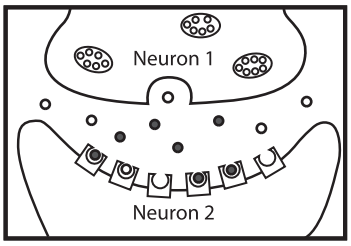
Key	
○	Acetylcholine
●	Nicotine
∪	Receptor

Nonsmoker: _____



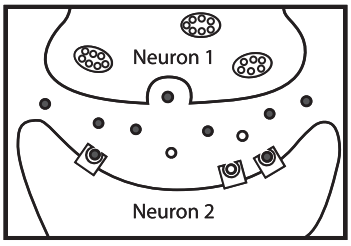
Acetylcholine receptors help with respiration, heart rate, memory, alertness, muscle movement, pleasure, and well-being. In a synapse of a nonsmoker, there is a normal amount of acetylcholine and receptors, so the neuron is working just like it should.

New Smoker: _____



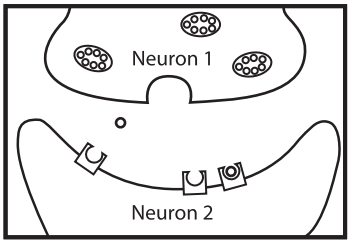
Nicotine is a similar shape to acetylcholine, so it fits into the same receptors. This makes neuron 1 send messages much more often than it should.

Addicted Smoker: _____



After a person has been smoking for a while, the brain decreases the amount of acetylcholine and the number of receptors. The brain does this to stop the neuron from sending too many messages.

Quitting "cold turkey": _____

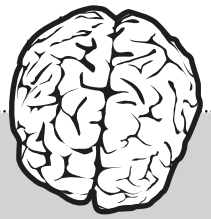


When nicotine use stops, the neuron is unable to send many messages because there is no longer enough acetylcholine. There are also fewer acetylcholine receptors. The user feels uncomfortable and has withdrawal symptoms.

Alcohol and the Brain

BRAIN PART	ALCOHOL'S EFFECTS ON BRAIN PARTS
Cerebral Cortex	When alcohol reaches this part of the brain, a person can lose judgment and lower his or her inhibitions. Alcohol here also affects how the brain gets information from the senses, which might cause blurry vision and difficulty in smelling, tasting, and hearing.
Frontal Lobes	This lobe of the cerebral cortex helps a person with planning, making decisions, and using self-control. Alcohol can harm a person's ability to plan, make decisions, and use self-control. If alcohol is used over a long period of time, this part of the brain can be damaged permanently.
Hippocampus	When alcohol reaches this part of the brain, a person can lose the ability to remember something he or she may have just learned, like another person's name or a phone number. Drinking a lot of alcohol in a short period can cause a blackout, when a person cannot remember entire events. Long-term alcohol use can cause permanent memory and learning damage in this part of the brain.
Cerebellum	This part of the brain helps a person with thinking, coordination, balance, and being aware of everything around them. Alcohol interferes with these abilities. Changes in this part of the brain may cause loss of balance and coordination.
Hypothalamus	When alcohol reaches this brain area, it can cause increased blood pressure, increased hunger and thirst, decreased body temperature, and a decreased heart rate.
Medulla	Drinking alcohol interferes with this part of the brain's ability to maintain the body's normal temperature. Alcohol can also cause slower breathing and heart rate. If a lot of alcohol is used over a short period of time, it can even cause a person to go into a coma when this part of the brain shuts down.

Alcohol and the Brain



BRAIN PART	ALCOHOL'S EFFECTS ON BRAIN PARTS
	When alcohol reaches this part of the brain, a person can lose judgment and lower his or her inhibitions. Alcohol here also affects how the brain gets information from the senses, which might cause blurry vision and difficulty in smelling, tasting, and hearing.
	This lobe of the cerebral cortex helps a person with planning, making decisions, and using self-control. Alcohol can harm a person's ability to plan, make decisions, and use self-control. If alcohol is used over a long period of time, this part of the brain can be damaged permanently.
	When alcohol reaches this part of the brain, a person can lose the ability to remember something he or she may have just learned, like another person's name or a phone number. Drinking a lot of alcohol in a short period can cause a blackout, when a person cannot remember entire events. Long-term alcohol use can cause permanent memory and learning damage in this part of the brain.
	This part of the brain helps a person with thinking, coordination, balance, and being aware of everything around them. Alcohol interferes with these abilities. Changes in this part of the brain may cause loss of balance and coordination.
	When alcohol reaches this brain area, it can cause increased blood pressure, increased hunger and thirst, decreased body temperature, and a decreased heart rate.
	Drinking alcohol interferes with this part of the brain's ability to maintain the body's normal temperature. Alcohol can also cause slower breathing and heart rate. If a lot of alcohol is used over a short period of time, it can even cause a person to go into a coma when this part of the brain shuts down.

Puzzle Pieces

ACETYLCHOLINE	Nicotine has a similar chemical structure as this neurotransmitter and copies its actions
WHAT CAUSES NICOTINE WITHDRAWAL?	Nicotine has disrupted the normal relationship between acetylcholine and its receptors, and now the brain needs nicotine to feel normal
GABA	Alcohol increases the activity of this inhibitory neurotransmitter
INHIBITORY NEUROTRANSMITTER	Decreases the activity of neurons
EXCITATORY NEUROTRANSMITTER	Increases the activity of neurons
DOPAMINE	This neurotransmitter is a part of the brain's "reward system"
HIPPOCAMPUS	Alcohol can cause memory loss by damaging this part of the brain
LIVER	This part of the body works to remove poisons and germs from the blood, and can be damaged by long-term alcohol abuse
NICOTINE	The addictive drug found in tobacco products like cigarettes

Puzzle Pieces

INHIBITORY NEUROTRANSMITTER	Nicotine has a similar chemical structure as this neurotransmitter and copies its actions
EXCITATORY NEUROTRANSMITTER	Nicotine has disrupted the normal relationship between acetylcholine and its receptors, and now the brain needs nicotine to feel normal
LIVER	Alcohol increases the activity of this inhibitory neurotransmitter
DOPAMINE	Decreases the activity of neurons
HIPPOCAMPUS	Increases the activity of neurons
NICOTINE	This neurotransmitter is a part of the brain's "reward system"
GABA	Alcohol can cause memory loss by damaging this part of the brain
ACETYLCHOLINE	This part of the body works to remove poisons and germs from the blood, and can be damaged by long-term alcohol abuse
WHAT CAUSES NICOTINE WITHDRAWAL?	The addictive drug found in tobacco products like cigarettes

Prescription Drugs, Inhalants, and the Brain Fact Sheet

The following chart describes the effects of prescription drugs and inhalants when used appropriately and inappropriately.

	Example	How are they supposed to work?	What can happen when they are used inappropriately?
Opioids Prescribed for pain	Morphine, codeine, Oxycodone (Oxycontin), Hydrocodone (Vicodin)	Block pain messages in brain by attaching to opioid receptors	Addiction, respiratory problems, death
CNS Depressants Prescribed for sleep problems and anxiety	barbiturates and benzodiazepines	Cause calmness by increasing GABA release	Addiction, respiratory problems, death
CNS Stimulants Prescribed for ADHD, narcolepsy, and depression	dextroamphetamine (Dexedrine) and methylphenidate (Ritalin)	Cause increased alertness by copying activity of dopamine and norepinephrine	Addiction, irregular heart beat, high body temperature, heart attack, seizures
Inhalants	Some household products	Meant for purposes other than inhalation	Brain is deprived of oxygen, decreased coordination, heart attack, "sudden sniffing death"

Conclusions:

1. People should only take prescription drugs prescribed specifically for them by a doctor, and they should always closely follow the directions for use.
2. Prescription drugs affect the brain and body. These changes can be harmful in someone that does not need them.
3. Inhalants are household products that can be very dangerous if used inappropriately.

Prescription Drugs, Inhalants, and the Brain Fact Sheet

The following chart describes the effects of prescription drugs and inhalants when used appropriately and inappropriately.

	Example	How are they supposed to work?	What can happen when they are used inappropriately?
Opioids Prescribed for pain	Morphine, codeine, Oxycodone (Oxycontin), Hydrocodone (Vicodin)	Block pain messages in brain by attaching to opioid receptors	
CNS Depressants Prescribed for sleep problems and anxiety	barbiturates and benzodiazepines	Cause calmness by increasing GABA release	
CNS Stimulants Prescribed for ADHD, narcolepsy, and depression	dextroamphetamine (Dexedrine) and methylphenidate (Ritalin)	Cause increased alertness by copying activity of dopamine and norepinephrine	
Inhalants	Some household products	Meant for purposes other than inhalation	

Conclusions:

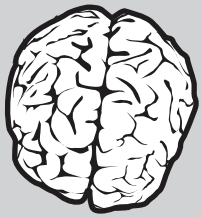
1.

2.

3.

1. This is the most commonly abused illegal drug in the United States. **(Marijuana)**
2. This is the active chemical ingredient in marijuana. **(THC)**
3. THC use can affect this function of the brain, which is the ability to retain information. **(Memory)**
4. Marijuana is used medically to treat the side-effects of this cancer treatment. **(Chemotherapy)**
5. The uncomfortable feeling or symptoms that one experiences when abruptly stopping marijuana use. **(Withdrawal)**
6. Marijuana disrupts this system in the brain that is responsible for feelings and emotions, and plays an important part in learning. **(Limbic System)**
7. This poisonous gas is found in marijuana smoke. **(Carbon Monoxide)**
8. Marijuana affects this ability to move, react, and stay balanced. **(Coordination)**
9. A slang name for marijuana. **(Weed)**
10. Marijuana comes from the dried flowers and leaves of this plant. **(Cannabis)**
11. These are located on dendrites, and receive messages during neurotransmission. A specific one of these is activated by THC. **(Receptor)**
12. This neurotransmitter is associated with feelings of pleasure, and is affected by marijuana. **(Dopamine)**
13. This part of the brain controls memory, and long term abuse of marijuana can permanently damage it. **(Hippocampus)**
14 Marijuana disrupts this process in the brain which involves the sending and receiving of messages. **(Neurotransmission)**
15. Long-term smoking of marijuana can lead to cancers and problems in this body organ. **(Lung)**
16. The status of marijuana use in the United States for nonmedical purposes. **(Illegal)**
17. This black liquid residue is found in marijuana smoke. **(Tar)**
18. This is the most common method of using marijuana. **(Smoking)**
19. The neurotransmitter that activates THC receptors. **(Anandamine)**
20. These effects can last more than four hours after marijuana use, and can include distorted perception, reduced coordination and balance, and sleepiness. **(Short term)**
21. These effects can occur when marijuana is used heavily over a long period of time and can include personality changes and memory problems. **(Long term)**
22. Long-term use of marijuana can cause personality changes, marked by a loss of this set of feelings that drives someone to achieve a goal. **(Motivation)**
23. This part of the brain, which takes in information from the senses and is in charge of higher order thinking, is affected by marijuana. **(Cerebral Cortex)**
24. Marijuana affects this part of the brain, which coordinates movement. **(Cerebellum)**

Bingo Card



Word Bank

Long term	Motivation	Lung
THC	Limbic System	Dopamine
Weed	Marijuana	Carbon Monoxide
Cannabis	Receptor	Memory
Withdrawal	Coordination	Chemotherapy
Neurotransmission	Hippocampus	Cerebellum
Smoking	Illegal	Tar
Cerebral Cortex	Short term	Anandamine

Do you think marijuana is safe for children and teens to use?

A. always
B. sometimes
C. never
D. not sure

Do you think marijuana affects the brain?

A. always
B. sometimes
C. never
D. not sure

Do you think marijuana can damage the brain or the body?

A. always
B. sometimes
C. never
D. not sure

Do you know anyone who uses marijuana?

A. yes
B. no
C. not sure

Students collected responses from their peers for each of the questions above. Use the chart below to tally the results.

Question	always	sometimes	never	not sure
Do you think marijuana is safe for children and teens to use?				
Do you think marijuana affects the brain?				
Do you think marijuana can damage the brain or the body?				
Question	**yes**	**no**	**not sure**	
Do you know anyone who uses marijuana?				

Marijuana Survey

Please fill out this survey. Your answers will be kept confidential.

Do you think marijuana is safe for children or teens to use?

A. always
B. sometimes
C. never
D. not sure

Do you think marijuana affects the brain?

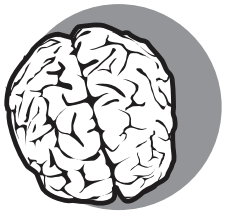
A. always
B. sometimes
C. never
D. not sure

Do you think marijuana can damage the brain or the body?

A. always
B. sometimes
C. never
D. not sure

Do you know anyone who uses marijuana?

A. yes
B. no
C. not sure



Marijuana Fact Sheet

_____ (tetrahydrocannabinol) is the active ingredient in marijuana.

THC activates THC _____ in the brain.

These receptors are located in the: _____ ,

_____ , and _____ .

When THC activates these receptors, it interferes with the _____

functioning of these areas of the brain.

Activity in the _____ is reduced when someone is using marijuana,

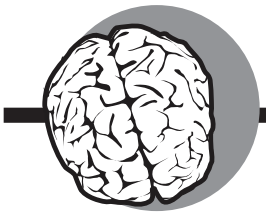
causing problems with short-term memory. Long-term use can cause

permanent _____ and _____ .

The amount of tar, carbon monoxide, and cancer-causing chemicals can be

_____ in marijuana smoke than in tobacco smoke.

Long-term marijuana users can become _____ to the drug.



Marijuana Fact Sheet

THC (tetrahydrocannabinol) is the active ingredient in marijuana.

THC activates THC **receptors** in the brain.

These receptors are located in the: **limbic system**,

cerebral cortex, and **cerebellum**.

When THC activates these receptors, it interferes with the **normal**

functioning of these areas of the brain.

Activity in the **hippocampus** is reduced when someone is using marijuana,

causing problems with short-term memory. Long-term use can cause

permanent **memory loss** and **learning problems**.

The amount of tar, carbon monoxide, and cancer-causing chemicals can be

greater in marijuana smoke than in tobacco smoke.

Long-term marijuana users can become **addicted** to the drug.

Heroin and Cocaine Fact Sheet

HEROIN

Changes in the brain are responsible for heroin addiction. Using heroin activates the brain's opiate receptors and increases the amount of dopamine released, which results in a short-lived rush. By acting on the opiate receptors, users can experience feelings of euphoria and decreased pain. Users can also experience nausea and cloudy thinking. After repeated use, receptors decrease and heroin users need more and more of the drug just to feel the same effects, or to avoid withdrawal symptoms. Withdrawal symptoms are intense for a heroin addict, and include insomnia, muscle and bone pain, vomiting, and cold flashes.

Word Bank: opiate, addiction, rush, withdrawal, receptors

COCAINE

Cocaine prevents the normal reabsorption of dopamine during neurotransmission. This causes a build-up of dopamine in the synapse, which gives a cocaine-user strong feelings of pleasure. When a person stops using cocaine, dopamine levels decrease and the person needs more of the drug to restore the dopamine level and to feel normal again. Repeated cocaine use can cause damage to neurons and lead to problems with memory and learning. Cocaine withdrawal can lead to feelings of depression, anxiety, and paranoia.

Word Bank: dopamine, memory, reabsorption, depression, synapse

Heroin and Cocaine Fact Sheet

HEROIN

Changes in the brain are responsible for heroin _____. Using heroin activates the brain's opiate _____ and increases the amount of dopamine released, which results in a short-lived _____ . By acting on the _____ receptors, users can experience feelings of euphoria and decreased pain. Users can also experience nausea and cloudy thinking. After repeated use, receptors decrease and heroin users need more and more of the drug just to feel the same effects, or to avoid _____ symptoms. Withdrawal symptoms are intense for a heroin addict, and include insomnia, muscle and bone pain, vomiting, and cold flashes.

Word Bank: opiate, addiction, rush, withdrawal, receptors

COCAINE

Cocaine prevents the normal _____ of dopamine during neurotransmission.This causes a build-up of dopamine in the _____ , which gives a cocaine-user strong feelings of pleasure. When a person stops using cocaine, dopamine levels decrease and the person needs more of the drug to restore the _____ level and to feel normal again. Repeated cocaine use can cause damage to neurons and lead to problems with _____ and learning. Cocaine withdrawal can lead to feelings of _____ , anxiety, and paranoia.

Word Bank: dopamine, memory, reabsorption, depression, synapse

STEROIDS

METHAMPHETAMINE

"CLUB DRUGS"

STEROIDS

METHAMPHETAMINE

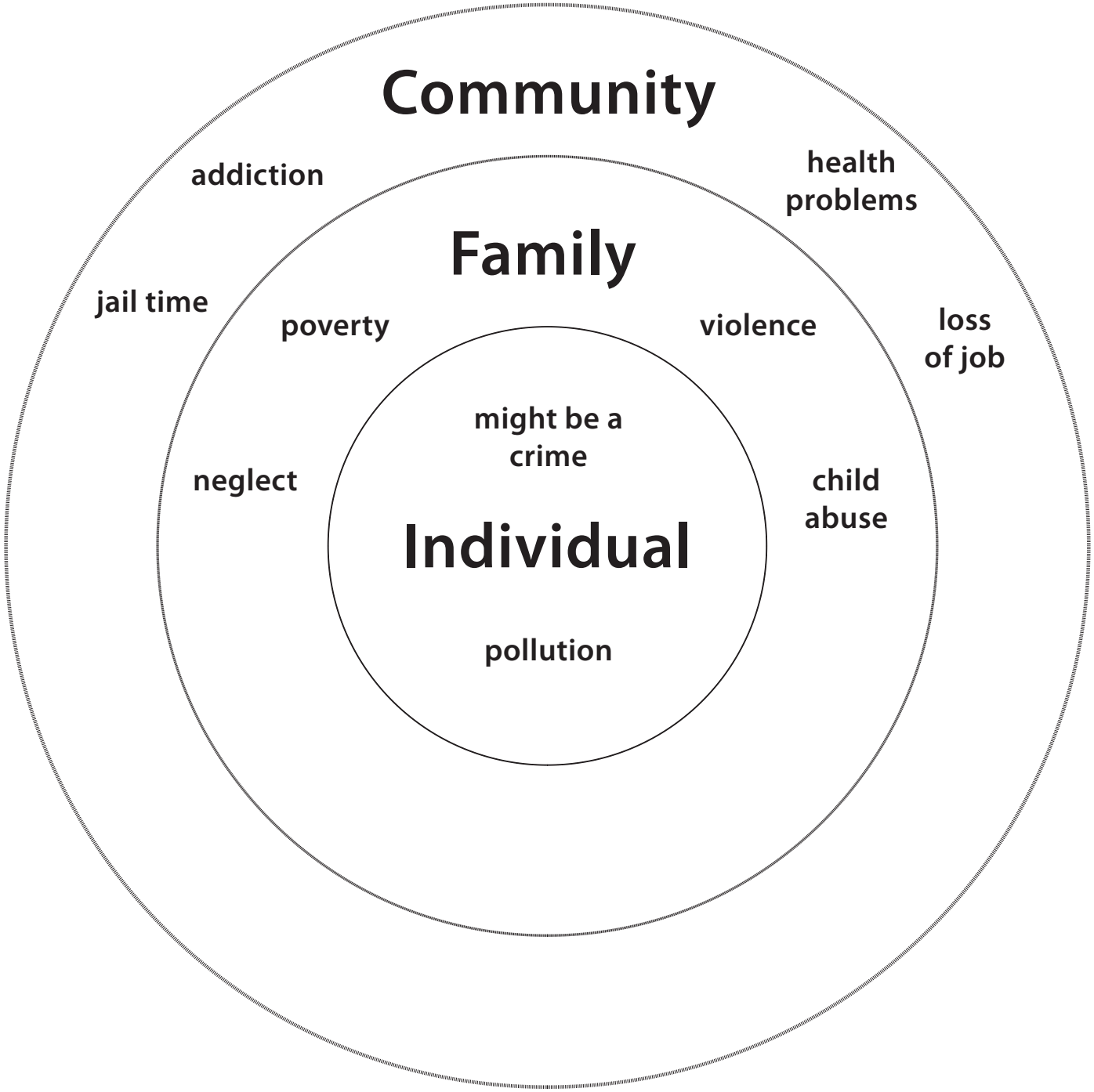
"CLUB DRUGS"

Drugs in the News Fact Sheet

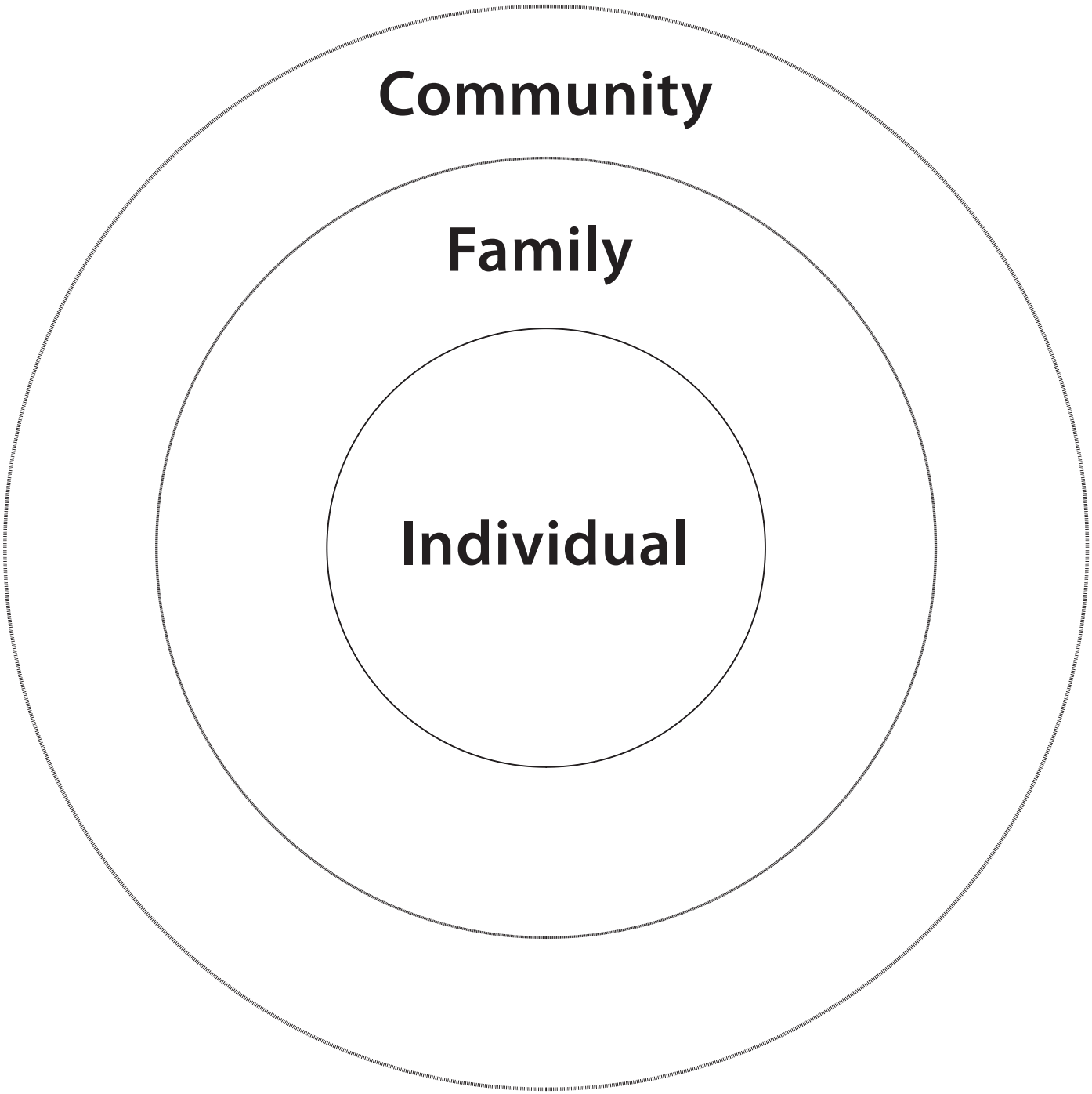
STEROIDS

METHAMPHETAMINE

"CLUB DRUGS"


Community
addiction
health problems
Family
jail time
poverty
violence
loss of job
might be a crime
neglect
child abuse
Individual
pollution

Ripple Effects



Media Chart

Use the chart below to tally the numbers of articles each group brings in for the competition.

Group	Number of articles that discuss drug abuse (one point per article)	Number of articles that discuss the impact of the drug on the brain and body (two points per article)	Number of articles where students have identified an imbalance in the presentation of information (three points per article)
1. 2. 3. 4. 5. 6.			
1. 2. 3. 4. 5. 6.			
1. 2. 3. 4. 5. 6.			
1. 2. 3. 4. 5. 6.			
1. 2. 3. 4. 5. 6.			

Media Report Card

Television Show or Movie Name	Grade	Comments