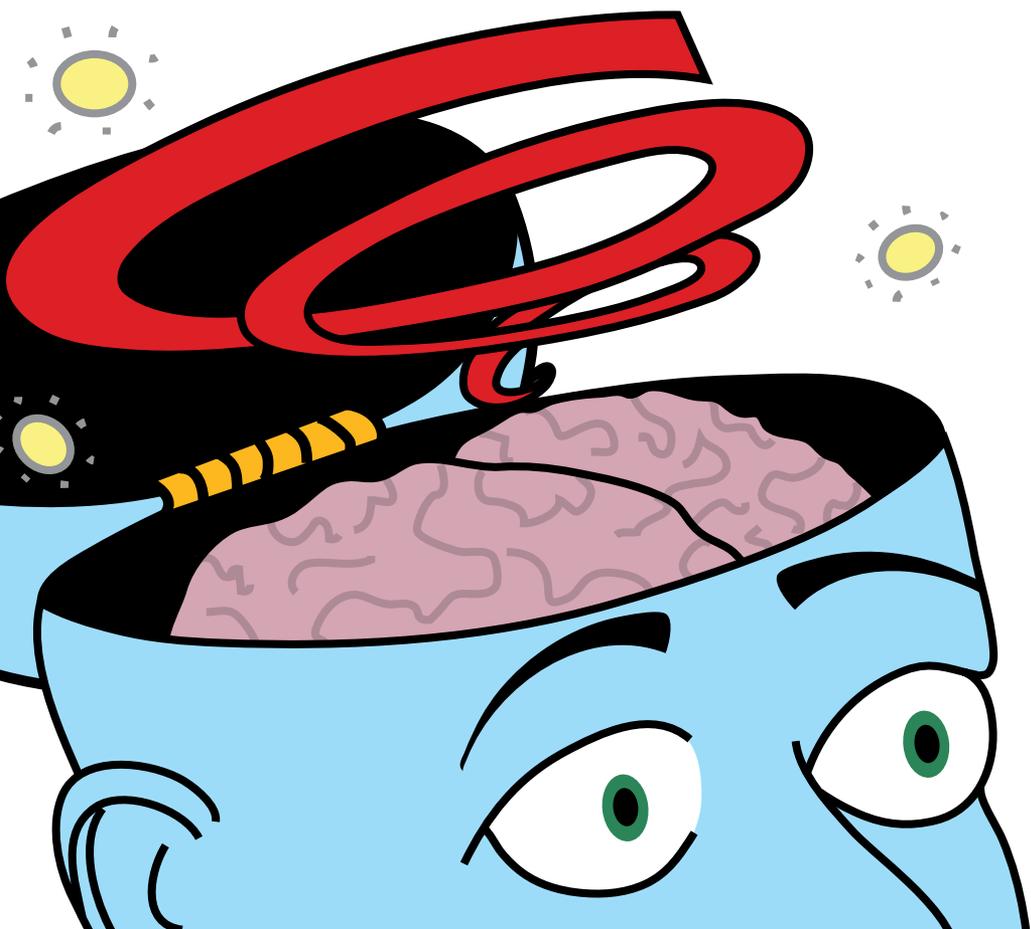


From the people who brought you *It's Mindboggling!*

MORE

MIND

BOGGGLERS!



This booklet is the result of collaboration between the Dana Alliance for Brain Initiatives and the Center for Educational Outreach at Baylor College of Medicine (BCM). It is adapted, by permission of the authors, from BCM's *BioEd/BrainLink* series components, "Brain Chemistry Teacher's Guide" and "Brain Chemistry Explorations." © Baylor College of Medicine. The BrainLink project was funded through Science Education Partnership Awards from the National Center for Research Resources of the National Institutes of Health.

The Dana Alliance is a nonprofit organization committed to advancing public awareness about the progress and benefits of brain research and to disseminating information on the brain in an understandable and accessible fashion. Supported entirely by the Dana Foundation, the Dana Alliance does not fund research or make grants.

The mission of the Center for Educational Outreach at Baylor College of Medicine is to advance quality teaching and learning in science and health, and to promote access to careers in medicine and science-related fields. Projects are aimed at diverse student audiences, from pre-school through high school, undergraduate and graduate school, and also include teacher professional development, and the creation of unique curriculum materials.

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Check It Out!

This puzzle contains hidden words that relate to the brain—names of parts of the brain, functions it performs and things that may affect how the brain works. There are **eleven words in bold on the following pages** that are in this puzzle **plus nineteen words** relating to how your brain and body work.

X	V	N	C	N	U	B	R	A	I	N	S	T	E	M	E	T	C
R	I	T	H	E	N	F	E	R	M	E	D	I	C	I	N	E	E
D	T	N	E	U	R	O	T	R	A	N	S	M	I	T	T	E	R
I	A	N	M	R	A	O	P	B	R	A	I	N	E	I	M	L	E
N	M	T	I	O	P	D	A	S	I	L	T	C	T	N	O	E	B
H	I	O	C	N	R	I	H	E	J	E	L	I	M	B	I	C	R
A	N	B	A	X	O	N	A	L	U	R	H	I	E	L	T	T	U
L	E	A	L	G	T	D	O	P	A	M	I	N	E	A	L	R	M
A	O	C	S	T	E	E	X	O	N	I	C	U	A	S	C	I	H
N	A	C	P	E	I	N	A	R	A	M	C	S	Y	T	A	C	E
T	A	O	E	A	N	D	A	R	I	N	O	S	C	I	F	A	S
P	I	R	E	C	E	R	E	B	E	L	L	U	M	M	F	L	I
L	B	O	D	N	M	I	N	E	R	A	L	G	O	U	E	N	G
T	R	E	C	E	P	T	O	R	A	T	L	A	M	L	I	E	N
S	Y	N	A	P	S	E	A	C	D	A	B	R	E	A	N	B	A
T	R	A	H	E	A	L	T	H	S	T	A	C	G	N	E	I	L
C	A	R	B	O	H	Y	D	R	A	T	E	E	C	T	A	R	N

Circle each word and learn about the mystery of your brain in the following pages.



The Brain

The human brain directs almost everything that we do. It controls our voluntary movements and it regulates involuntary activities such as breathing and heartbeat. The brain stores our memories, allows us to feel emotions and gives us our personalities.

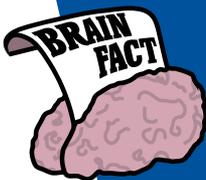
As the command center of your body, it receives and processes information from the world around you and controls your emotions, thoughts, movements and automatic body functions.

Made up of 100 billion nerve cells with more than 100 trillion connections, the brain is the most complex organ in your body. In fact, it is the most complicated arrangement of matter in the known universe.

The brain can be divided into several regions, each with a specific function. These include:

- The **brainstem** connects directly with the spinal cord and is responsible for automatic functions of the body.
- The **cerebellum** is located near the back of the brain at the top of the brainstem. It is about the size of a tennis ball.
- The **cerebrum** is the largest part of your brain. It sits above the brainstem and cerebellum and covers most of the remaining brain structures. It is divided into left and right hemispheres, which are connected. Different parts of the hemispheres handle different functions. Even though the hemispheres look similar, some functions are handled more by one hemisphere than the other.

Our emotions are governed by a region of the brain known as the limbic system. Buried under the cerebrum, the limbic system is involved in many emotions and motivations, especially those related to survival, such as anger, fear and the fight-or-flight response. The limbic system also plays an important role in feelings of pleasure.



Circuits of neurons work together each time we feel, smell, taste, see or hear something.

Cerebrum

- Thinking
- Learning
- Remembering
- Sensing
- Speaking
- Feeling Emotions
- Voluntary Movement (Movements you choose to do)
- Planning
- Decision making
- Reasoning

Limbic System

- Feeling emotions related to survival, such as fear and anger
- Processing of memories for long-term storage
- Feeling pleasure
- Regulation of body temperature, thirst and appetite or hunger

Brainstem

Automatic body functions, such as:

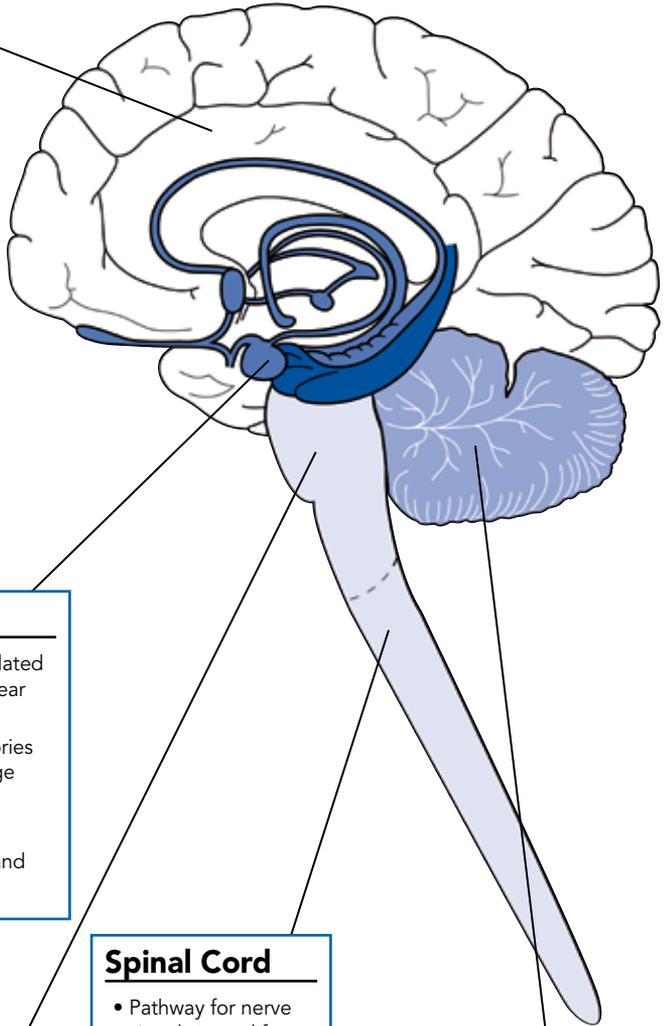
- Swallowing
- Breathing
- Sneezing
- Heart beat
- Eye movements and blinking

Spinal Cord

- Pathway for nerve signals to and from the brain
- Coordination of reflex actions, like jerking your hand away from something hot

Cerebellum

- Controlling balance and movement
- Remembering well-learned tasks and skilled movements
- Processing some types of memory



The Nervous System

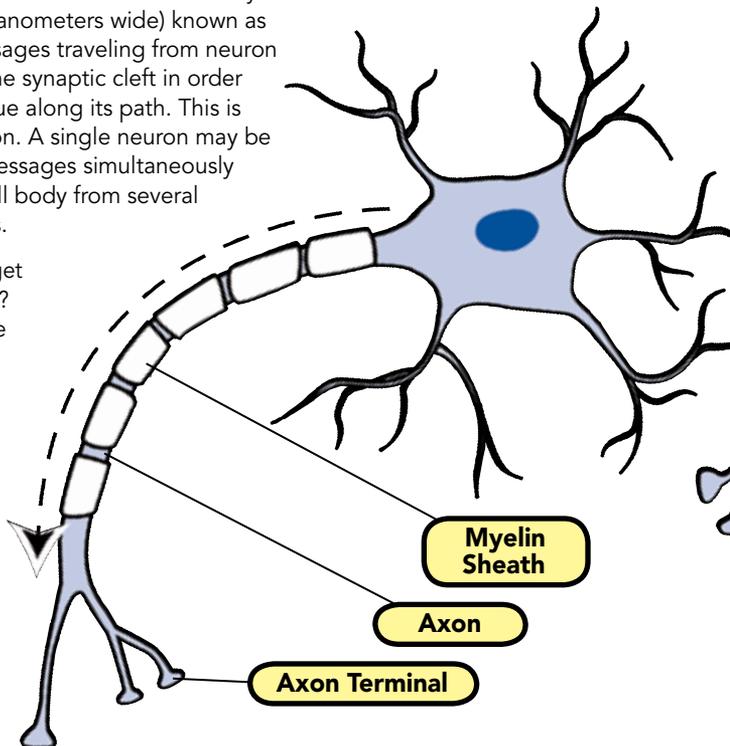
The nervous system is made up of two classes of cells known as glial cells and neural cells (neurons). Glial cells are the “support cells” of the nervous system; they perform a number of important jobs that help keep the nervous system running smoothly.

Neurons are specialized to receive and transmit information. In fact, almost all functions of the **nervous system** are based on electrical and chemical communications inside and among neurons. Types of neurons differ in appearance, but they all collect information from inside our bodies, from our senses or from other neurons. All neurons also transmit information to other neurons or other kinds of cells (such as muscle cells). Some neurons can receive messages from several thousand different cells at once!

A typical neuron has an enlarged area, the cell body, which contains the nucleus. Neurons typically also have several branches or extensions that project away from the cell body. The branches on which information is usually received are known as **dendrites**. Most neurons have many dendrites and a longer, tail-like branch called the **axon**, which transmits information to the next cell. The axons of many kinds of neurons are surrounded by a fatty, segmented covering called the myelin sheath. This covering acts as a kind of insulation and improves the ability of axons to carry nervous system signals rapidly.

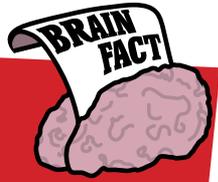
Neurons communicate with one another and with other cells such as muscles through a special junction known as a **synapse**. At the synapse, the axon of one neuron usually is separated from the next cell by a narrow gap (20 to 40 nanometers wide) known as the synaptic cleft. Messages traveling from neuron to neuron must cross the synaptic cleft in order for the signal to continue along its path. This is called neurotransmission. A single neuron may be capable of receiving messages simultaneously on its dendrites and cell body from several thousand different cells.

How does information get across the synaptic cleft? Chemical changes cause an electrical signal, or impulse, that can move from one end of an axon to the other. This movement along an axon resembles a line of dominoes in which each domino causes the next one to fall. Once the impulse reaches the end of the neuron, it triggers

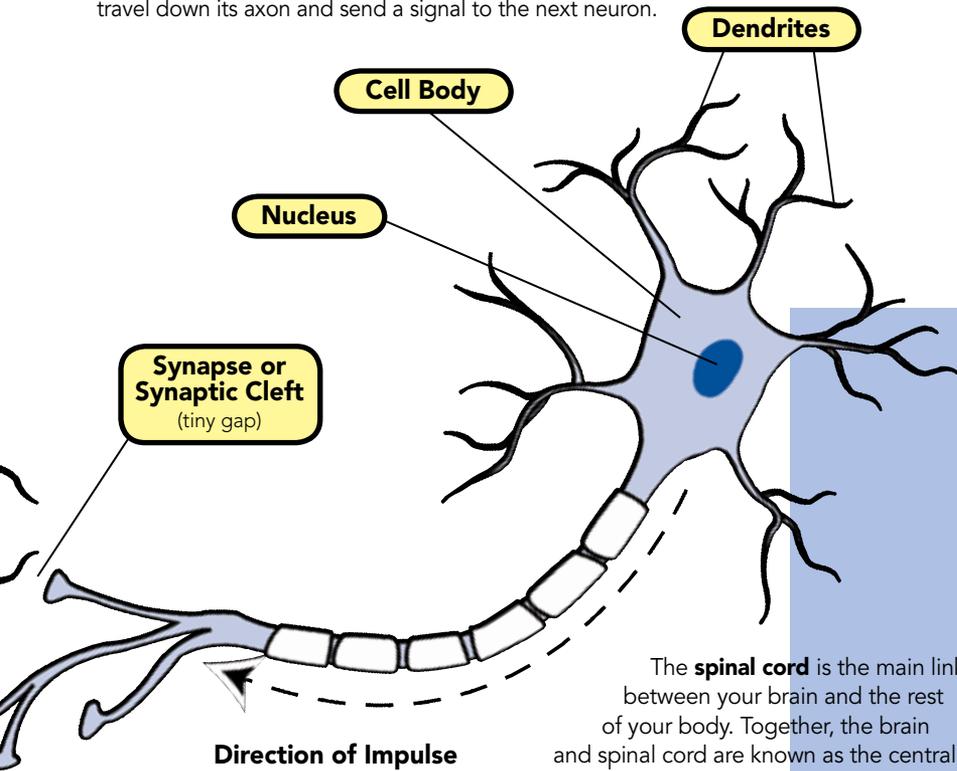


the release of special chemicals known as **neurotransmitters**, which cross the synaptic cleft and attach to matched **receptors**, usually on the dendrites or cell body of another neuron or on a muscle fiber.

There are many different kinds of neurotransmitters (more than 100!). Some of them are “excitatory”—they make it easier for the neuron to fire. A single neuron may receive excitatory and inhibitory messages simultaneously from thousands of other neurons. The neuron must sort out all of that information and, based on the types of messages it received, either remain silent or generate its own electrical impulse that will travel down its axon and send a signal to the next neuron.



“Nano” means one billionth. A nanometer is one billionth (or 0.000,000,001) of a meter. A synaptic cleft is usually 20 nanometers across. Just imagine how tiny a synapse is if the width of a single hair is 50,000 nanometers!



The **spinal cord** is the main link between your brain and the rest of your body. Together, the brain and spinal cord are known as the central nervous system. Your spinal cord is made of

millions of neurons (cells that are the building blocks of the nervous system) that allow your brain to communicate with the rest of your body. Each year thousands of people suffer spinal cord injuries, usually from auto and sports accidents and falls. Often the result is paralysis – not being able to move parts of the body. Scientists are trying to find treatments that get these spinal neurons to grow back after injury.

Learning and Memory

Learning is the process of gaining new information.

Memory is the system our brain uses to hold on to information and to get it back when we need it. All the facts we know, our knowledge of how to do things and our ability to make sense of what is going on around us depends on learning and memory. Located deep within the brain, the hippocampus is a part of the brain that is important for many forms of memory and learning.

How long do memories last? Some of our memories last for only a short time. Have you ever forgotten a telephone number right after making your call? This brief kind of memory, called working memory or short-term

memory, is what you remember only as long as you are paying attention.

Some things are saved as long-term memories. Things that are important to us or arouse strong emotions are more likely to be placed in “permanent storage” than ordinary life events. Creating long-term memories often involves repetition or rehearsal. Long-term memories can last from a few hours to a lifetime.

Practice – Practice – Practice

We often have to practice what we want to learn – from multiplication tables, to getting the right curve on a soccer kick, to playing a song on the piano.



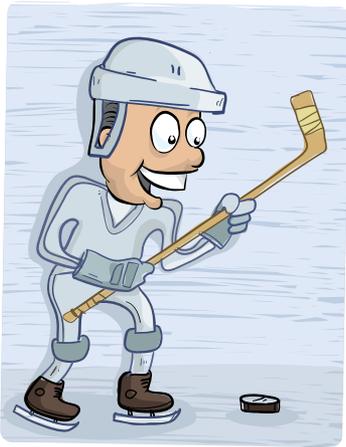
Long-term memories also can be made when you experience something very exciting or frightening. What are some of your most vivid memories from a long time ago and why do you remember them?



Learn how to ride a bike and you never forget—why?

Think of how many things you do each day that require your body to move. There are many parts of the brain that achieve this. Remember when you learned how to ride a bicycle or to ice skate? In the beginning, you probably fell down a lot. This is because your brain first had to learn how to bike or skate. Next, your brain told your muscles how to make the correct movements. The part of the brain that gives the orders to move the muscles is the motor cortex. It is located in the cerebrum.

When you are first learning a new set of motor skills, you have to concentrate. The motor cortex directs all of the muscle movements with instructions from all over the cerebrum, the “thinking” part of your brain. At the same time, other parts of your brain, such as your cerebellum, are “remembering” how the movements are made.



After you have learned to ride a bike or to ice skate well, the motor cortex receives instructions from these other brain areas that maintain “motor memories” for all your familiar actions. You don’t have to think about them. That’s why you can walk and talk at the same time or sing while you skate. You don’t have to concentrate hard on telling your muscles what to do. Your cerebellum is doing a lot of the work for you.

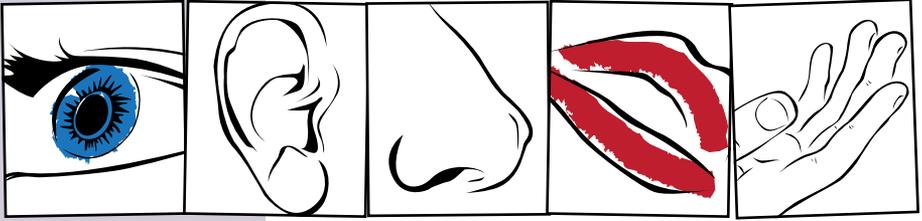
Memory Power:

Using rhyme or rhythm to help remember something is one way that you can “boost” your memory power. Most of us learned to say the letters of the alphabet in order by singing the “alphabet song.” This is called **mnemonics**.

Another good example is using a phrase or word to remember a longer list. For example, HOMES helps us remember the names of the five Great Lakes – Huron, Ontario, Michigan, Erie and Superior. You can also create a picture in your mind to help remember a difficult word or phrase. Imagining a hippo attending summer camp, for example, is a mnemonic to help remember the word, hippocampus.



Senses

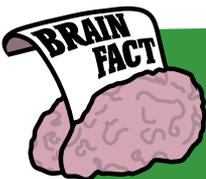


It is our senses that let us know what is going on inside and outside our bodies. Every moment, your brain is bombarded by sensory signals. It receives messages from sensory receptors in your eyes, ears, nose, mouth, skin and from inside your body. All the messages travel along neurons to the brain. Signals from each kind of sensory receptor go to different areas of the cerebrum.



So many messages come in to the brain all the time that it is almost as if a thousand balls of different kinds were being thrown at your brain at once! Incredibly, your brain sorts out the signals, knowing which ones to pay attention to and which to ignore. In an amazingly complex process, the brain combines information from different senses and memories of past experiences to reach conclusions and begin actions.

External information is gathered by specialized receptors in the sense organs (the nose, eyes, ears, tongue and skin.) Signals are then translated into electrical activity that the entire nervous system understands and relayed to the brain via sensory neurons. Specialized parts of the cerebrum receive the signals. Other areas process, integrate and interpret the sensory signals.



Most of the time the eyes and brain work together to tell us what is around us. Sometimes, though, the brain can be fooled or confused by what the eyes take in.

Most sensory receptors are specialized to respond to a particular type of information. For example, there are different receptors in the skin devoted to receiving and transmitting information about pain, pressure, heat, cold and touch. Senses work within our bodies to provide cues about varying states of our body organs and positions of our muscles and limbs and enable us to interpret and react to our environment. Through our senses, we are able to investigate the world; to learn, to achieve and to discover.



What do you see in this picture? What you see depends upon what part of the picture you look at. Do you see the twin faces or do you see the table? You may notice that you cannot focus on both the faces and the table at the same time. The brain is selecting part of the information available to it in order to make sense of what you are looking at. We do this all the time without being aware of it. This may be one reason why different people will describe the same scene or occurrence in very different ways.

Read the names of the colors. Is it easy or hard? Now try saying the colors instead of reading the words. Do you find that you have to go slowly in order to get the colors right? Seeing the words, the brain expects the colors and names to match. They do not match, so the brain has to rethink and decide which information to use and which to ignore. Often we will be fooled and think that we see something that is not present (or not see something that is) because of what we expect to see.

RED	LAVENDER	BLUE	
GREEN	YELLOW	PINK	
RED	BLUE	BLACK	GREEN
YELLOW	RED	ORANGE	
BLUE	GREEN	YELLOW	
RED	BLUE	PURPLE	PINK
YELLOW	RED	ORANGE	
LAVENDER	BLUE	GREEN	
YELLOW	RED	BLACK	
BLUE	ORANGE	GREEN	

Drugs and the Brain

Drug addiction is a complex brain disease. It is characterized by compulsive, at times uncontrollable, drug craving, seeking and use that persist even in the face of extremely negative consequences. For many people, drug addiction becomes chronic, with relapses possible even after long periods of abstinence.

How does addiction happen? Pleasure, which scientists call reward, is a very powerful biological force for our survival. If you do something pleasurable, the brain is wired in such a way that you tend to want to do it again.

This temporary feeling of pleasure is a powerful biological force for survival. Addictive drugs can activate the brain's pleasure circuit. Drug addiction is a pathological twist of the biological process by which the pleasure center, as well as other parts of the brain, functions. To understand this process, it is necessary to examine the effects of drugs on neurotransmission.

Almost all drugs that change the way the brain works do so by affecting chemical neurotransmission. Some drugs, like heroin and LSD, mimic the effects of a natural neurotransmitter. Others, like PCP, block receptors and thereby prevent neuronal messages from getting through. Still others, like cocaine, interfere with the molecules that are responsible for returning neurotransmitters back into the neurons that released them. Finally, some drugs, such as methamphetamine, act by causing neurotransmitters to be released in greater amounts than normal.

Addictive substances like nicotine, alcohol, prescription painkillers, marijuana, cocaine and heroin change the brain in fundamental ways by acting on the "reward pathways" in the brain. A rush of neurochemicals are released to produce a euphoric high. With continued use, the underlying brain circuits physically change. These long-lasting changes are a major component of the addiction itself. In many instances, the brain quickly gets used to a drug, so that more and more is needed to recreate the original feelings of pleasure.

Scientists are studying this brain circuitry and the underlying addiction to identify targets for therapies that might help stop the compulsion to use drugs or ease withdrawal.



Many abused substances have side effects that people don't think about. Look at the substances listed in the white boxes and study the numbered lists of effects. Write the numbers for all corresponding effects in each substance box. Keep in mind that each substance can cause more than one effect and that each effect can go with more than one substance. The effects of tobacco are given. Check the answers and see if there were any surprises!

Alcohol

Cocaine

Codeine

Ecstasy

Heroin

Inhalant

LSD

Marijuana

Tobacco 4, 8, 11, 14

EFFECTS

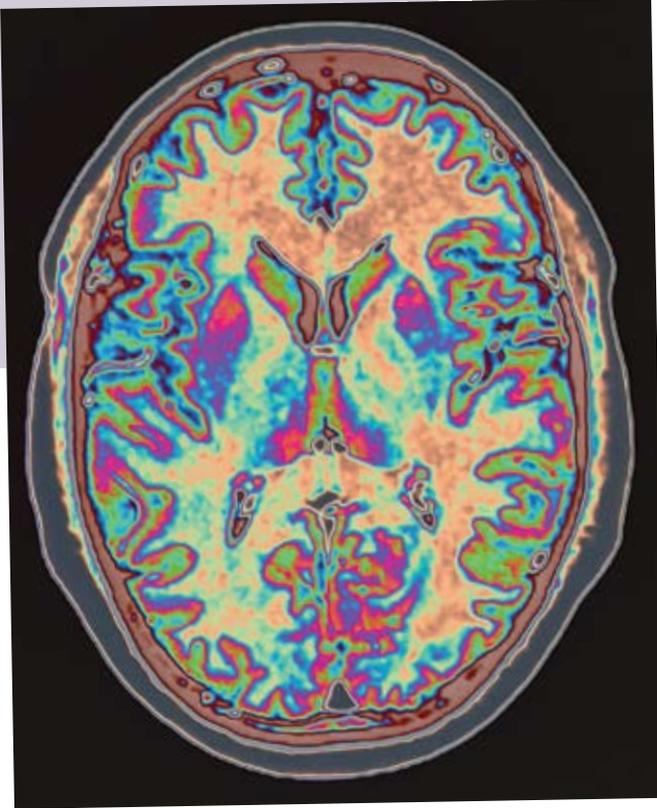
1. Slowed thinking or confusion
2. Poor balance and coordination
3. Panic Attacks
4. Addiction
5. Short-term feeling of well-being
6. Liver disease
7. Memory loss or poor learning
8. Abnormal heart rate or heart failure
9. Nausea
10. Seeing or hearing things that are not real
11. Temporary feelings of energy
12. Ulcers inside nose
13. Unconsciousness
14. Heart disease
15. Sudden death
16. Lowered inhibitions
17. Pain relief
18. Slurred speech

For more information about addictive substances, go to the National Institute on Drug Abuse web site at www.drugabuse.gov/drugpages.

How Quickly Can I Become Addicted to a Drug?

There is no easy answer to this. If and how quickly you might become addicted to a drug depends on many factors including your genes (which you inherit from your parents) and the biology of your body. All drugs are potentially harmful and may have life-threatening consequences associated with their use. There are also vast differences among individuals in sensitivity to various drugs. While one person may use a drug one or many times and suffer no ill effects, another person may be particularly vulnerable and overdose with first use. There is no way of knowing in advance how someone may react.

It's Amazing!



Scientists have worked for many years to unravel the complex workings of the brain. Their research efforts have greatly improved our understanding of brain function. Using new imaging techniques, scientists can visualize the human brain in action. Images produced by these techniques have defined brain regions that play a role in attention, memory and emotion. New findings show that some adult brain cells (stem cells) can divide and become new neurons and glial cells. Advances in research are allowing scientists

to analyze and make progress toward understanding the causes of brain disorders such as Alzheimer's disease and Parkinson's disease.

Despite these and other significant advances in the field of brain research, most of the processes responsible for the integrated functioning of billions of brain cells remain a mystery. Research on the brain continues to bring new insights into how the brain is put together, how it works and whether damage to the brain can be reversed. Scientists who study the brain and nervous system are called **neuroscientists**.

Given the brain's staggering complexity, it is hardly surprising that the nervous system can malfunction in countless ways. **Neuroscience** is a vast field with opportunities for research in brain function, in diseases and disorders, in brain imaging and in providing important insights into thought, emotion and behavior. For more information, check out Sources and Resources.

Food for Thought!

Have you ever felt cranky after missing a meal or had trouble concentrating on a test when you skipped breakfast?

A healthy brain and nervous system require many different kinds of raw materials. These raw materials come from food. Did you know that glucose (a kind of sugar) is the main source of energy for the brain? Under normal conditions, the brain depends on a continuous supply of glucose provided by the blood. Carbohydrate-rich foods such as bread, pasta, and potatoes are important sources of glucose and your body can manufacture glucose from proteins and other energy-rich foods. Candy and other sugary foods actually deprive your brain of fuel because they cause glucose levels in the bloodstream to rise rapidly and then crash. Eat healthy!

Sources and Resources

- Baylor College of Medicine, Center for Educational Outreach: <http://www.ccitonline.org/ceo>
- Dana Alliance for Brain Initiatives: <http://brainweek.dana.org/education.cfm>
- National Institute on Alcohol Abuse and Alcoholism: www.niaaa.nih.gov
- National Institute on Drug Abuse: www.nida.nih.gov
- National Institutes of Health Office of Science Education: <http://science.education.nih.gov/>
- National Institute of Mental Health: www.nimh.nih.gov
- National Institute of Neurological Disorders and Stroke: www.ninds.nih.gov
- Neuroscience for Kids: <http://faculty.washington.edu/chudler/neurok.html>
- Society for Neuroscience: www.sfn.org

Answers

Check It Out (page 1):

Axon, Brain, Brainstem, Caffeine, Carbohydrate, Cerebellum, Cerebrum, Chemical, Dendrite, Dopamine, Electrical, Food, Health, Inhalant, Limbic, Marijuana, Medicine, Mineral, Neuron, Neurotransmitter, Protein, Receptor, Signal, Speed, Stimulant, Sugar, Synapse, Tea, Tobacco, Vitamin

Think About It (page 8):

Alcohol (1, 2, 4, 5, 6, 7, 13, 16, 18); Cocaine (4, 5, 8, 9, 11, 12); Codeine (1, 4, 5, 9, 13, 17); Ecstasy (7, 8, 10, 11); Heroin (1, 2, 4, 5, 9, 13, 17); Inhalant (2, 7, 8, 9, 11, 13, 15, 16, 18); LSD (8, 9, 10); Marijuana (1, 2, 3, 4, 5, 7)

Thank You to...

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Karen Graham, Dana Alliance

Access the online edition of
More Mindbogglers! at
www.dana.org/kids/lesson.cfm

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