

THE SECRET LIFE OF THE BRAIN

TEEN GUIDE

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WNET NEW YORK

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David Grubin

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www.pbs.org

THE SECRET LIFE OF THE BRAIN

TEEN GUIDE

www.pbs.org/brain

To the Teacher

This Teen Guide accompanies THE SECRET LIFE OF THE BRAIN, the five-part public television series co-produced by David Grubin Productions, Inc., and Thirteen/WNET New York. We recommend that educators use the guide in after-school science workshops or in science classes as a supplement to high school curricula.

The guide provides a general overview of the series and explores in detail key aspects of the brain's development from infancy to old age. How does a child learn language? When do our reasoning abilities develop? What is the relationship between reason and emotion? Along with delving into these and other questions, the educational materials introduce teens to neuroscience professionals — neurosurgeons, MRI technicians and brain research scientists.

Like the television series, the guide stresses the brain's plasticity over its lifelong development. Your students will learn that the human brain is both resilient and vulnerable, particularly in the teenage years. We hope that the guide's sober discussion of the brain's vulnerability can help students better understand and cope with problems in their lives.

How to Use This Guide

You may use these materials in conjunction with in-class screenings of THE SECRET LIFE OF THE BRAIN. First, view the programs and look over the guide. When you have determined what your session's brain topic will be, select one or two video segments and their corresponding educational cards. The teacher's pages are for your use. The student cards should be photocopied and distributed. You may give students a copy of the comic book pages as a way of introducing the series.

You can pick and choose from the cards in this guide to create your lesson. You will find the Table of Contents on page 3. For example, if you want to teach about **infant development**, you might combine the four cards for Program One with the comic book pages and "What's Going On in My Little Brother or Sister's Brain?" If you want to teach **how substance abuse alters the brain**, you can use segments of Program Three along with "Addictive Drugs and the Brain."

In addition to photocopying the student cards for distribution, you might want to photocopy the glossary and the brain illustration on the back of the folder.

The Secret Life of the Brain, by Richard Restak, M.D., has been published by The Dana Press and Joseph Henry Press to accompany the public television series.

THE SECRET LIFE OF THE BRAIN
Web site (www.pbs.org/brain) offers additional information and many exciting features.

Utilization Strategies for Video

Media is most effective when used interactively, rather than passively, in class or group discussion. Consider using some of the following strategies when planning lessons or discussions based on THE SECRET LIFE OF THE BRAIN:

1. **Preview** video(s) to determine suitability for your objectives and your group members.
2. **Select Segments** that are directly relevant to your topic and appropriate for your group — you need not use an entire video or presentation at one time: A few well-chosen minutes may be more effective in illuminating your topic.
3. Provide a **Focus for Interaction** — something specific to do or to look or listen for in relation to the chosen segment or presentation. This assures that the group will focus together on the information most relevant to your topic.
4. Don't be afraid to **Pause** for discussion, or to **Rewind and Replay** to underscore or clarify a particular point. This allows video to play a more interactive role in discussion.
5. Consider **Eliminating Sound or Picture**. Allowing your group members to provide their own narration of what they see, or to predict what the content accompanying narration might be, is especially useful in working with younger groups or groups whose primary language is not English.

THE SECRET LIFE OF THE
BRAIN

ACKNOWLEDGMENTS

TEEN GUIDE

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www.pbs.org/brain

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THE SECRET LIFE OF THE B R A I N

WHEN AND WHERE TO USE THE SECRET LIFE OF THE BRAIN

www.pbs.org/brain

THE SECRET LIFE OF THE BRAIN may be used in science, health, psychology and even language arts classes. Video segments and animation sequences from Programs One through Five may be used to discuss topics including science and technology, the nervous system, brain health and more. See the Program Highlights on the first Teacher's Page in each program section. Also check the animation list below to see which sequences you would like to use. Language arts teachers may be interested in using Program Five segments that feature poet Stanley Kunitz.

ANIMATION SEQUENCES

(Times are in minutes and seconds)

The Baby's Brain: Wider Than the Sky

- 2:16 the baby's brain
- 7:05 brain cells forging links
- 9:11 the neural tube/formation of the brain
- 10:52 glial fibers
- 13:12 dividing stem cells
- 13:59 migrating neurons
- 15:12 networking neurons
- 28:45 ferret's brain; visual cortex/auditory cortex

The Child's Brain: Syllable From Sound

- 3:05 the child's brain
- 17:11 language in the left cerebral hemisphere
- 43:41 attentional systems: frontal regions — prefrontal cortex, anterior cingulate gyrus, thalamus — brain during reading; visual systems (areas) — occipital regions, Wernicke's region, angular gyrus, Broca's region
- 48:12 angular gyrus region underactive, extra-striate cortex (visual cortex), Wernicke's region

The Teenage Brain: A World of Their Own

- 2:30 the teen brain
- 9:02 frontal cortex
- 12:15 schizophrenia, ventricles; frontal cortex shrinks
- 13:21 normal adolescent brain: prefrontal cortex pruning
- 24:18-24:45 schizophrenia: hallucinations; auditory cortex; higher regions of the brain
- 25:25 schizophrenia: hallucinations, psychosis and dopamine
- 25:39 synapse and neurotransmitters
- 26:50 schizophrenia: hallucinations
- 27:00 effect of antipsychotic medications
- 33:08 addiction's high: brain with courting chemicals; reward pathway, dopamine
- 34:42 addiction's high: synapse and dopamine
- 36:18-37:00 addiction's high: neural net; loss of receptors on dopamine's target

The Adult Brain: To Think by Feeling

- 2:57 the adult brain
- 8:51 emotional brain, amygdala
- 9:38 region of emotional awareness in the brain
- 22:52-24:35 the amygdala and the limbic system; amygdala and the frontal cortex
- 25:27 frontal cortex and the amygdala
- 25:30 post-traumatic stress and the amygdala; stress hormones
- 26:59 stress hormones, amygdala and hippocampus
- 34:42 emotion and the prefrontal cortex
- 39:30 neurons, synapses
- 40:09 neurons, synapses, serotonin
- 41:00 depressed brain and serotonin

The Aging Brain: Through Many Lives

- 2:50 the brain in old age
- 3:00-3:50 neurons
- 6:50 neurons and stroke
- 8:47 neurons and stroke
- 13:16 stroke and brain recovery
- 18:43 neurons and memory
- 20:02 hippocampus and synapses
- 20:16 neurons, synapses, calcium and NMDA receptor
- 30:14 neurons and aging brain
- 31:40 stem cell
- 31:50 stem cell
- 35:20-36:04 neurons and stem cells in mice
- 46:43 neurons and nourishment
- 45:54 neurons and tau; Alzheimer's disease
- 48:55-49:22 Alzheimer's brain and protein fragments, beta amyloid

THE SECRET LIFE OF THE BRAIN PROGRAM SCHEDULING

Programs are scheduled to be broadcast on the dates indicated below. Broadcast times, however, may vary slightly from area to area. Please check your local listings.

PROGRAM BROADCAST DATES

- Program 1 The Baby's Brain: Wider Than the Sky
January 22, 2002
- Program 2 The Child's Brain: Syllable From Sound
January 22, 2002
- Program 3 The Teenage Brain: A World of Their Own
January 29, 2002
- Program 4 The Adult Brain: To Think by Feeling
February 5, 2002
- Program 5 The Aging Brain: Through Many Lives
February 12, 2002

Videotaping Rights

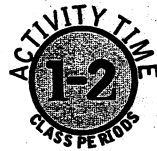
You may assign programs to your students for viewing when they are first broadcast, or you have the right to tape the programs and play them for instructional purposes for one year after the original broadcast.

Video Ordering Information

THE SECRET LIFE OF THE BRAIN is available from PBS Video by calling 1.800.PLAY.PBS.

THE SECRET LIFE OF THE B R A I N

THE BABY'S BRAIN: WIDER THAN THE SKY



Broadcast Date: January 22, 2002

TEACHER'S PAGE 1

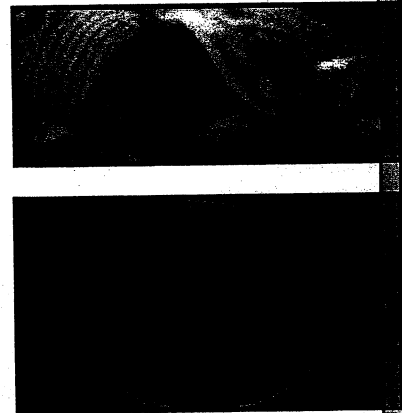
www.pbs.org/brain

At a Glance

Theme: As a human grows from a fetus to a toddler, how does its brain develop? Program One uses two case studies to explore this question and examine the ways in which brain cells are influenced by genetic and environmental factors. By applying the latest brain research, scientists help the babies in these case studies develop normally.

Program Highlights

- Scientists used to believe that the newborn's brain was just a smaller version of the adult brain, that it was completely "wired" at birth. Today we know that the baby's brain is a dynamic structure; it makes many new connections each day as it develops. The baby's brain strengthens appropriate, useful connections and prunes inappropriate, less helpful connections. These connections have a dramatic impact on the baby's physical, intellectual, emotional and social development.
- Elizabeth Traphagen was born three months before she was due. At birth, she weighs just three pounds and is only 14 inches long. Although her lungs and heart can function, her brain still needs time to develop properly. Billions of brain cells still need to make links with billions of other brain cells. In the hospital, the researchers reduce external stimulation (light and sounds), so that the baby's brain has a better chance of normal development.
- Both genetics and environment play important roles in the development of a baby's brain. Through experiments, scientists have found that some genetic traits of neurons can be modified by changing the baby's environment.
- To examine the relationship between genetic and environmental factors on brain development, a scientist restructures the brains of newborn ferrets. By recording images from the brains of the rewired ferrets, scientists find that the ferrets' brains had been reorganized to accommodate this "rewiring."
- Holly MacMillan, a five-week old baby, was born with a faulty lens in her right eye — a cataract — that clouds her vision. The vision in her left eye is normal. Holly's doctor is concerned. Even one or two months of poor visual experiences in one eye can have permanent consequences for the way her brain cell connections develop. So, the cataract in her right eye is removed immediately. Then, she begins a special program to restore her vision. She will wear a patch over her good eye for most of her waking hours for at least five years or until her visual development stabilizes.



Discussion Questions

- 1 If a baby is born three months early, what are some challenges it might face?
- 2 How are brain cells different than other types of body cells in terms of development and reproduction?
- 3 What are some ways in which the world influences the developing brain?
- 4 What does poet Emily Dickinson mean when she says, "The brain is wider than the sky"? In the last line of this poem, what do you think she means by "The brain is just the weight of God... "?

For more on topics covered in Program One of THE SECRET LIFE OF THE BRAIN, log on to

Frequently Asked Questions

Infant Cataracts:

www.pbs.org/wnet/brain/episode1/faq

Infant Vision

www.pbs.org/wnet/brain/episode1/infantvision

Mind Illusions (Interactive visual illusions)

www.pbs.org/wnet/brain/illusions

3D Brain Anatomy

www.pbs.org/wnet/brain/3d

Objectives

- To understand some of the key stages of brain development in babies
- To apply neuroscience research to the evaluation and creation of educational products

What you'll need

(Note: This activity can be done with or without the use of the Internet, depending on computer availability.)

- A Web site list of educational toys aimed at parents of 0-12 month old children.

- Computer with the following Web sites bookmarked:

"The Best Toys for Tots" (from *Today Show* special)
www.msnbc.com/news/602167.asp

Oppenheim Toy Portfolio — Infants
www.toyportfolio.com/Infants/Index.asp

Developmental Toys
www.thebumblebeebush.com/development.html

KB Kids.com — Toys for Ages 0-12 months
www.kbkids.com/mp/Age012.html?style=default

Access Quality Toy
www.accessqualitytoys.com/0to3.cfm?storeid=1&CFID=786706&CFTOKEN=78577787

Live and Learn
www.liveandlearn.com/contents.html

- Toy catalogs (if the Internet is not available)



Procedure

- 1 Distribute the student page and explain that in this activity students will work in pairs to evaluate and compare three educational toys intended for children.
- 2 Review some of the milestones of human brain development from birth to 12 months. You can find a chart with this information at the following Web site: ZERO TO THREE Brainwonders
www.zerotothree.org/brainwonders/index.html
- 3 Divide students into pairs or small groups and have them read about three different educational toys intended for 0-12 month olds. They can either use the Web sites mentioned above or review catalogs from these companies that you can order beforehand. If possible, have another group research the benefits of baby/adult play that doesn't depend on toys. Alternately, students can visit a local toy store and look at the packaging of relevant toys, as well as talk with the salespeople about the intended educational benefits of these products. As students review these toys, they complete the information on the chart on the student page.



EXTENSION ACTIVITY

Once students have completed their research, they can create a three-minute news story about the latest children's toys. Alternately, they can write a 250-word newspaper story about the top three new toys for babies.

Can Toys Make Babies Smarter?

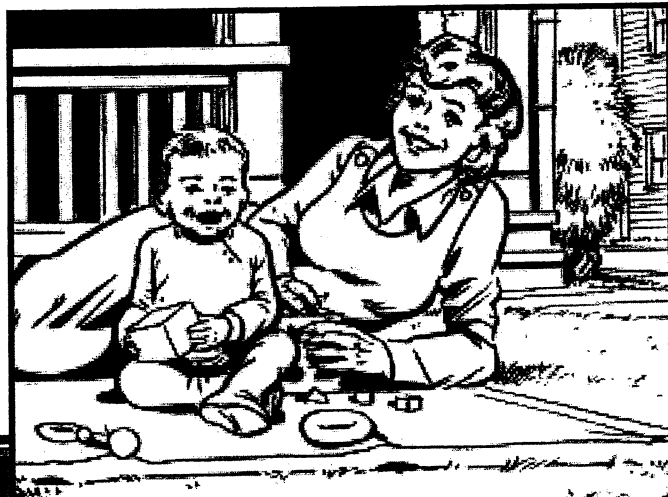
Each year, millions of dollars worth of educational toys are sold in the U.S. The companies that make these toys claim that they are specially designed to stimulate babies' brains and can even make newborns and infants smarter.

In this activity, you will examine three educational toys intended for children age 0-12 months and will write a critical review, giving your opinion about their strengths and weaknesses.

	toy 1	toy 2	toy 3
age of children it's intended for			
intended educational benefits (listed on packaging)			
strengths			
weaknesses			
ways you would improve it			
questions you would ask the inventor of this toy			

What might be some of the benefits of baby/adult play that doesn't involve toys?

"A baby's
brain: Less
than one pound...
and within its milky,
convoluted folds, one
finds a universe of
meaning."

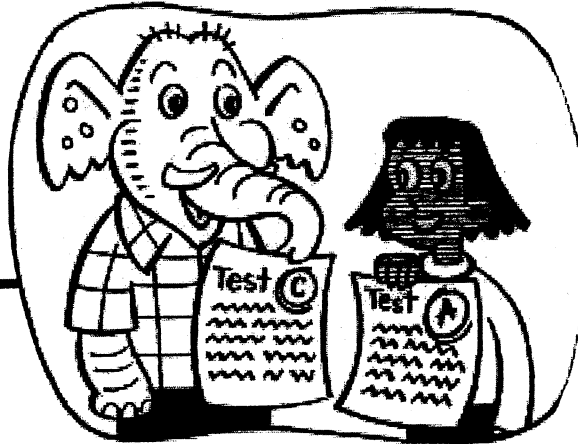


Rick Veitch

FACT SHEET

Brain Myths

by Eric H. Chudler, Ph.D.



Myth

People with larger brains are smarter than people with smaller brains.

Fact

There is no correlation between brain size and intelligence. Although whales, dolphins and elephants have brains that are larger than those of humans, they are not necessarily more intelligent than humans. Also, on average, men have larger brains than women. However, men are not smarter than women.

Myth

We use only ten percent of our brain.

Fact

We use all of our brain. Brain imaging methods, such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), show that the entire brain is active, although not at the same time. The amount of brain activity depends on what the brain is doing. Certainly all 100 billion nerve cells (neurons) of the brain are not firing impulses at the same time, but all of the brain is used at one time or another. Damage to far less than 90 percent of the brain can cause devastating changes in the ability to talk, move, think and remember.

Myth

When we sleep our bodies and brains are at rest.

Fact

The brain is active 24 hours a day. Although our bodies are at rest when we sleep, recordings of brain activity show that the brain goes through different stages when we sleep. One stage, called rapid eye movement (REM) sleep, is accompanied by brainwave patterns and levels of cellular electrical activity that are similar to those seen when a person is awake. REM sleep is also the stage when most dreams occur.

Myth

When we learn something new, we get a new "wrinkle" in our brain.

Fact

Although brain changes, such as strengthening of the connections between neurons, do occur when new things are learned, new wrinkles in the brain are not formed. The "wrinkles" that are seen on the outside of the brain are formed by folds in the cerebral cortex. These folds allow the large surface area of the cerebral cortex to fit into the limited volume of the skull.

Myth

Humans have right-brain or left-brain personalities.

Fact

Personality is not a right- or left-brained function. Rather, personality and other complex higher functions depend on both the right and left sides of the brain. Although one side of the brain may be "dominant" for some behaviors, especially language, both sides of the brain play a role in most tasks.

Myth

Touching the brain will hurt.

Fact

The brain is not sensitive to touch. Poke it, pull it, prod it... the brain won't feel a thing. Although the brain receives and interprets information from the senses, it doesn't have the ability to detect anything itself. Unlike the skin, eyes and other sense organs, the brain has no specialized receptors to detect light, pressure, heat or cold.

THE SECRET LIFE OF THE BRAIN

THE CHILD'S BRAIN: SYLLABLE FROM SOUND



Broadcast Date: January 22, 2002

TEACHER'S PAGE 1

www.pbs.org/brain

At a Glance

Theme: Program Two of THE SECRET LIFE OF THE BRAIN explores how experience shapes the remarkably plastic brains of children as they encounter language. First they learn to speak and understand speech and then, when they are slightly older, they tackle the complex skill of reading.

Program Highlights

- In the first months of life, a baby's brain lays down astonishing numbers of new neural connections. By the end of the first year, the baby has twice as many neural connections as an adult. But then, experience shapes the brain, paring away those connections that are not reinforced by interaction with the world.
- In their first year of life, researchers have found, babies are "citizens of the world" — they can distinguish between sounds in other languages that are indistinguishable to an adult who doesn't speak that language. But by 11 months old, babies lose the ability to hear distinctions that do not occur in their native language.
- Year-old babies listen to and understand speech with both the right and left hemispheres of the brain, but by 20 months the language functions have begun to shift to the left hemisphere in most children. One researcher performed an ingenious experiment with bilingual babies that showed it is experience with a language, not age, that drives this hemisphere specialization. Although the brain is most plastic (adaptable) before this occurs, if necessary it can adapt even after it has matured.
- Children who have had the left hemispheres of their brains surgically removed (to stop severe seizures) can re-learn, slowly and with lots of practice, how to speak. The right hemisphere can take over for the missing left, but it is not as efficient in its work.
- Reading is one of the most complicated activities the brain learns to perform, involving at least 17 different brain areas. Many things can go wrong in learning such a complex skill. Millions of children in the U.S. are dyslexic: they have trouble learning to read even though they are intelligent and can reason normally. One cause of dyslexia appears to be a difference in parts of the brain used in reading. But, with effort and special techniques, it appears that dyslexic children can re-train their brains — and read.



Discussion Questions

- 1 If you tried to learn a foreign language now, why would it take so much more work than when you learned to speak your native language as a very young child?
- 2 What difficulties do 8-year-old Katie Warrick and 14-year-old Michael Rehbein face after their brain surgeries? How do they deal with them?
- 3 Think back to when you learned a new skill, like riding a bicycle or playing a particular sport. Did practicing help? Did there eventually come a time when you suddenly felt like you "got it"? What do you think was going on in your brain at that time and during the attempts leading up to it?

For more on topics covered in Program Two of
THE SECRET LIFE OF THE BRAIN, look on to

Frequently Asked Questions

Epilepsy, Rasmussen's Syndrome

www.pbs.org/wnet/brain/episode2faq

Video Segment

Motherese

www.pbs.org/wnet/brain/episode2babytalk

THE SECRET LIFE OF THE BRAIN

Memory, Practice and Learning



TEACHER'S PAGE 2

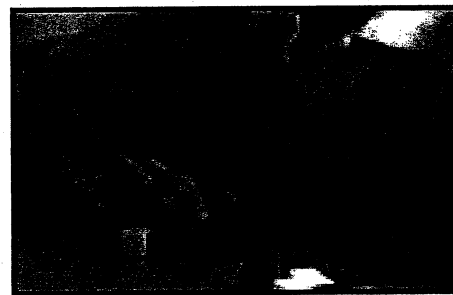
www.pbs.org/brain

Objectives

- To conduct an experiment in how practice and repetition results in improved performance
- To investigate how practice is related to learning

What you'll need

- Small object (like a ball or book)
- A stopwatch or clock with a second hand
- Pencil and paper to record times
- A blindfold



Procedure

After viewing the program, tell students that, as they saw in the program, practicing something over and over will usually improve one's performance at it, as experience literally reshapes the brain. (Think of the dyslexic kids in the program who gradually improve their ability to read by practicing over and over with the sounds that make up words.)

Distribute the student page and explain that this activity demonstrates how repeating something causes learning.¹

Resources for Students

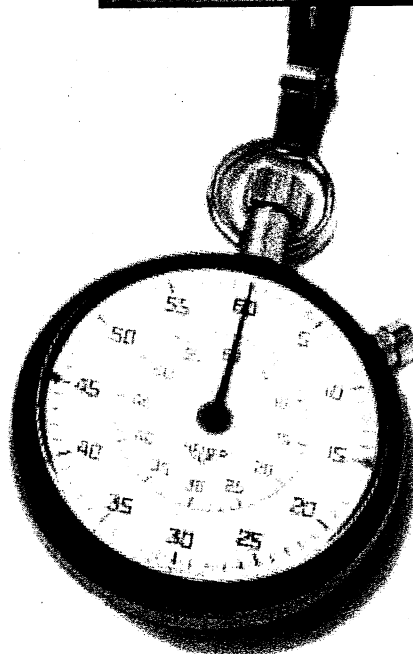
Book

Golinkoff, Roberta Michnick, and Kathy Hirsh-Pasek. *How Babies Talk*. New York: Dutton, 1999.

Web Sites

Neuroscience for Kids
faculty.washington.edu/chudler/neurok.html

Dana Kids Online
www.dana.org/kids/lab.cfm



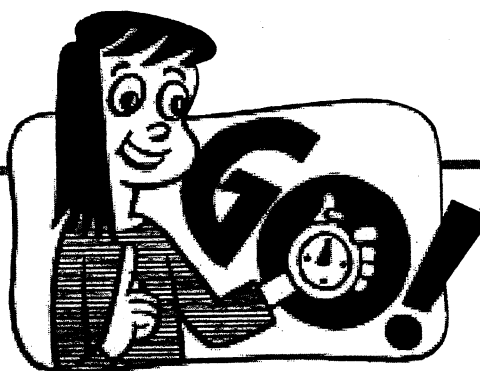
© Joe Sinnott

¹ Adapted from the "Neuroscience for Kids" Web site (<http://faculty.washington.edu/chudler/neurok.html>)

Memory, Practice and Learning

Pick one member of the class to be the subject. Get a small object like a ball, book or even a crumpled piece of paper. Put a blindfold on your subject. Place the object on the floor about ten feet away from your subject, but don't tell your subject where it is. Tell your subject that he or she must find the object on the floor when you say "Go." When you do say "Go," start a stopwatch and record how long it takes your subject to find the object. (Don't let your subject get too far away from the object, and don't let him or her bump into anything dangerous, but let him or her find the object without too much help.)

Repeat your experiment with the same subject. Bring your subject back to the exact same spot where you started and place the object in the same spot as it was the first time. Say "Go" and start your stopwatch again. Did your subject take less time to find the object? You may want to repeat the test several more times and plot the amount of time it took to find the object for the different times you ran the test. Do you see a decrease in the amount of time to find the object in later tests? What would happen if you tested the same subject the next day? What do you think is going on in the subject's brain during these trials?



"I used to think the brain was the most important organ in the body until I realized, look who's telling me that."
— Emo Philips





Ron Barrett

FACT SHEET

ATTENTION-DEFICIT DISORDER

by Sue Young Wilson

You've probably heard of ADD, or ADHD, as it is sometimes called — it's gotten a lot of press lately, and some of your friends (or you) may even have been diagnosed with it. Attention-Deficit Disorder or Attention-Deficit Hyperactivity Disorder is a physical problem in the brain that makes it difficult for a person to pay consistent attention, keep to a task (especially one the person finds boring), and sit still. Between five and ten percent of children are thought to have ADD. But estimates vary widely, and there is disagreement about whether ADD is over-diagnosed or under-diagnosed.

There is likewise a lot of debate about what causes ADD — theories range from genes to childhood head trauma — but most experts agree that its immediate cause is a problem with the prefrontal cortex, which is the part of the brain that controls attention, planning, organization, goal-setting and impulse inhibition.

There is also disagreement — some of it quite loud — about the best way to treat ADD. There are effective medications, like the well-known Ritalin, but some people are concerned because Ritalin, which is a stimulant, can be abused if you take a lot more than the amount prescribed (though research has shown that kids with ADD who are appropriately treated with stimulants are much less likely to abuse drugs when they get older than kids with ADD who are not treated). Other ways to treat ADD include learning new organizational and coping skills and some experimental methods like neurofeedback. Also called EEG biofeedback, it involves using technology to

help people gain control over involuntary mental processes.

ADD generally has three types of symptoms: inattentiveness, impulsiveness and hyperactivity (this last is more common in boys with ADD than girls). Inattentiveness means trouble paying attention. A kid with ADD might have trouble focusing on a school lesson, reading more than a paragraph at a time, or absorbing what a teacher is telling him or her. Kids with ADD tend to daydream a lot, and they might get a reputation as a "space cadet." Impulsiveness is what it sounds like: a tendency to do or say things impulsively without thinking them through. A kid with ADD might often blurt something out in class and interrupt the teacher without even meaning to. Hyperactivity means physical restlessness and fidgetiness; a kid with ADD might jiggle his pencil or tap his foot constantly or have great difficulty sitting through class. (As mentioned before, girls with ADD tend to have this symptom less than the boys and may instead be quiet and dreamy.)

It used to be thought that kids outgrew ADD, but researchers now think many, if not all, continue to have it into adulthood.

ADD can make things like schoolwork very challenging, but having ADD doesn't mean one is stupid — in fact, many people with ADD are very bright, creative, intuitive and outgoing. Teens with ADD often go on to excel at work in the arts, media, sales and other fields that excite them and give them scope to move around and be themselves.

THE SECRET LIFE OF THE BRAIN

THE TEENAGE BRAIN: A WORLD OF THEIR OWN



Broadcast Date: January 29, 2002

TEACHER'S PAGE 1

www.pbs.org/brain

At a Glance

Theme: New research has shown that during puberty, just as the brain begins teeming with hormones, the prefrontal cortex, the center of reasoning and impulse control, is still a work in progress. For the first time, scientists can offer an explanation of what parents already know — adolescence is a time of roiling emotions and poor judgement. As the brain matures, teenagers also face special risks — from addictive drugs and alcohol that can hijack the brain, to the chaos of schizophrenia, which strikes most often during adolescence.

Program Highlights

- "The brain is a work in progress, and adolescence is the last great time of enormous brain change and brain development," says Steven E. Hyman of the National Institute of Mental Health (NIMH). Development of the brain's centers for reasoning and judgement make adolescence a time of great risk, both for the mental illness schizophrenia and for drug addiction.
- Schizophrenia is the cruelest disease imaginable, Hyman says, because it strikes during young adult life, when society's investment in a human being has reached its peak. "Schizophrenia is a disease that affects the highest human functions... our ability to think at high conceptual levels," says Nancy Andreasen of the University of Iowa.
- Addiction is a chronic disease. Addictive drugs cause changes in the brain. These drugs mimic the brain's natural neurotransmitters, Hyman says. They hijack the reward pathways, so that all the things that normally produce feelings of pleasure "go into hibernation," says James C. Berman of the Caron Foundation.
- Those who feel alcohol's effects the least are most likely to become addicted. For some people, it's as addictive as cocaine. "Alcohol has a huge impact on brain waves," says Marc Schuckit of the VA San Diego Healthcare System.
- The brain carries a permanent imprint of drug addiction. Experiments by Anna Rose Childress at the University of Pennsylvania show how old associations stimulate renewed cravings, perhaps explaining why so many addicts relapse.



Discussion Questions

- 1 In this program, Steven E. Hyman says, "The brain is a work in progress, and adolescence is the last great time of enormous brain change and brain development." Think about your experiences and feelings in recent months. Do you see any evidence that your brain is changing?
- 2 As you watched the program, how did Courtney Hale Cook's experiences with schizophrenia challenge your previous ideas or teach you something new?
- 3 What did you learn about drug addiction from this program that challenged your previous ideas or taught you something new?
- 4 If addictive drugs change their brains, are teenage addicts still responsible for their addictions? What are some ways teenagers can resist taking these drugs if their brains have been altered?

For more on topics covered in Program Three of THE SECRET LIFE OF THE BRAIN, log on to

Essay: Sleep and Learning

www.pbs.org/wnet/brain/episode3/sleep

Essay: A Cross-Cultural Exploration of Schizophrenia

www.pbs.org/wnet/brain/episode3/cultures

Objectives

- To learn about some of the symptoms of schizophrenia
- To research the diagnosis of and treatments for schizophrenia

What you'll need

- Library or Web site resources
- Writing materials

Procedure

Tell students that during adolescence, the prefrontal cortex, the center of reasoning and impulse control, is still a work in progress. Schizophrenia — which affects one in every hundred people, male and female, worldwide — most often appears during the teens or early twenties. Drug addiction also frequently begins in adolescence or early adulthood.

Distribute the student page. Explain that in this activity, students will read a fictional diary entry by a teenager who has some of the early symptoms of schizophrenia. Tell them that they will use the reading as a starting point for learning more about this common brain disease.



Resources for Students

Web Sites

National Institute of Mental Health

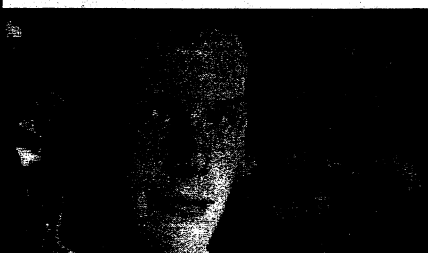
www.nimh.nih.gov

National Mental Health Association

www.nmha.org

EXTENSION ACTIVITIES

- Drug treatments improve life for many people with schizophrenia. In your library and on the Internet, research the history of some of the drugs used to treat the disorder. Find out how the drugs were developed and tested. Note their possible side effects and find out what alternatives doctors can prescribe. Make a bulletin board showing your research and write an accompanying "Viewer's Guide" detailing the pros and cons of drug treatments. Include information on current research and possible new drug developments in the future.
- Select a single statement about schizophrenia from Program Three. You may choose a quote from Courtney, Sabrina, a family member or an expert. Next, clip pictures from magazines (or draw your own) and create a poster-board collage that communicates the same idea as the quote. Use the quote as the title for your collage and display it — along with similar artworks created by other members of your class — in an exhibit that will help viewers understand schizophrenia better.



SCHIZOPHRENIA: A PERSONAL HISTORY

A girl we will call Lisa is worried about herself and her life. Although her diary is fictional, the problems it describes are real. Everyone experiences some of these thoughts and feelings. But for a few people — about one in every 100 worldwide — they lead to a diagnosis of schizophrenia.

Dear Diary,

Something is wrong with me. I have to face it now. For months, I've been denying the trouble, making excuses, saying it's just my imagination or that it will go away. But that's not true. People look at me funny sometimes when I talk. Mom says I'm talking silliness and Dad just shakes his head. The words come out of my mouth, but what are they? I don't know anymore.

I had this idea at school that some of the kids were after me, plotting to get me suspended or maybe even hurt me. My friends say it isn't true, but I still think it is. I can't eat. Everything tastes funny and I've lost a lot of weight. I look in the mirror and I don't blink. I just see this staring, expressionless face leering back at me. Sometimes, I can't sleep, and everything seems to worry me. Other times, I sleep for 12, maybe 14 hours straight and I feel like I don't care about anything. My brother says read a book or watch TV, but I can't concentrate. I just stare out the window at nothing. I laugh at all the wrong times. Maybe I cry at all the wrong times too. Dear Diary, what's wrong with me?

Is Lisa developing schizophrenia?

Maybe, but only a qualified physician can make a reliable diagnosis. Some of Lisa's complaints are normal. Everyone has trouble getting to sleep sometimes, and a loss of appetite is not unusual when we're ill or troubled. But Lisa shouldn't dismiss such changes in her body and mind as unimportant.

What should Lisa do?

She should talk openly and honestly with someone she trusts — a parent, teacher, doctor or counselor. That conversation might be her first step toward getting the help she needs.

1 In your library and on the Internet, learn more about schizophrenia — its symptoms, diagnosis and treatment. To get started, you might check out the Web sites of the National Institute of Mental Health (www.nimh.nih.gov) or of the National Mental Health Association (www.nmha.org). You may use these resources to answer the following questions: Does schizophrenia run in families? Does stress bring on schizophrenia? What drugs are used to treat schizophrenia?

2 Make fictional entries for five or more days representing the next year or two of Lisa's life. Describe her thoughts and feelings as she is diagnosed with schizophrenia and comes to grip with her disorder. What happens when she seeks help? How do her parents and brother help her? What treatment does she receive? Does her situation improve? If so, how? Discuss your diary entries with others in your class as you learn more about schizophrenia.



FACT SHEET

Addictive Drugs and the Brain

by Donna Boundy

Scientists have performed extensive research into how addictive substances affect the brain. They've found that the repeated use of any mood-altering drug produces fundamental changes in a brain's chemistry. What we call addiction is not just a word to describe "a lot of drug use." Addiction is actually a chronic, relapsing disease, the result of observable changes in brain function.

Alcohol and inhalants are actually the most brain-damaging drugs of all, as they literally destroy neurons. But *all* mood-altering drugs alter the way neurons receive, process and transmit information. They do this by altering the level of certain neurotransmitters in the synapse, the space between neurons.

The part of the brain most affected by drugs is the **reward pathway**, an area involved in the processing of emotions. This pathway of neurons regulates our basic survival drives — for food, water and reproduction. Repeatedly stimulating it by drug use can result in what amounts to biochemical "reprogramming" of our survival priorities.

Here's how it happens: When we do something that brings us pleasure (like scoring a soccer goal or eating a hot fudge sundae), a neurotransmitter called **dopamine** travels across the synapse and stimulates receptors on the target neuron, resulting in a feeling of well-being and satisfaction. It is then quickly "neutralized" by an enzyme, and any extra dopamine that did not connect with a receptor is carried back into the neuron that released it.

A mood-altering drug stimulates neurons to release a *flood* of dopamine, much more than the normal amount. This

surges into the synapses, connects with receptors, and is neither neutralized nor reabsorbed. As a result, the amount of dopamine in the synapse is artificially boosted, producing a pleasurable feeling (a "high").

Because our bodies always seek balance, when these blasts of dopamine start occurring from drug use, the brain responds by reducing the number of dopamine receptors on the target neurons. Without receptors to go to, the dopamine can't stimulate the neurons and so the drug high is reduced. The problem is, by cutting back on receptor sites, the person's ability to enjoy *all* normal pleasures is also reduced. Resulting feelings of depression and hopelessness lead the person to crave another blast of dopamine, and the pattern is set.

Once a person is caught in this cycle, things that used to give him pleasure stop making him feel so good. The cravings that come from the drug override all other pleasures, and the person begins to seek *that* above all else. It's as if the brain thinks it needs the drug to survive.

Who's at risk? Some people — once they try a drug — like the way it makes them feel so much that they want to do it again and again. Eventually, repeated use will cause those irreversible changes in the brain that we call addiction.

Researchers have identified "risk factors," characteristics of a young person's life that can make him more likely to go from simply experimenting to abusing drugs. Some risk factors include a family history of substance abuse, lack of involvement from parents and friends who use. But the fact is that *anyone* who uses an addictive drug over a long enough period of time and in sufficient doses will trigger the addictive process in his or her brain.

THE SECRET LIFE OF THE BRAIN

THE ADULT BRAIN: TO THINK BY FEELING



Broadcast Date: February 5, 2002

TEACHER'S PAGE 1

www.pbs.org/brain

At a Glance

Theme: "The Adult Brain: To Think by Feeling," Program Four of THE SECRET LIFE OF THE BRAIN, reveals how the thinking and the feeling areas of the brain interact constantly, and how our lives are governed by emotion and the interaction of emotion with our thought processes.

Program Highlights

- Our feelings and our thinking interact constantly. Our brains are not logical computers but "feeling machines that think," according to cognitive scientist Antonio Damasio.
- Scientists have discovered it is not possible to reason properly without a properly functioning emotional system. This is seen in some people who have had the "feeling" areas of their brains damaged, as by a stroke, and can no longer make everyday decisions. Marvin Bateman, 56, had a stroke 23 years ago that has destroyed his ability to be aware of his emotions. Today, he cannot make everyday decisions because he has no emotional memories, "gut feelings," to guide him.
- Emotions can run out of control, purposelessly reinforcing themselves in the brain and resulting in chronic problems like post-traumatic stress disorder and depression. Johnny Cortez was in a serious car crash. Though his body has healed, he now suffers from post-traumatic stress disorder (PTSD). This is a condition in which a traumatic event triggers a vicious cycle in the brain that makes it overreact to small stressors with a full-blown panic reaction, effectively making the sufferers relive the original trauma over and over. Researchers are experimenting with preventing PTSD by injecting trauma victims with a drug that can help prevent the flood of fear chemicals right after the trauma happens.
- In depression, a disorder of the moods, prolonged feelings of sadness, worthlessness and hopelessness can destroy a person's ability to function. Depression is likely caused by a combination of genetic vulnerability and life experience. Depression runs in families and genetics can predispose a person to it. Traumatic childhood experiences like abuse or abandonment can prime the brain for the illness and stress or loss can bring it on. Anti-depressants, as well as certain kinds of talk therapy, can help heal depression and restore sufferers' ability to enjoy life and live up to their potentials.



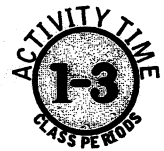
Discussion Questions

- 1 Why does not being able to feel his emotions make it so hard for Marvin Bateman to make daily decisions?
- 2 How is fear a useful emotion? How can it be a harmful one? Can you give examples from your own life?
- 3 Why do you think Lauren Slater is "suspicious" of her medication, even though it has helped her so much? Do you think her worries are valid, or not?
- 4 Poet Theodore Roethke writes: "We think by feeling. What is there to know?" How can we think by feeling? In what way is Roethke making the same point as Damasio?

For more on topics covered in Program Four of
THE SECRET LIFE OF THE BRAIN, log on to
Essay: Why We Laugh
www.pbs.org/brain/episode4/laughter

THE SECRET LIFE OF THE BRAIN

JUST RELAX!



TEACHER'S PAGE 2

www.pbs.org/brain

Objectives

- To conduct two experiments showing how the mind can cause physiological changes in the body
- To learn a relaxation technique and a visualization technique

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What you'll need

- Stopwatch or clock with a second hand
- Pencil and paper to record times

Procedure

Introduce the student activity for this program by telling students that they will be able to experience for themselves how thinking, feeling, and the body interact and affect each other. Divide the class into pairs, and explain that one person in each pair will do a relaxation exercise, while the other is responsible for taking the first person's pulse both before and after the exercise. Explain how to take a pulse (see the Student Activity Master), and have the pulse-takers take their partners' pulses and write them down. Guide the other members of the pairs through the relaxation exercise by reading to them as they close their eyes and imagine the scenarios. Have the pulse-takers take the relaxers' pulses again and report to the class if they have slowed (evidence of relaxation).



Resources for Students

Book

Greenfield, Susan A. *The Human Mind Explained*. New York: Henry Holt and Co., 1996.

Web Sites

Neuroscience for Kids
faculty.washington.edu/chudler/neurok.html

TeensHealth – Mind Matters
kidshealth.org/teen/mind_matters/index.html

Scientific American: Feature Article: The Neurobiology of Depression
www.sciam.com/1998/0698issue/0698nemeroff.html

EXTENSION ACTIVITY

For another example of how thoughts can affect the body, ask students to try this:

Think of holding a lemon in your hand. Feel the pebbly, waxy texture of its skin and see how bright yellow it is. Bring it closer to your nose and smell the sharp aroma. Now, picture yourself slicing it open with a knife and seeing the juice squirt. The tart smell rises into the air. Bring a slice to your mouth and suck on it. The juice runs over your tongue. It's so sour that your mouth puckers and your eyelids flutter!

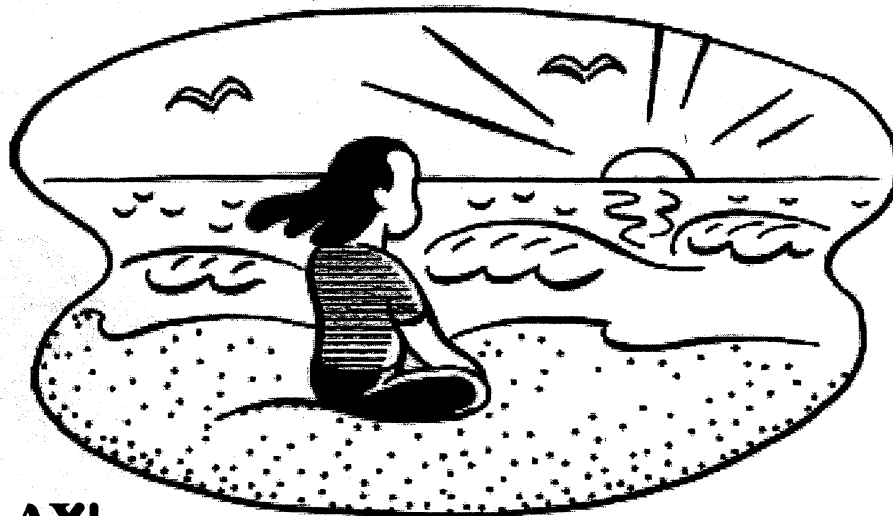
Now, open your eyes.

Did your mouth start to water as you did this exercise? Maybe your eyes even watered a little or the inside of your nose tingled. And all just by thinking!

THE ADULT BRAIN: TO THINK BY FEELING

STUDENT ACTIVITY MASTER 1

www.pbs.org/brain



Illustrations: Ron Barrett

JUST RELAX!

One of the themes of "The Adult Brain: To Think By Feeling" is that there is a constant interplay between the feeling areas of the brain, the thinking areas of the brain, and the body. Each of these can and does affect the others. We saw how hearing a verbal retelling of a traumatic car crash caused Johnny Cortez's body to react as though he were actually reliving the traumatic crash: His pulse rate soared, sweat flowed.

You can do the reverse yourself: By thinking, you can change your physical and emotional state to one of great relaxation.

Working in pairs, try this experiment:

One person should take the other's pulse. (It's probably easiest to take a pulse on the artery that runs down the wrist from just under the ball of the thumb. When you've found your partner's pulse, use a stopwatch or the clock to count how many pulse beats you feel for 30 seconds, then multiply the number by two to calculate the person's pulse rate per minute. Write it down.)

The person whose pulse was just taken should then do the following exercise:

Make yourself comfortable in a chair, with your feet flat on the floor. Be as comfortable as possible. Breathe deeply and evenly.

When you feel relaxed, imagine a peaceful scene of

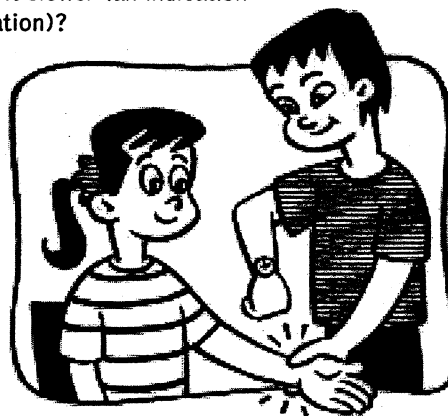
natural beauty. It could be a beach, a mountain scene, the desert or a forest meadow with a waterfall. Let the image become more vivid and focused.

Now, imagine yourself in that place. Pick a nice spot and sit down. Feel the sun on your face and closed eyes, and the breeze ruffling your hair and caressing your skin. You know that you are totally safe and secure here. Relax into the feeling and enjoy it fully.

After you feel satisfied and happy, think about coming back to the room you are in. Focus again on your breathing. Gradually become aware of your real-life surroundings. Open your eyes, stretch and smile.

Do you feel more relaxed now? Less stressed?

Have your partner (the pulse-taker) take your pulse again. Is it slower (an indication of relaxation)?



FACT SHEET

Emotion and the Brain

by Sue Young Wilson

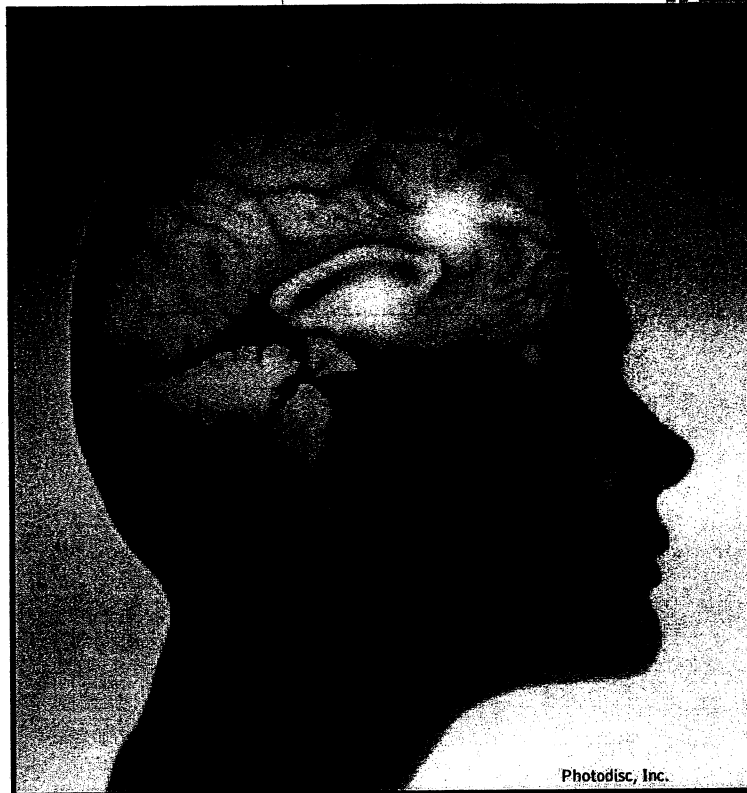
Emotions have sometimes gotten a bit of a bad rap. If you say someone's "emotional," usually you mean he or she is too much under the control of his or her feelings, rather than his or her thinking and common sense. It's supposed to be better to make decisions based on logic, reason, and cold, hard facts.

But researchers are learning that our emotions are key in our ability to make decisions and function on a daily basis. There's no strict separation in the brain between "thinking" and "feeling"; rather, the thinking and the feeling areas of the brain interact constantly. When we make a decision — Should I take a dip or not in that water where I met the jellyfish last time? — we rely heavily on what cognitive scientists call "emotional memory," or the memories stored in our brains of the feelings that resulted from our previous choices and their outcomes. Our brains and bodies use these "gut feelings" to make many of our daily decisions.

Emotions are a vital part of the way our brains work, but they can also run out of control, as they do with illnesses like depression and anxiety disorders. Fortunately, researchers are discovering new ways to prevent and/or treat such conditions.

For example, Johny Cortez was in a serious car crash and now suffers from post-traumatic stress disorder (PTSD). PTSD is a condition in which a traumatic event triggers a vicious cycle in the brain that makes it overreact to later small scares with a full-blown panic reaction, dumping fear chemicals into the person's system as though the original event were happening again. Researchers are experimenting with preventing PTSD by treating trauma victims right after the trauma happens with a drug that can help prevent the flood of fear chemicals from "scarring" the brain and causing PTSD.

In depression, severe and inappropriate bad feelings can destroy a person's ability to function. Scientists think that genetics can predispose a person to depression, but experience also plays a role: Traumatic childhood experiences like abuse or bereavement can prime the



Photodisc, Inc.

brain for the illness. What is going wrong in the brain of a depressed person is complicated, and scientists have not precisely pinpointed it, but MRI scans show that in depressed people the prefrontal cortex (the part of the brain that controls impulses, decisions, thinking and planning) is less active than normal. Their levels of certain neurotransmitters (chemical messengers in the brain) are also abnormal.

Today, depression can be treated with antidepressant medications that restore the brain's balance. In "The Adult Brain: To Think by Feeling," Lauren Slater tells how her life was crippled by decades of depression, how she attempted suicide, and how her doctor's last try at treating her in 1988 with a new drug almost miraculously restored her ability to enjoy life and live up to her potential. Today, many people with depression have been successfully treated with this and other new medications and are leading productive, satisfying lives.

Broadcast Date: February 12, 2002

TEACHER'S PAGE 1

www.pbs.org/brain

At a Glance

Theme: The longstanding belief that we lose vast numbers of brain cells as we age turns out to be wrong. As we grow older, many mental functions remain intact, and may even provide the brain with advantages that form the basis for wisdom. The aging brain is also far more resilient than was previously believed.

Program Highlights

- Sixty-three-year-old Kent Miller has a stroke that paralyzes his left side. Even after months of rehabilitation, he is unable to use his left arm or hand. Desperate, Miller tries an experimental treatment developed by neuroscientist Edward Taub. This therapy requires Miller to *not* use his good hand at all, in order to force his bad hand to do the work. This method makes the neurons that control Miller's left side resume their old jobs.
- At Harvard Medical School, Dr. Jeffrey Macklis works with patients who have neurological disorders. One of his patients is Sally Carlson, who has Parkinson's disease. Deep inside her brain, in a region that coordinates movement, thousands of neurons are slowly dying. Carlson is no longer able to do simple tasks such as folding clothes. Dr. Macklis hopes that one day he can restore her abilities by tapping the potential of stem cells.
- Dr. John Morris studies Alzheimer's disease. One of his patients, Alvin Johnson, used to run an insurance company until he developed Alzheimer's. Today, he can no longer sign his name, doesn't know the date, the day or the time. He doesn't even recognize his daughter anymore. Dr. Morris is trying to find the cause of Alzheimer's so that he can treat those who are afflicted.
- Scientists once thought that the brain of a stroke victim caused permanent damage to the neural network and that millions of neurons died. During the 1990s, researchers discovered that the aging brain actually experiences very little nerve cell loss. The brain is a dynamic structure that can rejuvenate connections that have become weak due to lack of use. No matter how old a person is, his or her brain is still capable of change.



Discussion Questions

- 1 What are some differences between short-term and long-term memory? Give some examples from your own experience that illustrate the differences.
- 2 Imagine the world in 2025. What kinds of medical treatments do you think there might be to help people suffering from neurological conditions such as Alzheimer's?
- 3 The physical therapy that Kent Miller uses to combat the paralysis of his left side requires many hours of tedious work. Do you think you would have the emotional strength to endure such a procedure if you were in his position? Why or why not?
- 4 In his poem, "The Layers," Stanley Kunitz writes:
I have walked through many lives,
some of them my own,
and I am not who I was,
though some principle of being
abides, from which I struggle
not to stray.

What do these lines of poetry have to do with the theme of the entire series? Why might a poet be especially sensitive to a new scientific idea?

For more on topics covered in Program Five of
THE SECRET LIFE OF THE BRAIN, log on to

Alzheimer's: Searching for a Cure
www.pbs.org/wnet/brain/episode5/alzheimers

Video: Poet Stanley Kunitz Reads
www.pbs.org/wnet/brain/episode5/kunitz

THE SECRET LIFE OF THE
B R A I N
GIVE YOUR BRAIN A WORKOUT



TEACHER'S PAGE 2

www.pbs.org/brain

Objective

- To explore some mnemonic devices that can enhance short-term memory

What you'll need

- Stack of index cards (ten for each student)
- Paper and pencils
- A list of memory tips (culled from some of the Web sites on the right)

Procedure

Distribute the student page, and explain that in this activity students will try to recall a list of unrelated words, then learn some mnemonic devices that can enhance short-term memory. Finally, they will try to apply these mnemonic techniques on a different list of words.

To collect and compare the results, have students submit their scores on a coded sheet of paper so names and personalities don't enter into comparisons. Later, collect and compare the second round results.

"Poetry is an exercise of the spirit, the spirit within one, and every time you exercise it, you increase your vitality."

— Stanley Kunitz

WEB SITES

Stem Cells: A Primer

www.nih.gov/news/stemcell/primer.htm

Alzheimer's Association

www.alz.org/

Free Tips to Improve Memory

www.studyhall.com/MEM/memory.html

Mind Tools — Memory Techniques and Mnemonics

www.demon.co.uk/mindtool/memory.html

Study Shows Sleep Improves Memory

www.cnn.com/2000/HEALTH/11/22/sleep.memory.ap/

The Memory Page

www.premiumhealth.com/memory/

The Memory Exhibition

www.exploratorium.edu/memory/index.html

Playing Games With Memory

www.exploratorium.edu/memory/dont_forget/playing_games.html

Ways to Remember

www.exploratorium.edu/memory/dont_forget/playing_games_2.html

Memory Marathon

www.pbs.org/saf/1102/segments/1102-2.htm

Name Game

www.pbs.org/saf/1102/features/name_game.htm



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THE AGING BRAIN: THROUGH MANY LIVES

STUDENT ACTIVITY MASTER 1

www.pbs.org/brain



GIVE YOUR BRAIN A WORKOUT

Here's an experiment you can try with others in your class. It will show you how tricky it can be to remember unrelated objects. After the first part of the experiment, you'll learn some memory tricks that will help you next time around.

DIRECTIONS

- 1 Everyone fills out five blank index cards, using the following guidelines. Each card should have words only (no pictures).
 CARD 1: an animal
 CARD 2: an object that begins with the same letter as your first name
 CARD 3: an object from the room you are now in
 CARD 4: a fruit or vegetable
 CARD 5: an object used in a sports game
- 2 Have a volunteer shuffle all the cards together into a large stack. (NOTE: If you have fewer than ten people in your class, have everyone fill out two sets of cards, so that you have a large stack.) Then, have this volunteer read out the top ten cards in the stack. As the volunteer does this, everyone else in the class concentrates and tries to remember the objects. The volunteer should put the ten cards in a small stack so they can be read aloud later.
- 3 Everyone in the class — including the teacher — is given three minutes to try to write down the ten objects that were read aloud by the volunteer. The order that the objects are written in doesn't matter.
- 4 The volunteer reads aloud the ten words and everyone looks at their own paper to see how many of the words they correctly remembered.
- 5 Have a discussion about which objects were easier to remember and why.
- 6 Your teacher will explain some memory tricks that will help you recall a random list of words. Then repeat Steps 1-4 and see if you are able to remember more words than you did the first time.



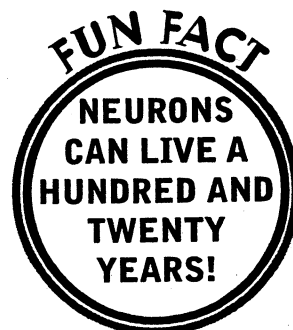
Illustrations: Ron Barrett

BONUS

Try this again but this time, as an extra challenge, see if you can recall the objects in order from smallest to biggest.

GOING FURTHER

Try this experiment with groups of people of different ages, especially older adults. Do you find that the ability to recall the list of objects is affected by age?



FACT SHEET

Memories in the Making

by Faith Brynie

Take a list of ordinary words—paper, apple, clock, book — then throw some emotionally-laden ones—blood, murder, sex, war. Chances are, your brain will capture the high-impact words. Later, you'll remember those that caught your attention and forget the rest. That's the way memory works, and a part of your brain called the amygdala gets the credit... or the blame.

Where and How Are Memories Made?

Although storing and retrieving memories uses many parts of the brain, two structures, the amygdala and the hippocampus, are essential for forming memories. These regions lie deep inside the brain, in a region called the limbic system. That region processes emotions and screens information coming from the sensory systems. The left side of the amygdala, research has shown, attaches emotional significance to words such as murder and makes them more memorable.

The link between an emotion and an event is different for each of us. The event is forever linked to the emotion present when the memory was stored. For example, the odor of a woodfire may remind one person of cozy evenings by the campfire. For another, the smell evokes the terror associated with a rampaging forest fire.

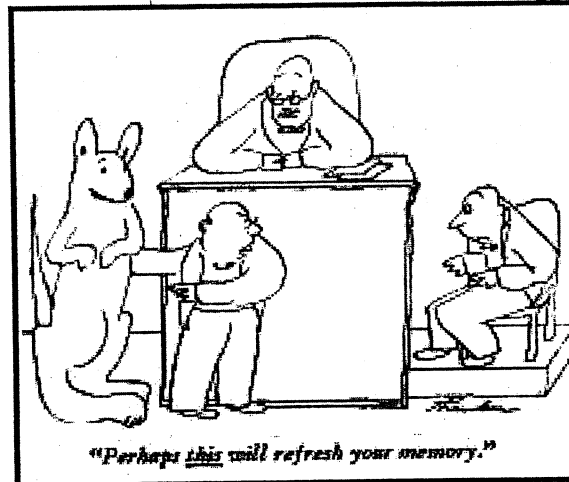
What is Memory?

In a word, chemistry.

Experiences send impulses traveling along neurons (nerve cells). Impulses jump the gap between nerve cells—not electrically, but chemically. Substances called neurotransmitters released from the end of one neuron move across the gap and stimulate an impulse in another neuron. Each time that pathway is used, the neurons become chemically more sensitive. They can stimulate each other more easily in the future.

Short-term memories, those that last for a few minutes or until you no longer need them, depend on chemicals that disappear almost as quickly as they are manufactured. Remembering a telephone number long enough to call it belongs in this category.

Long-lasting memories require a more complicated series of chemical changes. Although much of this process remains to be discovered, one theory holds that experience-generated chemicals activate genes, segments of the master control molecule of cells, DNA. The genes cause brain neurons to make proteins that permanently alter the cell's architecture and functioning.



The New Yorker Collection 1935 James Thurber from Cartoonbank.com.
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ACTIVITIES

- Smells are powerful triggers for forming and recalling memories. Saturate cotton balls with strong odors such as vanilla, peppermint, or lavender. Ask test subjects to tell you what memories the scents bring to mind, when in their lives the association was made, and what emotions they recall when presented with the smell. You may be surprised at the range and diversity of responses.
- Test your ability to remember a series of random numbers or words. Have a partner present the words to you — either orally or in writing — then see how many you can remember after a measured period of time. If you are like most people, you will do well until asked to recall more than eight items. Why is eight the magic number? No one knows.

THE SECRET LIFE OF THE BRAIN

HYPOTHESES IN SCIENCE

by Sue Young Wilson

www.pbs.org/brain

You've probably heard of the scientific method, by which scientists observe things, interpret them and test their interpretations.

It's usually described as consisting of four stages:

- 1 Observe what's going on. (Example: "My gym locker smells bad.")
- 2 Come up with a tentative explanation — known as a hypothesis. ("My gym socks need washing.")
- 3 Use the hypothesis to make predictions about other phenomena or other observations (that can be measured). ("If I remove and wash the socks, my locker will smell better.")
- 4 Test the predictions with experiments to see if the hypothesis holds up. ("I washed the socks and my locker now smells fine, so it was probably the socks.")

In science, if experiments support a hypothesis, it may come to be regarded as a theory (a widely accepted explanation or model that both explains existing observations and successfully predicts new ones). If the experiments do not bear out the hypothesis, it must be rejected or modified.

Different sciences use slightly different versions of the scientific method. In physics or chemistry, for instance, scientists rely heavily on experiments with numerical results to test hypotheses. In neuroscience, especially the study of the human brain, scientists rely

somewhat more on observation. (There are obvious ethical problems with performing intrusive experiments on living human brains.)

The scientific method for coming up with and testing hypotheses is a powerful tool, but sometimes it's not so easy for scientists to apply it properly. Scientists are human, and they can make errors, have biases they don't account for, and draw incorrect conclusions from their data. (For instance, if they have strong feelings about what the outcomes of their experiments should be, they can be tempted to overlook or discard evidence that doesn't fit.) That's why, ideally, there should be many different lines of evidence to support a hypothesis before it is accepted, and experiments should be done and confirmed by a number of researchers working independently of each other.

The field of neuroscience is one in which scientists are still learning a great deal. Some hypotheses are promising and intriguing, but a long way from proven.

Scientists also try to find as many different kinds of evidence as possible that back up the hypothesis. The more a hypothesis is independently confirmed by different researchers, the more likely it is that it is true.



THE SECRET LIFE OF THE BRAIN

GLOSSARY

www.pbs.org/brain

The Baby's Brain: Wider Than the Sky

cataract — the clouding of the lens of the eye

genes — the sections of DNA that carry inherited traits

glia — cells that surround and provide a supportive framework for nerve cells

migration — in fetal brain development, a process in which neurons travel to the sections of the brain where they belong

nervous system — the network of nerve cells that enables an animal to adjust to changes in its environment

neurons — the billions of special cells that make up the nervous system. Nerves form a network of pathways that carry information quickly throughout the body

stem cells — very young, non-specialized cells that can transform into any kinds of cells, such as liver cells, skin cells or brain cells

The Child's Brain: Syllable From Sound

developmental psychologist — a social scientist who studies how human behaviors and the mind develop and change over a lifetime

dyslexia — a reading disorder often characterized by a significant difference between intellectual ability and reading performance without an apparent physical, emotional or cultural cause

hemisphere — one half of the cerebrum. The left and right cerebral hemispheres are connected and communicate through the corpus callosum.

hemispherectomy — surgery to divide the brain's two hemispheres, sometimes performed in order to prevent seizures

neuroscientist — a scientist who studies the anatomy, physiology, biochemistry, or molecular biology of nerves and nervous tissue

plasticity — the brain's ability to develop adaptively, to be molded by experience throughout life

The Teenage Brain: A World of Their Own

dopamine — a chemical released by certain nerve cells in the brain that acts as a neurotransmitter

neurotransmitter — a chemical that stimulates receptors on adjacent nerve cells, producing in them a cascade of reactions

nucleus accumbens — a part of the brain that may play a role in the regulation of movement, including the control of complex motor activity and the cognitive aspects of motor control. In addition, the nucleus accumbens might play a role in situations of reward and punishment.

prefrontal cortex — the region of the brain located directly behind the forehead. Part of the frontal lobe, it allows us to make decisions, judgments and future plans. It plays a role in such highly abstract functions as personal responsibility, morality and self-control.

schizophrenia — a mental disorder that may include delusions and hallucinations, alterations to the senses, and an altered sense of self

synapse — the gap between the axon of one neuron and the dendrite of another. When neurotransmitters cross this gap, they send a neural signal that causes brain activity along specific circuits.

The Adult Brain: To Think by Feeling

depression — an emotional (mood) disorder in which a person feels sad, worthless and hopeless for a long period

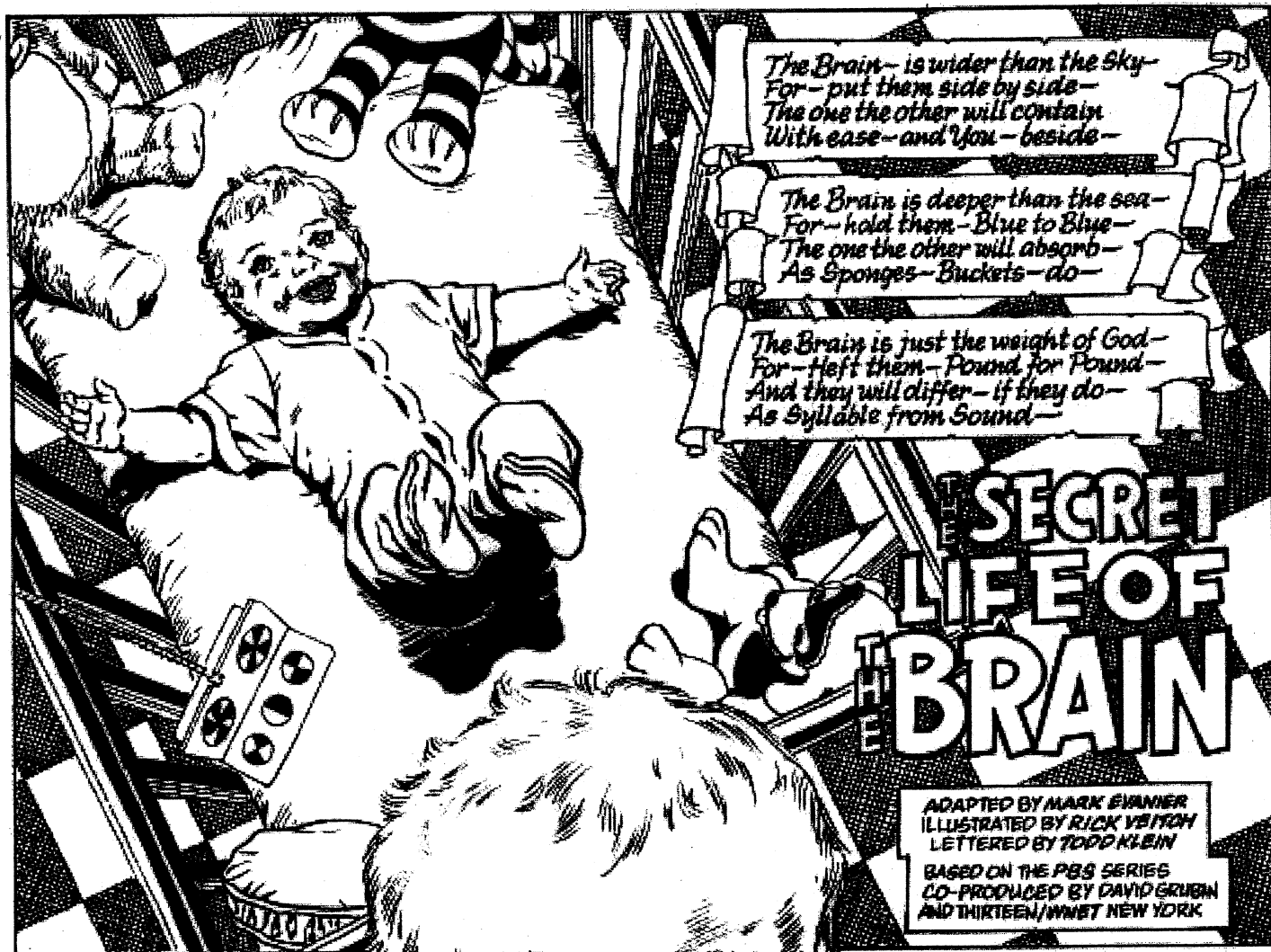
post-traumatic stress disorder (PTSD) — a psychiatric disorder in which the sufferer, following the experience or witnessing of traumatic events such as military combat, natural disasters or serious accidents, relives the experience through nightmares and flashbacks

The Aging Brain: Through Many Lives

stroke — an injury to the brain, in which a blood vessel breaks or becomes blocked, sometimes resulting in paralysis

Parkinson's disease — a disorder of the brain that reduces muscle control. Symptoms include trembling hands, rigid muscles, slow movement, and balance difficulties. Most cases affect people from 50 to 70 years old. The disease is named for the English physician James Parkinson, who described it in 1817.

Alzheimer's disease — a slowly progressive, degenerative disorder of the brain that eventually results in memory loss, abnormal brain function, and sometimes death. The disease was first recognized and described by Dr. Alois Alzheimer in 1907.



The Brain- is wider than the sky-
For- put them side by side-
The one the other will contain
With ease- and You- beside-

The Brain is deeper than the sea-
For- hold them- Blue to Blue-
The one the other will absorb-
As Sponges- Buckets- do-

The Brain is just the weight of God-
For- Heft them- Pound for Pound-
And they will differ- if they do-
As Syllable from Sound-

THE SECRET LIFE OF THE BRAIN

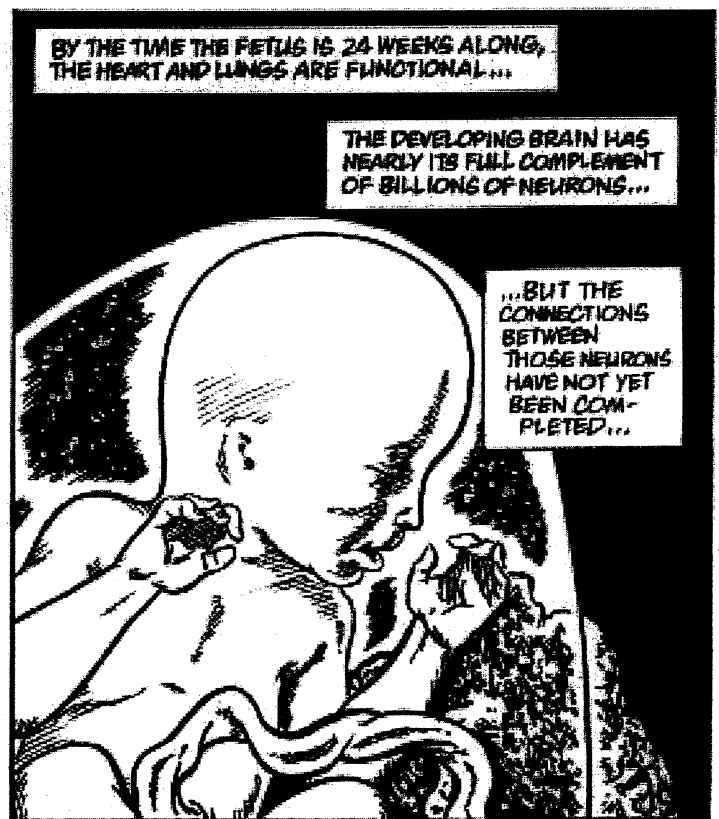
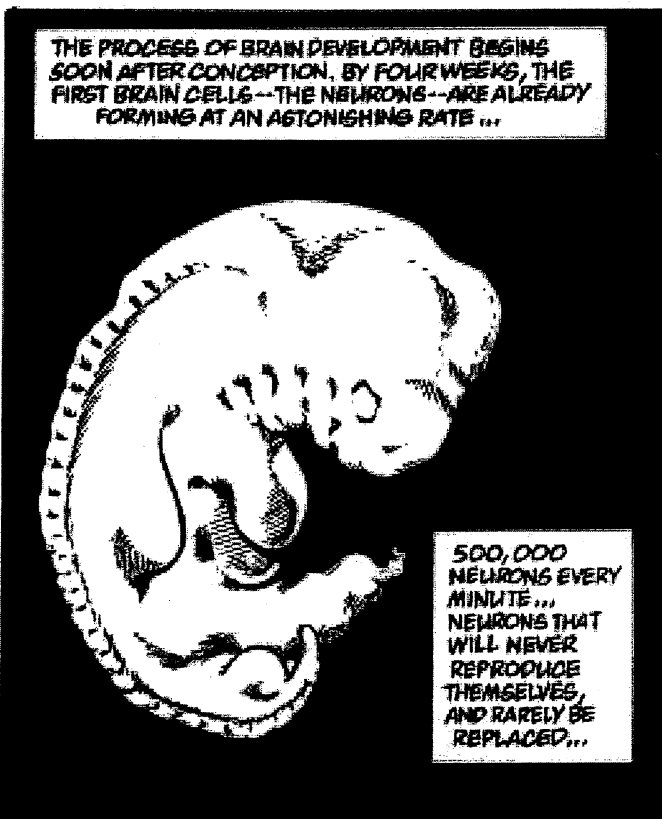
ADAPTED BY MARK EVANIER
ILLUSTRATED BY RICK VEITCH
LETTERED BY TODD KLEIN
BASED ON THE PBS SERIES
CO-PRODUCED BY DAVID GRUBIN
AND THIRTEEN/WMET NEW YORK

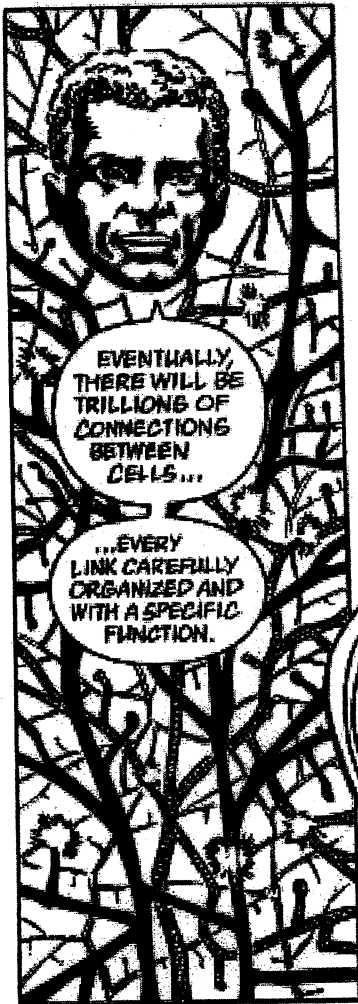
A BABY'S BRAIN: LESS
THAN ONE POUND OF
GELATINOUS TISSUE...

...AND WITHIN ITS MILKY,
CONVOLUTED FOLDS, ONE FINDS
A UNIVERSE OF MEANING.

EMOTIONS
IDEAS
MEMORIES
DREAMS
CONCEPTS
EXPERIENCES
OBSERVATIONS
FEARS







BILLIONS OF CONNECTIONS ARE MADE WITH LIGHTNING SPEED...

...NEARLY TWO MILLION EVERY SECOND, ALL ACCORDING TO A PLAN BUILT INTO THE GENETIC CODE...

EVENTUALLY, THERE WILL BE TRILLIONS OF CONNECTIONS BETWEEN CELLS...

...EVERY LINK CAREFULLY ORGANIZED AND WITH A SPECIFIC FUNCTION.



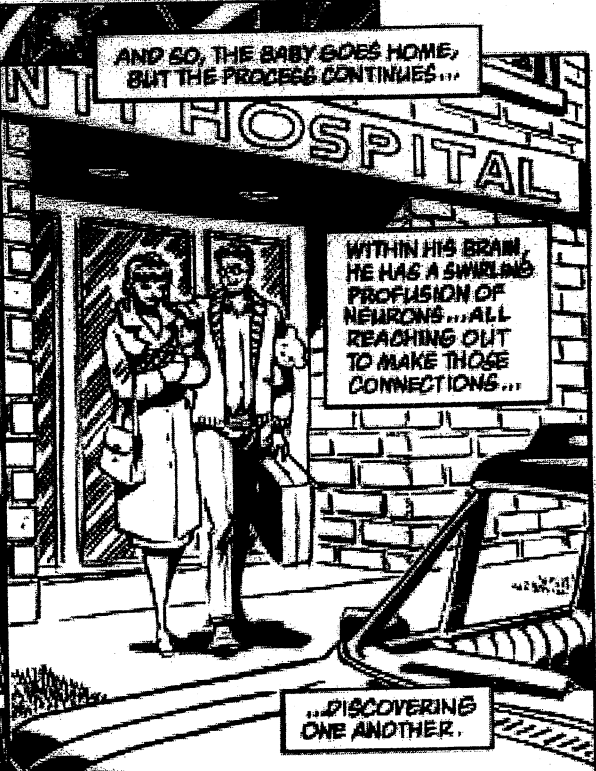
SO HOW DOES THE BRAIN KNOW WHERE TO SEND ALL THESE NEURONS?

THAT WE WOULD LOVE TO KNOW.



IT'S LIKE A PLAY... BUT ONE THAT HAS NO DIRECTOR, NO PRODUCER, AND A CAST OF ACTORS WHO HAVE NEVER SPOKEN THEIR LINES BEFORE...

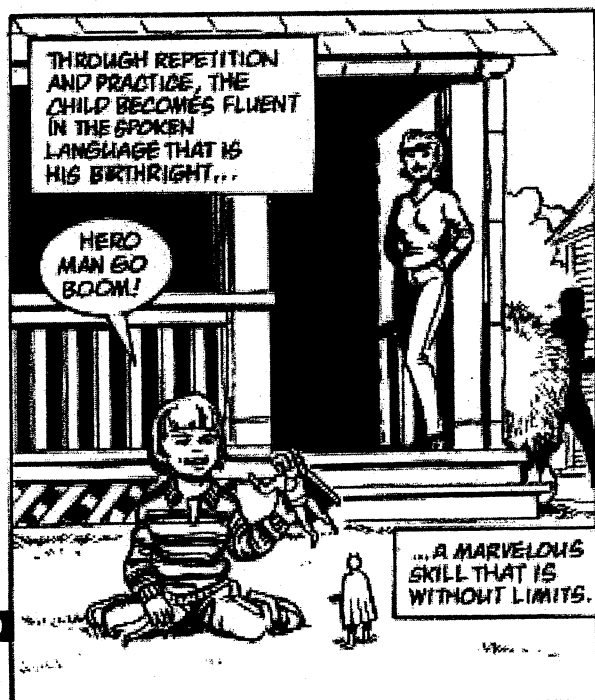
SOMEHOW, IN SPITE OF THIS, THE "PLAY" GETS PERFORMED...



AND SO, THE BABY GOES HOME, BUT THE PROCESS CONTINUES...

WITHIN HIS BRAIN, HE HAS A SWIRLING PROFUSION OF NEURONS... ALL REACHING OUT TO MAKE THOSE CONNECTIONS...

...DISCOVERING ONE ANOTHER.



ADOLESCENCE IS THE LAST GREAT TIME OF ENORMOUS BRAIN CHANGE AND BRAIN DEVELOPMENT...



...AN AGE WHEREIN IS DETERMINED SO MUCH OF WHAT THE PERSON CAN AND WILL BE IN THE FUTURE...

DURING PUBERTY, THE BRAIN BEGINS TEEMING WITH HORMONES...



THE PRE-FRONTAL CORTEX--THE CENTER OF REASONING AND IMPULSE CONTROL--IS ESPECIALLY UNDERGOING CHANGES...

IT IS A TIME OF ROILING EMOTIONS AND POOR JUDGMENT...

AS THE BRAIN MATURES, THE TEENAGER ALSO FACES SPECIAL RISKS...



...FROM ADDICTIVE DRUGS AND ALCOHOL THAT CAN HIJACK THE BRAIN, TO THE CHAOS OF SCHIZOPHRENIA WHICH STRIKES MOST OFTEN DURING ADOLESCENCE.



THE DEVELOPING BRAIN IS IN A STATE OF FLUX, SHAPING PERSONALITY BEHAVIOR... EVEN IDENTITY ITSELF...



THE BRAIN IS ALWAYS A WORK-IN-PROGRESS.

THE SECRET LIFE OF THE BRAIN

A NEUROSCIENCE TIMELINE

www.pbs.org/brain

THE WHEN, WHO AND WHAT OF BRAIN RESEARCH

Eric H. Chudler, Ph.D.

Department of Anesthesiology, University of Washington, Seattle, WA

(modified from "Milestones in Neuroscience Research" at: <http://faculty.washington.edu/chudler/hist.html>)

ca. 1700 B.C. — The Edwin Smith surgical papyrus is written by an unknown Egyptian physician. This papyrus contains the first written record about the brain.

1791 — Luigi Galvani shows that frog nerves respond to electrical stimulation.

1826 — Johannes Muller publishes the theory of "specific nerve energies," stating that perceptions of different senses are carried by specific nerves.

1838 — Robert Remak suggests that a nerve fiber and a nerve cell are joined.

1839 — Theodor Schwann proposes the cell theory, stating that the nervous system is composed of individual elements.

1848 — Railroad worker Phineas Gage has his brain pierced by an iron rod. His change in behavior following the injury leads to theories about the role of the frontal lobes in cognition and emotion.

1861 — Paul Broca discusses how specific functions are related to specific areas of the cerebral cortex.

1873 — Camillo Golgi publishes work using the silver nitrate method to stain brain tissue.

1873 — Carl Wernicke publishes work on aphasia (language disorder caused by brain damage).

1875 — Richard Caton is the first to record electrical activity from the brain.

1878 — Claude Bernard describes the nerve-muscle blocking action of curare.

1889 — Santiago Ramon y Cajal argues that nerve cells are independent elements.

1895 — Wilhelm Konrad Roentgen invents the X-ray.

1897 — Charles Scott Sherrington coins the term "synapse."

1907 — John N. Langley introduces the concept of receptor molecules.

1909 — Harvey Cushing is the first to stimulate the human sensory cortex electrically.

1914 — Henry H. Dale isolates the neurotransmitter called acetylcholine.

1921 — Otto Loewi publishes work on "Vagusstoff," suggesting that neurons release chemicals when stimulated.

1924 — Charles Scott Sherrington discovers the stretch reflex.

1929 — Hans Berger demonstrates the first human electroencephalogram (EEG).

1972 — Godfrey N. Hounsfield develops the X-ray computed tomography.

1974 — Michael Phelps, Edward Hoffman and Michel Ter-Pogossian develop the positron emission tomography (PET) scanner.

1981 — Roger Wolcott Sperry is awarded the Nobel Prize for work on the functions of the brain hemispheres.

2000 — Arvid Carlsson, Paul Greengard and Eric Kandel share the Nobel Prize for their discoveries concerning signal transduction in the nervous system.

**For a history of the brain timeline, log on to
www.pbs.org/wnet/brain/history/**

Top: Edwin Smith Surgical Papyrus, Courtesy of the New York Academy of Medicine Library/Below: Leonardo da Vinci drawing

THE SECRET LIFE OF THE BRAIN

RESOURCES

BOOKS

www.pbs.org/brain

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- Matsakis, Aphrodite. *I Can't Get Over It: A Handbook for Trauma Survivors*. Oakland: New Harbinger Publications, 1996.
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- The Brain: Understanding Neurobiology Through the Study of Addiction*. The National Institutes of Health, 2002. To request a free copy, visit science.education.nih.gov/supplements and click on "High School."

THE SECRET LIFE OF THE B R A I N

ONLINE RESOURCES & ORGANIZATIONS

GENERAL INFORMATION

THE SECRET LIFE OF THE BRAIN

www.pbs.org/brain

Dana Foundation

www.dana.org

Neuroscience for Kids

faculty.washington.edu/chudler/neurok.html

EARLY CHILDHOOD

Zero to Three

<http://www.zerotothree.org>

MENTAL HEALTH

National Depressive and Manic-Depressive Association

www.ndmda.org

National Foundation for Depressive Illness

www.depression.org

National Institute of Mental Health: Depression

www.nimh.nih.gov/publicat/depressionmenu.cfm

National Institute of Mental Health: Schizophrenia

www.nimh.nih.gov/publicat/schizoph.htm

National Institute of Mental Health, "Teenage Brain: A Work in Progress," 2001.

www.nimh.nih.gov/publicat/teenbrain.cfm

Psychology Information Online: Depression in Teenagers

www.psychologyinfo.com/depression/teens.htm

Schizophrenia.com

www.schizophrenia.com

Symptoms of Teen Depression

www.prairiepublic.org/features/healthworks/depression/teen.htm

World Fellowship for Schizophrenia and Allied Disorders

www.world-schizophrenia.org

ADDICTION

Center on Addiction and Drug Abuse

www.casacolumbia.org

Focus Adolescent Services

www.focusas.com/Alcohol.html

Freevibe

www.freevibe.com/index.shtml

Marijuana Facts for Teens

www.nida.nih.gov/MarijBroch/Marijteens.html

BRAIN HEALTH

Brain Injury Association, Inc.

www.biausa.org/

ADD/ADHD

National Attention Deficit Disorder Association

www.add.org

ORGANIZATIONS

American Association for the Advancement of Science (AAAS)

1200 New York Avenue, N.W.

Washington, DC 20005-3920

Tel: 202.326.6670 www.aaas.org

AAAS's mission includes improving the effectiveness of science in the promotion of human welfare, advancing education in science and increasing the public's understanding and appreciation of the promise of scientific methods in human progress.

Association for the Education of Teachers in Science (AETS)

College of Education

Dept. of Early Childhood Education

Georgia State University

Atlanta, GA 30303

Tel: 404.651.2584 Email: mweinburgh@gsu.edu www.aets.unr.edu/

AETS is an organization to promote leadership in, and support for those involved in, the professional development of teachers of science.

Association of Science-Technology Centers, Inc. (ASTC)

1025 Vermont Avenue, N.W., Suite 500

Washington, DC 20005-3516

Tel: 202.783.7200

Email: info@astc.org

www.astc.org

ASTC is an organization of science centers and museums dedicated to furthering the public understanding of science.

Association for Women in Science (AWIS)

National Office

1200 New York Avenue, N.W., Suite 650

Washington, DC 20005

Tel: 202.326.8940

Email: awis@awis.org

www.awis.org

The Association is dedicated to achieving gender equity and full participation for women in science, mathematics, engineering and technology.

Boys & Girls Clubs of America

National Headquarters

1230 West Peachtree Street NW

Atlanta, GA 30309

Tel: 404.487.5700 www.bgca.org

Boys & Girls Clubs of America comprises a national network of 2,800 neighborhood-based facilities annually serving more than 3.5 million young people, primarily from disadvantaged circumstances.

The Dana Alliance For Brain Initiatives

745 Fifth Avenue, Suite 900

New York, NY 10151

Tel: 212.223.4040 www.dana.org

The Dana Alliance for Brain Initiatives is a nonprofit organization of more than 200 leading neuroscientists, including nine Nobel laureates.

Indians Into Medicine (INMED)

University of North Dakota School of Medicine

P.O. Box 9037

Grand Forks, ND 58202-9037

Tel: 701.777.3037 www.med.und.nodak.edu/depts/inmed/home.htm

INMED is a comprehensive program offering educational support for students from elementary through professional school levels.

National Council of La Raza (NCLR)

1111 19th Street, N.W., Suite 1000

Washington, DC 20036

Tel: 202.776.1756 www.nclr.org

The National Council of La Raza (NCLR), the largest constituency-based national Hispanic organization, has developed its own bilingual math and science curriculum.

Society for Neuroscience (SfN)

11 Dupont Circle, N.W., Suite 500

Washington, DC 20036

Tel: 202.462.6688

Email: info@sfn.org

www.sfn.org

The Society for Neuroscience is the world's largest organization of scientists and physicians dedicated to analyzing the nervous system and its role in everything we do.

THE SECRET LIFE OF THE BRAIN

BRAIN BRIEFS

www.pbs.org/brain

BRAIN(Y) PHOTOGRAPHY

by Faith Brynie

As you read these words, different regions of your brain go to work. You “see” the words not with your eyes, but with the brain’s visual center at the back of your head. A brain area farther forward interprets the meaning of the words. Should you decide to read aloud, you will probably use an area in the left side of the brain near the temple. Listen to someone reading aloud, and the brain’s auditory region just behind the ear will spring into action.

How do we know? There was a time when the bony barrier of the skull prohibited photography inside the living brain, but today that’s changed. Imaging techniques such as PET (positron emission tomography) and MRI (magnetic resonance imaging) let doctors and scientists take pictures inside the skull — and more! In real time, they can watch the living brain at work!

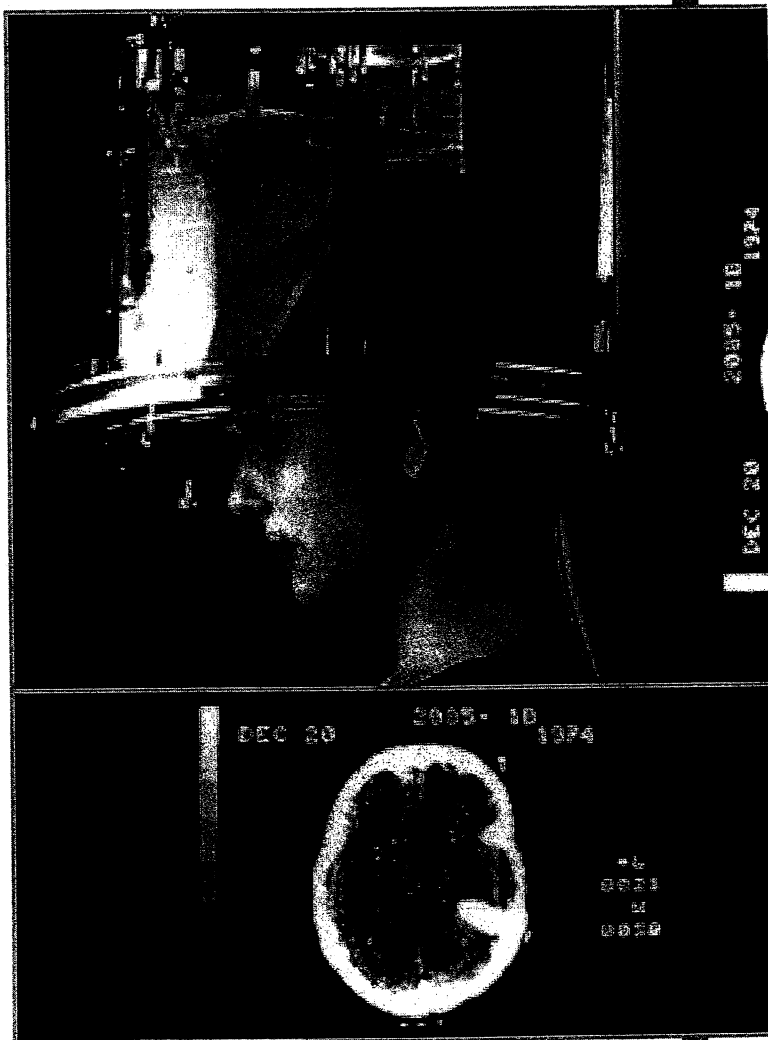
How Did Brain Imaging Begin?

The first technique developed for looking inside the brain was CT (for computed tomography). It was developed in the 1970s. CT uses ordinary X-rays, but computers combine pictures taken from many different angles into a single picture — one that’s far sharper and more detailed than ordinary X-ray images.

CT greatly increased doctors’ ability to locate, diagnose and treat brain tumors, epilepsy and many other disorders. It also allowed researchers to see the structure of the normal brain inside the living body. Along with other, newer technologies such as PET and MRI, CT is helping scientists restore diseased brains and understand healthy ones.

What is PET?

PET stands for positron emission tomography. It allows doctors and researchers to watch the living brain at work. It works because more blood flows to active areas of the brain than to “resting” regions. More blood flow means greater use of sugar (for fuel) and oxygen (for releasing food energy). Both sugar and oxygen can be tracked and mapped using radioactive isotopes. (An isotope is an atom of an element that differs in the number of neutrons it contains.)



Photodisc, Inc.

Here’s how it works. A solution containing an oxygen isotope is injected into the person whose brain will be scanned. As the isotope travels through the brain, it emits positively charged particles called positrons. The positrons collide with electrons in the body, which are negatively charged. When the opposites destroy each other, gamma rays are released. The PET scanner detects the gamma rays, and the computer turns the signals into colored pictures of “where the action is” in the brain.

THE SECRET LIFE OF THE B R A I N

BRAIN BRIEFS

BRAIN(Y) PHOTOGRAPHY

www.pbs.org/brain

What is MRI?

MRI stands for **m**agnetic **r**esonance **i**maging. It works because a hydrogen atom's single-proton nucleus has a property called spin, which is like a magnetic field. An MRI scanner looks like a hollow tube, but it's actually a powerful magnet. The magnet aligns the spinning atoms in a single direction — like dancers pirouetting in unison.

When a tiny pulse from a radio transmitter interrupts the "dance," the atoms bounce out of line with the magnetic field for an instant. As they return to their proper positions, they emit a weak radio signal. Computers convert the signals into pictures that show the depth and density of living tissue.

Ordinary MRI pictures show only structures, but functional MRI (fMRI) can show what's going on inside the living brain. It works on the same principle as PET: more blood flows to an area of the brain that is active. With MRI, the increased oxygen in an active area changes the radio signal, pinpointing which neurons are receiving and processing input messages.

Are PET and MRI the Only Ways to Take Pictures Inside the Brain?

No, and still more ways are likely to be developed in the future. For example, SPECT (for single photon emission computer tomography) is similar to PET, but detects a different type of energy. Its images aren't as good as PET's, but it's much less expensive. Another technology, called MEG (for **m**agneto**e**ncephalography) measures changes in magnetic fields caused by the brain's tiny electrical output.

New computer applications are changing and improving brain images too. For instance, an application called CARET (for computerized anatomical reconstruction and editing toolkit) allows scientists to reconfigure the "slices" from MRI scans into "flat-map" projections that show "what's in the grooves" of the brain's folded surface.



Photodisc, Inc.

Activities

- To demonstrate how a magnetic field can align particles, sprinkle some iron filings on a sheet of paper. Place a magnet beneath the paper and move it about. With practice, you can make the filings line up in neat rows, tilting any direction.
- At your library or on the Internet, go treasure hunting for PET and MRI images. Lots of them are available, and more are added every year. Some on the Web invite site visitors to view different "slices" of the brain from various angles and to compare normal brains with injured or diseased ones.
- Find out what imaging procedures are used at hospitals, medical centers and research facilities in your community. Interview health care providers and scientists to find out what purposes the technologies serve.

**For more on scanning the brain, log on to
www.pbs.org/wnet/brain/scanning!**

What's Going On in My Little Brother's or Sister's Brain?

by Sue Young Wilson

Well, a whole lot, actually!

An eight-month-old baby has about 1,000 *trillion* neural connections, or synapses. That's about twice as many as you have. By the time you were age ten, your brain had pared its connections down to about 500 trillion synapses. But don't worry, that doesn't mean your little brother or sister is smarter than you — it's a normal part of the brain's development process for it to shed neural connections that it hasn't regularly used, so that the more active connections can grow stronger.

What that *does* mean is that your little brother's or sister's brain is more *plastic* than yours — its basic structure is changing and developing all the time in response to stimuli it is getting from the outside world. (Your brain is plastic, too, but not as much so.)

Researchers believe the human brain goes through five major phases: before birth, from birth to three years old, between ages four and 12, 12 to early 20s, and in adulthood.

- **Before birth (fetus):** During the first months in the womb, the fetus sprouts hundreds of billions of brain cells (neurons), at the amazing rate of 500,000 neurons per minute. Half of these will die off before birth, as the fetus's brain is molded by hormones and other forces, but a baby is still born with more than 100 billion brain cells, about the same number as it will have for the rest of its life.
- **0 to 3 years:** This is when those trillions of brain connections, or synapses, are formed between the brain cells. Experience then pares away the connections to form the brain's basic physical "maps," in charge of things like movement, vision, hearing and language. For instance, when a baby is three months old, its brain can respond to hundreds of spoken sounds; but in the next few months, the brain will become more efficient by recognizing spoken sounds in the language it regularly hears, and filtering out subtle differences between other sounds.



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- **4 to 12 years (childhood to puberty):** New learning continues to organize and reinforce neural connections, but at a slower rate than in babies.
- **12 to early 20s:** The brain is still developing. Scientists used to think it was in final form by the teen years but have recently discovered that significant changes are still going on in areas like the prefrontal cortex (in charge of planning, organizing, impulse inhibition, and more). The brain is not changing as rapidly as in childhood, though, and it does, for instance, get much harder to learn new languages after about age 12 — someone who starts learning one then will rarely learn to speak it as fluently as a native, the way younger kids can. All the more reason to learn foreign languages early!
- **Adult:** The brain's basic structure is set, but of course you can continue to learn and remember new things for life.

THE SECRET LIFE OF THE B R A I N

BRAIN BRIEFS

www.pbs.org/brain

What's Going On in the Teenage Brain?

by Sue Young Wilson

Ever feel like your brain hurts? Well, maybe it's got growing pains.

Scientists used to think the brain, though it grows explosively in early childhood, was pretty much in final form by puberty. But, just in the past few years, with the help of new technologies like magnetic resonance imaging, they've discovered that the teenage brain is still very much a work in progress.

One brain area that undergoes major change in the teen years is the prefrontal cortex, the part that's in charge of setting goals, making plans, ranking priorities, organizing and inhibiting impulses. Starting around nine or ten, the prefrontal cortex goes through a growth spurt, adding many more connections. Then, a couple of years later, these tangles of connections start to get pruned away to leave the prefrontal cortex in its final form. With all this change going on in a brain area responsible for higher decision-making, no wonder teens can get a little scattered. The good news is that this pruning actually makes the connections more efficient, helping teens get it together as they finish growing up.

Scientists have also recently found evidence that in adolescence, the brain's cells aren't completely covered yet by the fatty sheaths, called myelin, that help them function. Myelination, as the growth of these sheaths is called, may not be complete until the early 20s.

The fact that a teenager's brain is still developing means that it may be particularly vulnerable to the harmful effects of alcohol and drugs, including nicotine. Researchers have done experiments on adolescent rats and found that alcohol and nicotine caused brain damage in the "teenaged" rodents in ways that they didn't in adult rats. Another good reason not to drink, smoke or take drugs.

In your teen years, your brain is completing its "hard wiring." It "decides" what connections to wire in and what to eliminate based largely on what you spend a lot of time learning and doing. That means that you, as a teenager, have a rare opportunity to mold your brain to be good at things just by doing them a lot. If you want to learn a sport or a language or how to play guitar, now is a great opportunity to develop these skills for life. (It follows that it's kind of dumb to waste this "brain-wiring window" lounging in front of the television for hours. You might want to save that for your retirement and go learn how to do something cool.)



This well-known optical illusion shows both a young lady and an older woman. Which do you see first? A key to the illusion is that if you look closely, you'll see that the young lady's chin can be the older woman's nose. Created by cartoonist W. E. Hill, it was originally published in *Puck* in 1915 as *My Wife and My Mother-in-law*.

**For more optical illusions, log on to
Exploratorium Web site
Seeing Exhibits at
www.exploratorium.com/exhibits/f_exhibits.html**

THE SECRET LIFE OF THE BRAIN

BRAIN HEALTH

www.pbs.org/brain

Exercise and Sports: For "Brains" Only

by Faith Brynie

Want to get smarter? Get moving!

Shakespeare and calculus aside, the first job of a brain is to run a body. The brain controls, learns and coordinates movements. Movement, in turn, affects the health of the brain.

How Does the Brain Control Movement?

Two areas of the brain play major roles in physical activity. The first is the motor cortex, a region of the brain's thin outer layer. It sends impulses to muscles, initiating voluntary movements. Communication between the senses and the motor cortex coordinates motion. Your hand can catch a ball because information on a ball's position, direction and speed is relayed from the brain's visual center.

Automatic movements reside in a second area, the cerebellum. Lying at the base of the brain, this region coordinates balance, movement and posture. This area automatically keeps the body upright and the muscles working together. You don't have to think about maintaining balance, but when this part of the brain is impeded — as it might be when too little oxygen reaches the brain — the body's posture-maintaining ability is lost. What's this called? Fainting!

The cerebellum can also take over some movements that were once voluntary. Have you noticed that new skills — seeming difficult at first — become effortless with practice? The brain shifts neural activity from the motor cortex to the cerebellum as skills become automatic.

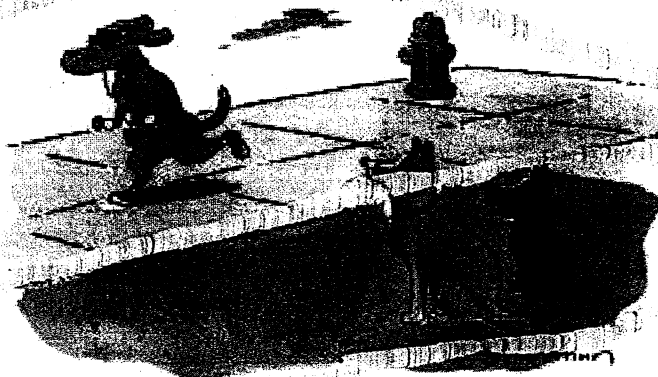
Does Exercise Affect the Brain?

A healthy brain needs two kinds of exercise daily. One kind is obvious — using the brain's reasoning and problem-solving capacities. Learning, thinking, remembering, and being active strengthen connections between neurons and stimulate new ones. Reading, writing, creative activities such as art, social interactions, hobbies, mental games and quizzes — all help build and maintain a healthy brain.

Less obvious — but equally important — are the benefits of physical activity. Exercise promotes blood flow and oxygen delivery to brain tissue. Perhaps as a result, exercise increases the number of neurons and connections

formed in the brain, especially in an area called the hippocampus. (The hippocampus makes and stores memories.)

Exercise combats stress, enhances the immune response against infection and improves mood. Exercisers perform better on learning and memory tasks than couch potatoes. They keep their mental sharpness well into old age, too. Certain patterns of physical activity — such as those used to rehabilitate stroke patients — can help repair a damaged brain.



"Still, a brisk walk can be just as effective."

The New Yorker Collection 1997 Danny Shanahan from Cartoonbank.com.
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Activities

- Working with a partner and a stopwatch, practice folding paper with one hand. (Agree on rules for the kind of fold and the adequacy of the result.) Time a number of trials, first with your dominant hand, then with your less-used hand. Compare times between trials. Do you improve with practice?
- Interview a professional athlete, physical education teacher, physician or health club trainer. Ask about the "brainy" benefits of regular exercise.

THE SECRET LIFE OF THE
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Keep Your Brain Healthy

by William Guido, Ph.D.

The brain is the most valuable organ of your body. While other organs can be repaired or sometimes replaced, your brain cannot. It acts as the command center for all your actions, thoughts and experiences. It also controls many bodily functions that we rarely think about such as heart rate, blood pressure and breathing. Although our brain is vital for survival, it is extremely vulnerable. While it is protected by a thick bony skull and isolated from the body's bloodstream by a blood-brain barrier, a simple fall from a bicycle or skateboard can lead to permanent and serious brain damage.



Traumatic Head Injury

Each year in the United States, an estimated 5.3 million Americans, a little more than two percent of the population, live with a disability resulting from brain injury. There are two types of brain injury. Open head injuries occur when the skull is penetrated. Closed head injuries are more common and are caused by rapid movements of the head which cause the brain to bounce back and forth against the skull. Closed head injuries result from car accidents, falls or injuries sustained during recreational/sporting activities. These injuries can lead to bruising, tearing and swelling of the brain.

Brain injuries can vary in their severity from a mild concussion to prolonged unconsciousness or coma. A blow to the head during a sporting event may be a lot worse than you think. Such hits may not be hard enough to crack the skull, but they cause the brain to bounce around inside the skull. (Think of what happens to the yolk of an egg that is shaken.) Common side effects of a concussion include headaches, lightheadedness, dizziness, or a brief loss of consciousness. New studies also show that college athletes who experienced a concussion perform worse on memory tasks for up to seven days after the injury!

Simple measures can be taken to prevent the risk of head injury. Wear proper safety equipment when playing sports. Every year, there are 300,000 head injuries sustained during sporting events. Always wear a helmet when biking, skating or skateboarding. Head injury is the leading cause of death in bicycle crashes. Always wear a seat belt when driving. Motor vehicle accidents account for 37 percent of all brain injuries.

Signs of Head Injury

Headaches • dizziness • loss of consciousness • memory impairment • trouble finding the right word • increased irritability • mood swings • trouble sleeping • impulsiveness • difficulty in concentration

Ten things to do to keep a healthy brain!

1. Wear a seat belt when in a car
2. Wear a helmet biking or skating
3. Stay away from drugs
4. Don't drink and drive
5. Look before diving into pools and unknown lakes or ponds
6. Look both ways before crossing the street
7. Stay away from guns
8. Eat right
9. Stay away from harmful chemicals, pesticides and cleaners
10. Drink plenty of fluids when working or playing in the heat

Discussion Questions

- Have you ever been around someone who was drunk or suffered from a concussion? How did their behavior change as a result?
- Knowing how common mishaps can affect brain function, what will you do differently?

THE SECRET LIFE OF THE
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BRAIN HEALTH

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Mental Illness & Brain Disorders

by Sue Young Wilson

The brain is an amazing, complicated organ, but sometimes things go wrong with it. More than one out of five Americans will suffer from some kind of mental illness in their lifetime.

One of the most frequent of the serious mental disorders is depression. Researchers estimate that about 17 percent of Americans will suffer an episode of major depression in their lifetimes. Schizophrenia and bipolar disorder (also called manic depression) are less common, each afflicting about one percent of the population.

Depression

Depression is an emotional (mood) disorder in which a person feels sad, worthless and hopeless for a long period. Other symptoms include trouble sleeping or sleeping too much, restlessness or being slowed down, feeling tired all the time, changes in appetite or weight, trouble concentrating or making decisions, and repeated thoughts of death or suicide. As with other mental illnesses, scientists still aren't sure exactly what causes depression, but most think it is some combination of biological factors, primarily genetics and environmental factors like stress, loss or early childhood trauma.

What Do You Do If a Friend Says He or She Is Thinking of Suicide?

1. Listen and let the person tell you how he or she is feeling. Be accepting and caring.
2. Encourage him or her to get help. If he or she won't, tell someone else (an adult), and make sure your friend does get help. Don't promise your friend you won't tell anyone. It's not true that people who talk about suicide don't do it. Places to start: the school nurse, a suicide-prevention hotline, a community mental-health center, a youth group leader you trust.
3. Consider talking to someone like a counselor about your own feelings and experiences. Dealing with a suicidal friend is troubling and emotional.

Schizophrenia

Schizophrenia is a serious brain disorder in which a person's sense of reality becomes distorted. He or she often has hallucinations and delusions and trouble feeling emotions and relating to others. Tragically, this personality-distorting illness often strikes an individual for the first time during the

teen years or young adulthood, just as the person is discovering who they are. (Note: "Schizophrenic" does not mean someone has a "split personality," as the term is sometimes misused in casual conversation.) In schizophrenia, scientists currently believe that the brain isn't properly processing a brain chemical called dopamine.

Schizophrenia often has a genetic basis. It is definitely not contagious, but some researchers suspect that a viral infection in childhood may play a role in causing schizophrenia. We still know relatively little about what causes this devastating disease.

Bipolar Disorder

Bipolar disorder is a serious mental illness in which a person suffers severe mood swings, from mania (an exaggeratedly "up" or "high" state) to depression. Some people with bipolar disorder have "mixed episodes" that combine symptoms of mania and depression.

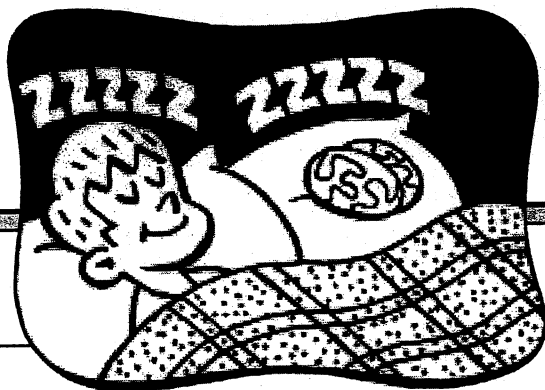
The symptoms of depression are listed above. Manic symptoms include: a "hyper" mood, agitation or irritability, excessive self-esteem (thinking that one can do anything or is "king of the world"), greatly increased energy, decreased need to sleep, talking too much and too fast, and risky behavior.

Bipolar disorder clearly seems to have a physical basis in the brain and is often treated with a drug called lithium.

There's Help for Mental Illness

Most mental illnesses are treatable, and most people who are treated return to fully productive and meaningful lives. Treatments for mental illness include medication and talk therapy. Often, a combination of both is most beneficial.

If you think you or someone you know may be suffering from depression or another mental illness, see a doctor or a counselor who can point you towards help. You might start by asking the school nurse or the adult leader of a teen group you belong to. Most communities have mental-health and suicide-prevention hotlines and crisis centers; you can check in the Yellow Pages (try under "Mental Health"). One suicide-prevention hotline with locations in many cities is the Samaritans (www.samaritans.org).



Your Brain: Sleeping and Dreaming

By Faith Brynie

What's awake when you're sleeping? Your VLPO!

At least that's what some Swiss scientists think, if your brain is anything like a rat's. They found that two-thirds of the nerve cells in the brain area called the ventrolateral preoptic nucleus (VLPO) fire during sleep. Hormones produced during the waking hours stop the cells from firing.

What else is your brain doing during sleep? Wake up and take this true-false quiz. Some of the answers may be eye-openers.

- | | | |
|---|---|--|
| T | F | 1. Dreams have hidden meanings. They are messages from the subconscious mind. |
| T | F | 2. Sleep promotes healing and regrowth of the brain's outer layer, the cortex. |
| T | F | 3. Dreaming occurs only during REM (for rapid eye movement) sleep. |
| T | F | 4. The brain can detect and understand sounds while sleeping. |
| T | F | 5. During sleep, the brain keeps the heart beating in a slow, regular rhythm. |
| T | F | 6. Studying all night keeps memories fresh for an exam the next day. |
| T | F | 7. Half the brain sleeps at a time. |
| T | F | 8. A fetus sleeps before birth. |
| T | F | 9. Teens need less sleep than children do. |
| T | F | 10. Every animal sleeps, even the common housefly. |

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Don't doze off before checking your answers:

- True or False (trick question). The answer depends on which expert you ask. Some say dreams are nothing more than the "thinking brain's" attempt to make sense of the random firings of nerve cells in other brain regions. Other experts say that, while the brain's thinking and reasoning areas go "offline," the less sophisticated centers can get their messages through.
- True.
- False. Although most dreams occur during the sleep stage known as REM, some dreaming can occur during non-REM sleep.
- True. Scientists at Harvard watched sleeping brains using an imaging technique called fMRI (for functional magnetic resonance imaging). Pure tones activated the sound-processing regions of the brain, while speaking the sleepers' names produced increased activity in the language centers, memory regions and prefrontal cortex.
- False. The time between heartbeats varies more during sleep than during wakefulness.
- False. Memories are stored during sleep, and experiments show that those who sleep after they study consistently perform better than those who study, but don't sleep.
- False for humans, but true for many kinds of birds. Scientists at Indiana State University studied napping mallards. Their brain hemispheres (sides) take turns sinking into the slow brain waves of sleep. The eye controlled by the sleeping hemisphere closes. The other stays open.
- True. And the fetus may dream as well, as REM sleep begins around week 17 of development. What a fetus may be dreaming, however, will remain forever a mystery.
- False. Researchers at Stanford measured the spontaneous sleep and waking (no alarm clocks!) of young people, ages 10 to 18. On the average, younger children slept 9 hours and 20 minutes and awoke naturally. The older sleepers slept past the 9 hour-20 minute mark without waking. They experienced more drowsiness during the day as well.
- True, says researcher Marcos Frank of the University of California, San Francisco—although "sleep-like state" may be a more accurate description of the housefly's daily dozes.

THE SECRET LIFE OF THE BRAIN

PROFILES

by William Guido, Ph.D.

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Susan McConnell, Ph.D.

Professor of Biological Sciences
Stanford University

"The brain of a baby is a work-in-progress."

Walk into Dr. Susan McConnell's lab and you will find her gazing through a microscope. McConnell, a developmental neurobiologist and research professor at Stanford University, is tracking the winding paths of migrating cells. She transplants newborn cells, not yet recognizable as neurons, into developing brains. She has found that the final destinations of these soon-to-be-neurons are determined by neighboring neurons.

Dr. McConnell's career path was influenced greatly by past experiences. She says, "I used to watch documentaries on TV about Jane Goodall and her studies of chimpanzees. For the longest time, I wanted to be a field behavioral biologist just like her. As I studied biology in college, I grew more interested in the brain as the basis of behavior and how neural circuits are created during development, thus enabling even newborn animals to exhibit complex behaviors." McConnell's research into animal brain development shapes our present thinking about how the human brain develops. Her work provides new hope for people suffering from degenerative brain diseases, because surgical transplants of newborn cells may restore brain regions ravaged by Alzheimer's or Parkinson's disease.

McConnell is an engaging speaker who travels the world describing how developing neurons make their journey to distant cortical regions. "What we would really love to understand is how the brain generates millions of neurons, sends them to the right position, and then somehow instructs each individual nerve cell to form very specific connections with one another. To me that's a miracle."

Courtesy: Susan McConnell

Benjamin S. Carson, M.D.

Director of Pediatric Neurosurgery
Johns Hopkins Children's Center

"Think big!"

In his best-selling book, *Think Big*, neurosurgeon Benjamin Carson reveals his philosophy about life, one that helped him to escape hardship and unleash his true potential. Dr. Carson is a world-class neurosurgeon. He is best known for separating the Binder Siamese twins, who were connected at the head. He performs hundreds of surgeries a year on children who are suffering from life-threatening neurological conditions.

Carson's childhood was difficult. He grew up in a tough Detroit neighborhood, where he struggled with a poor self-image and a bad temper. Carson says, "I did not like school very much. I always felt that I was the dumbest kid in my class. Others laughed at me and made jokes about me." Thanks largely to the guidance of his mother and her belief that a good education was the ticket out of poverty, Carson overcame his self-doubt and academic problems. His hard work and religious faith helped propel him to the top of his class and resulted in a full scholarship at Yale University. He continued his studies at the University of Michigan School of Medicine, where he trained to become a neurosurgeon.

At age 32, Carson became the youngest surgeon in the nation to hold the distinguished title of Director of Pediatric Neurosurgery. Despite his rigorous schedule, he still makes time to give motivational talks to the youth of America. Carson's message rings loud and clear — THINK BIG!

Keith Weiler

THE SECRET LIFE OF THE B R A I N

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Nancy Andreasen, M.D., Ph.D.

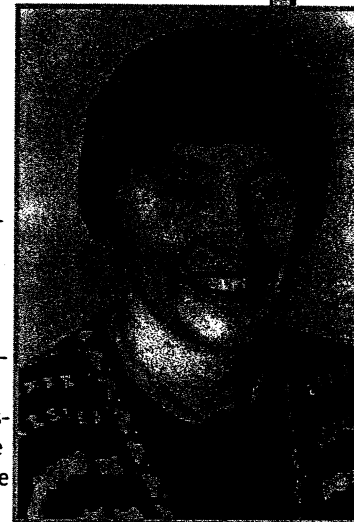
**Professor of Psychiatry
The University of Iowa College of Medicine**

"Above all, my greatest motivation is helping patients."

Nancy Andreasen is a brain science celebrity. Well-regarded for her clear explanations of complex neuroscience topics, she frequently appears on the Today Show, 20/20 and Dateline to discuss breakthroughs in brain research. A neuropsychiatrist at the University of Iowa College of Medicine, she has written two best-selling books on mental illness, *The Broken Brain* and *Brave New Brain*.

Dr. Andreasen's neuroimaging research has contributed significantly to our understanding of the cause and treatment of schizophrenia. Using highly sophisticated scanners that take three-dimensional pictures of the brain, she can peer inside the schizophrenic brain. Her pioneering work has shown that abnormal neural connections cause common schizophrenic symptoms like hallucinations and disorganized language. It has also allowed clinicians to pinpoint affected regions of the brain and shape successful treatments. Andreasen believes that neuroscientists will soon "peer into brain cells and see the poisons that cause schizophrenia."

In addition to chairing the psychiatry department, she serves as editor-in-chief for the *American Journal of Psychiatry* and was a member of the national task force that set treatment standards for psychiatric disorders. Last year, Congress and the President recognized her outstanding achievements and awarded her the prestigious National Medal of Science. Since its inception in 1959, over 350 scientists and engineers have received the medal. "To be numbered among these outstanding individuals is indeed gratifying and humbling," says Andreasen.



Courtesy: Nancy Andreasen

Erick Green

**Research Associate
Louisiana Health Sciences Center**

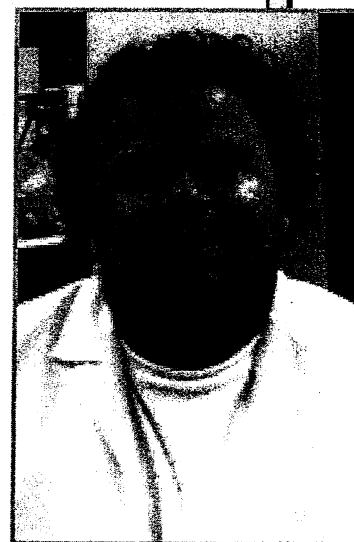
*"It's a great feeling to know you are helping
to unfold the mysteries of science."*

In the research laboratory at LSU Health Sciences Center where he works, Erick Green is a jack-of-all-trades. He uses a variety of chemical techniques to visualize brain structures, programs computers to analyze the brain's electrical activity, orders lab supplies and supervises students.

Erick grew up and still lives in one of the toughest neighborhoods in New Orleans. He was a football player at St. Augustine High School, an all-boys school known for producing successful athletes that now play in the NBA and NFL. But Erick's star power was in academics. He graduated in the top ten of his class and enrolled at Southern University. As a full-time college student, Erick held down several part-time jobs to pay for his tuition and often studied by the flickering light of a movie projector that he ran at a local cinema.

Hard work and perseverance paid off for Erick, and he landed a job as a research associate soon after graduation. After work, he takes preparatory classes for medical school to realize his lifelong dream of becoming a doctor.

Erick's supervisor can count on him for just about anything — even for making late night runs to the lab to check on ongoing experiments. Erick rarely gets public recognition for his work, but without him, the important research he helps with would come to a grinding halt.



Courtesy: Erick Green

