



Staying Sharp

current advances
in brain research

Learning Throughout Life



745 Fifth Avenue, Suite 900
New York, NY 10151
www.dana.org



AARP's Educator Community

601 E Street, NW
Washington, DC 20049
www.aarp.org/nrta



The Dana
Alliance
for
Brain
Initiatives



AARP's Educator Community

NRTA: AARP's Educator Community

NRTA (www.aarp.org/nrta) is AARP's educator community. Consistent with AARP's mission, NRTA is dedicated to enhancing the quality of life for all as we age, specifically through a focus on education and learning. NRTA works for positive social change in the field of education and provides members with valuable information, advocacy, and service initiatives related to learning and education. NRTA provides national leadership through its network of affiliated retired educators' associations in 50 states and 2,700 communities and through its national office at the AARP headquarters in Washington, D.C. The partnership with the Dana Alliance for Brain Initiatives, and the Staying Sharp initiative, recognizes and explores the intimate connection between the brain, human behavior, and the ability to continue to learn throughout life.

The Dana Alliance for Brain Initiatives

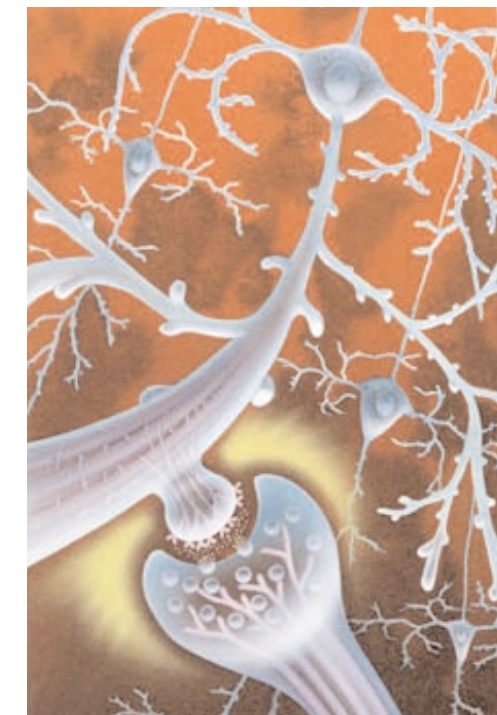
The Dana Alliance for Brain Initiatives (www.dana.org) is a nonprofit organization of more than 200 leading neuroscientists, including ten Nobel laureates. The Dana Alliance is committed to advancing public awareness about the progress and benefits of brain research and to disseminating information on the brain in an understandable and accessible fashion. Supported entirely by the Dana Foundation, the Dana Alliance does not fund research or make grants.

The Dana Foundation is a private philanthropic organization with principal interests in science, health, and education. The Foundation's current areas of emphasis are in immunology and neuroscience research, and in K-12 education, particularly the training of arts educators.

©2004 NRTA and the Dana Alliance for Brain Initiatives. All rights reserved. Reprinting with permission only.

We humans are learning machines, and the brain is the engine that drives the machine. Crammed into the three pounds of convoluted tissue inside our skulls is a dynamic mass of a hundred billion or more nerve cells, each one capable of making thousands of connections with others. These are the nuts and bolts of the learning machine.

From the day we are born—and even before—the brain is primed for learning, ready to capture the experiences of our lives and encode them into its web of nerve connections. Learning organizes and shapes and strengthens the brain's connections. It fine-tunes the brain, preparing us for all that life has to offer, whether mundane or extraordinary. And according to the latest brain research, actively engaging our brains in learning throughout life can have a significant impact on how well we age.



Communication between brain cells in a neural network

In this booklet, we'll explore what neuroscience has revealed about lifelong learning. Do we learn the same no matter what our age? How does learning throughout life influence how we age? Are there things we can do to "rev up" our brain for learning? Recent advances in understanding each of these issues proffers good news for anyone interested in maintaining brain health in the "second half" of life.

What Do We Mean by “Learning”?

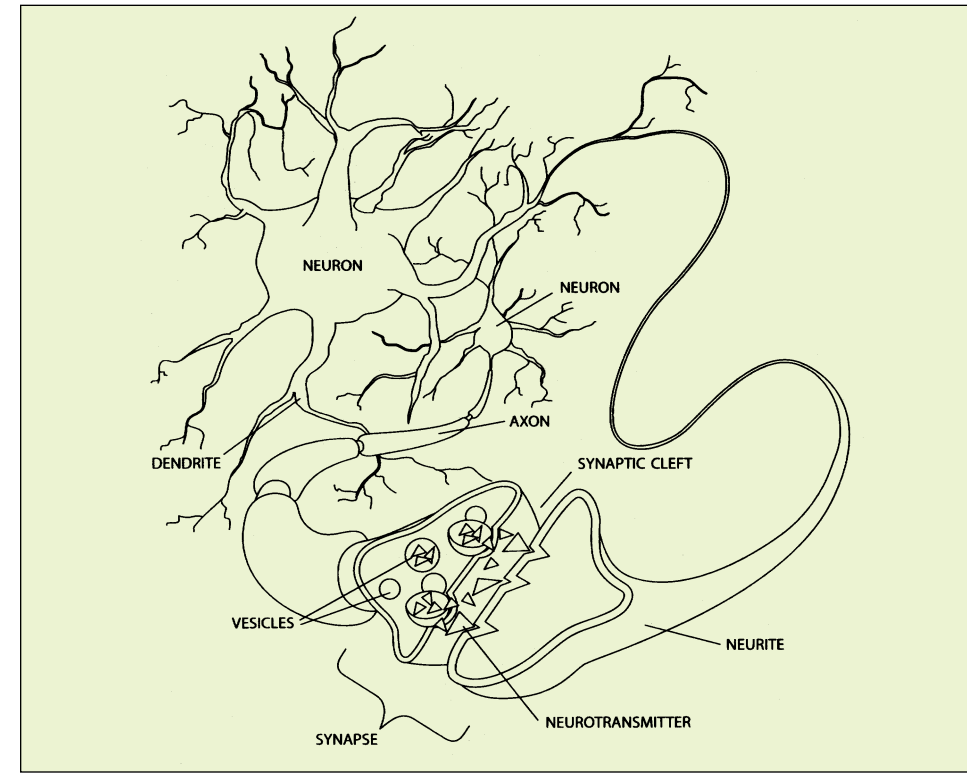
How much do you remember of what you learned in school? Algebraic formulas? Perhaps, if you’re a mathematician. Periodic table of the elements? If you’re a chemist, certainly. Sentence diagramming? Maybe, if you’re a writer.

The point is, you may have learned these things in grade school—you may have even aced the exams—but unless you’ve used them in your day-to-day life since, you may be hard pressed to remember the details. This illustrates a distinction that brain researchers are quick to make: learning and memory are not the same thing, though they are intricately linked.

“Learning is how you acquire new information about the world, and memory is how you store that information over time,” says Eric R. Kandel, M.D., vice chairman of The Dana Alliance for Brain Initiatives and recipient of the 2000 Nobel Prize in Physiology or Medicine for his work on the molecular basis of memory. “There is no memory without learning, but there is learning without memory,” Kandel says, because “you can learn things and forget them immediately.”

As a result, not all learning gets laid down into memories that last. We look up a phone number and retain it just long enough to dial it. This is sometimes called “working memory.” It still requires learning, just not for the long haul.

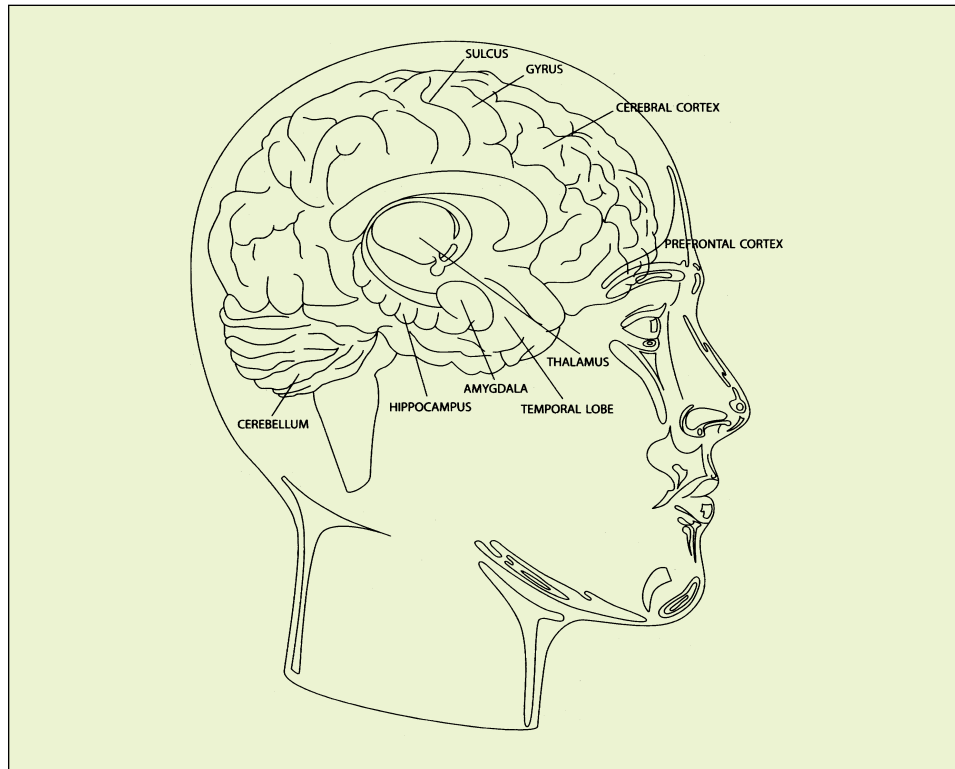
Scientific definitions aside, what most of us think of when we think of “learning” is really an attempt to establish a memory that sticks. Learning a new dance step, how to play a musical instrument, or the name of a new acquaintance all require that our brain encodes new information and stores it until we need it.



Getting to Know Your Brain

Every aspect of brain function, whether it’s solving a mathematical problem, hitting a ball with a club, or listening to music, is represented in the brain as patterns of electrical and chemical signals traveling between nerve cells. Each thought, action, or sensory perception stimulates distinct sets of nerve cells and brain chemicals. One can imagine each cell as a musician in an elaborate symphony orchestra, playing its individual notes in harmony with other sections of the orchestra to generate pieces of the musical score. The concerto that emerges from all the sections working together is nothing less than human behavior itself.

Nerve cells, or neurons, are the workhorses of the brain. Their fibers, or axons, form connections called synapses with other neurons. When activated, a neuron sends low-level electrical currents down its axon, releasing brain chemicals (neurotransmitters) that diffuse across the gap where one neuron meets another and latch onto receptors on the



receiving neuron. This sets off a cascade of changes inside the receiving cell—changes that ultimately pass the signal along, like runners in a relay race.

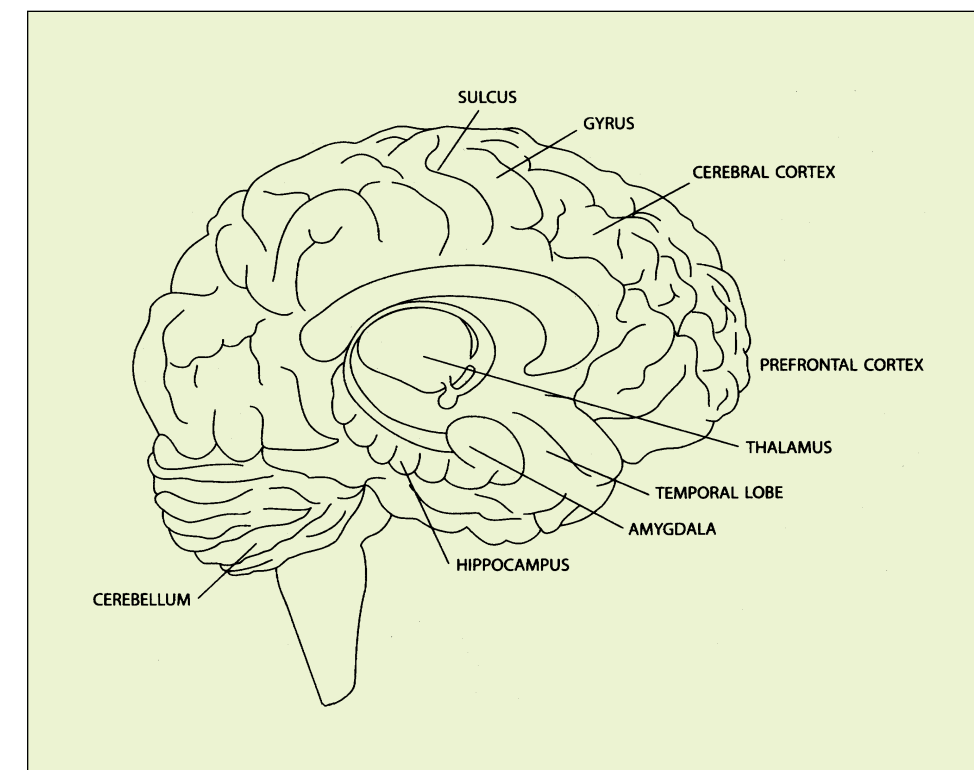
When we experience something repeatedly, such as practicing a musical score, we are reactivating the same circuit of synapses over and over again. After several repetitions, the synapse physically changes, enhancing the efficiency of the circuit and encoding the experience or behavior into a long-term memory.

Scientists believe that long-term memories are encoded within specific patterns of synapses within the irregular folds and ridges that comprise the brain's cortex. The frontal lobe of the cerebral cortex, especially the so-called prefrontal cortex, is essential to high-level mental functions such as reasoning and planning. The hippocampus, the amygdala, and neighboring structures within the temporal lobe form the core of the brain's memory processing system. These structures are connected to the cortex by elaborate pathways of neural circuitry.

How Does Learning Change the Brain?

It's remarkable to consider that we can change our brain just by learning. The brain is in a state of continual activation as we go about our daily life, with various systems turning on and making connections with others to respond to our environment and orchestrate our reactions in thoughts and behaviors. As we learn, the brain is adapting to reflect the new information that we're feeding it, so that our life experiences literally shape the brain as we age. Since no one else will have encountered the same set of experiences and learning as we have, no one else's brain looks exactly like ours.

“The adult brain, and even the adult aging brain, is fine-tuned by experience in both its performance and its abilities, essentially organizing itself in accord with its experience to prepare for the future,” says William T. Greenough, Ph.D., a Dana Alliance member and neurobiologist at the University of Illinois at Urbana-Champaign. “Since



one of the best predictors of future needs is past demands, having a brain that is optimally tuned to prior experience is ideal.”

This capacity of the brain to structurally adjust itself to reflect our life experience—which scientists called plasticity—is what enables us to learn and to change the brain by learning.

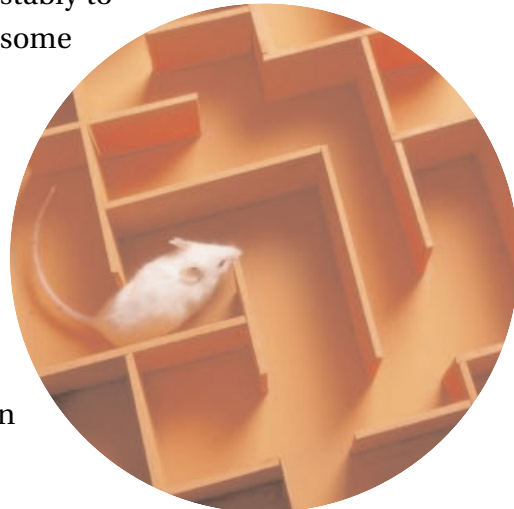
The Incredible Plastic Brain

Plasticity is reflected in many different ways in the brain. Much of what we know about how the brain processes underlying learning comes from studies of laboratory animals engaged in experimental learning situations. Taken together, these effects paint a picture of a brain capable of responding fairly rapidly and stably to new learning from experience. What are some of the changes occurring in the plastic brain when we learn?

Synaptic connections: When scientists raise laboratory animals in “enriched” environments, in which there are many opportunities for new experiences, the animals’ nerve cells form more and larger synapses than do animals reared in simple cages.

Capillaries: The tiny blood vessels that connect veins and arteries increase in certain areas of the brain when animals live in complex environments where they can exercise freely. Denser capillaries enhance the flow of blood and oxygen to brain tissue, which may in turn have other beneficial effects on neurons and brain chemical systems.

Support cells: Animal research shows that glial cells, the supportive cells of the brain, also increase both in individual size and overall number in response to complex environments. While these changes don’t appear to be as long-lasting as synaptic changes, their transient existence offers another clue to how enriching experiences change the brain.



Myelination: New data from animals suggest that learning increases myelin, the fatty sheath that wraps axons and enhances the transmission of nerve signals. Some studies have found a particularly pronounced effect in the corpus callosum, the large bundle of axons that unite the brain’s left and right hemispheres.

Birth of new neurons: Scientists have found strong correlations between learning and the generation of new neurons (“neurogenesis”) in the hippocampus. When researchers increase neurogenesis experimentally, animals perform better on learning tasks. Decreasing neurogenesis has the opposite effect.

Formation of new proteins: The transformation of newly acquired information into long-term memories requires a specific genetic switch that stimulates the formation of a new protein. Repeated exposure to the new information throws the switch to activate long-term encoding, and if scientists block the switch experimentally, they can prevent lasting memories. One important model used to study these processes is long-term potentiation, a long-lasting increase in the strength of the relevant synaptic connections.

How Does Learning Change With Age?

Neurobiologist and Dana Alliance member James L. McGaugh, Ph.D., of the University of California, Irvine, likes to tell the story of the older man who went to visit his minister.

“How’ve you been?” asked the minister.

“Not so great,” the man sighed. “I find that lately I’ve been thinking a lot about the hereafter.”

“Really?” said the minister, somewhat concerned. “Tell me about it.”

“Well,” the man replied, “every time I walk into a room, I turn around and wonder what I came in here after.”

As a memory expert, McGaugh says people come to him all the time, a look of desperation in their eyes, and say, “It’s happening to me: I can’t

remember people's names anymore." What these people don't realize, McGaugh says, is that they did the same thing in their 20s—they just didn't give it a second thought then. "But now, they think about it all the time, and they get stressed and anxious about it, when in fact it could just be a normal slip of the mind."

The truth is, such "slips of the mind" are ubiquitous, even among the young. Subtle deficits in certain types of memory processes—primarily memory for dates and events—begin showing up at about the age of 20 and continue in a relatively linear fashion right into old age. Similar trends are seen in some other aspects of cognition.

This is not surprising, say experts, and it parallels the changes over time in other body systems, from muscle coordination to lung capacity to cardiovascular strength. Why should the brain be any different?

"Part of the challenge is in educating people as to what to realistically expect from themselves," says Lawrence Katz, a Duke University neurobiologist and Dana Alliance member. "Nobody expects to run a 4-minute mile at age 50 or 60, even if they could when they were 20. Your body gives up some things as it ages, both in the brain and the body."



Cognition

Cognition means mental skills, including attention, learning, memory, language, and executive functions such as decision-making, goal-setting, planning, and judgment. Scientists often speak of brain aging in terms of cognitive changes.

What types of changes are common?

It's clear that not everyone ages in the same way, and our brains don't either. About a fifth of 70-year-olds perform as well on cognitive tests as 20-year-olds do. Still, some types of memory changes are common with normal aging. Practical strategies for coping with these changes are reviewed on page 10 ("Minding Your Memory"), and many good books are available that go far beyond what we can cover here (see "Further Reading" on page 22).

Taking longer to learn: As we age, our brain processes information at a gradually slower speed. As a result, it may take longer to learn new information and retain it, particularly larger amounts of information. Still, if we take the time to really commit the new information to memory—to focus on it and learn it well—then we will typically remember it just as well as a younger person. Processing speed comes into play in situations such as understanding a train schedule, remembering directions to a new place, or comprehending highway signs when you're zooming down the interstate.

Multitasking: Slowed processing speed may influence other aspects of cognition, including so-called executive functions such as planning and reasoning, and tasks that require a kind of "parallel processing" of holding and integrating multiple items in memory. Trying to do several things at once may become more difficult as we get slower at shifting from one set of skills to another. Think of looking up a phone number to make a call, but the phone rings before you can dial. By the time you finish talking, you may not remember the number you looked up.

Random facts and sources: Remembering names and numbers and recalling where or when you learned something are examples of “strategic” memory, which seems to undergo a lifelong decline beginning at about age 20. We may have to work a little harder to make sure our brain is engaged in learning something we want to remember later. In practice, this means paying attention to the information when it is presented; it may help to literally tell yourself, “This is important and I need to remember it.” Repeating the information out loud and making associations with other things you already know can also help improve recall when the time comes.

Forgetting to remember: Sometimes without a specific cue to jog our memory, we “forget to remember” things, such as an appointment made days or weeks earlier. When we get the phone call asking, “Where are you?” our brain clicks. In such cases, the problem is that we cannot access the information at the time we need it, rather than that we haven’t stored it properly. The best remedies for these kinds of problems are visual reminders: write notes to yourself; keep a calendar with important dates in a visible area; and post notices, invitations, or papers that need attention in a prominent designated space.

Minding Your Memory

Based on what brain science tells us about how memory changes with age, there are a number of simple strategies that we can use that should help us improve our ability to remember things when we need to.

Pay attention: Engage your brain and actively attend to what you’re trying to learn.

Stay focused: Concentrate on what you’re doing and reduce distractions or interruptions.

Repeat it: Repetition increases the strength of the relevant connections in your brain.



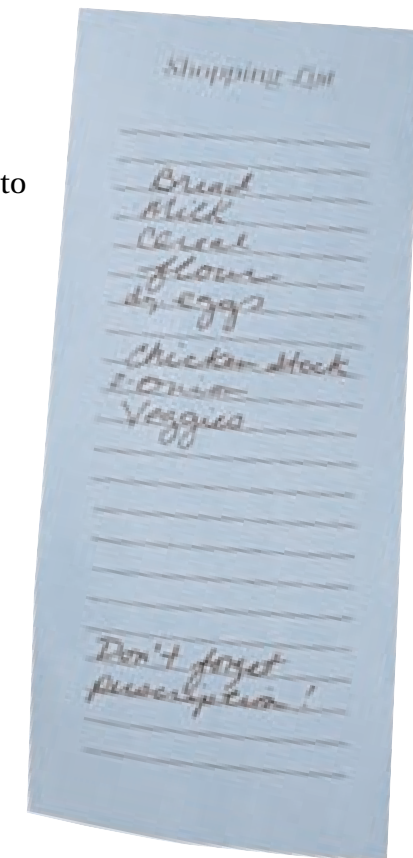
Write it down: Writing down important things serves two purposes: it constitutes another way to repeat the information, and it provides a visual reminder.

Visualize it: Creating a visual image of what you’re trying to remember can reinforce brain connections, essentially giving your brain another way to access the information.

Make associations: Relate new information to things you already know. By doing so, you’re using existing synaptic connections to learn something new. This strategy can also be useful when trying to remember names: at a dinner party, for example, you might associate “Pam” with “red dress,” “lawyer,” “friend of Bill,” “drinking red wine,” etc.

Stay organized: Keep things you use regularly in the same place, and always return them to their place—put keys on a hook by the door; wallet in a basket on your dresser, etc.

Plan and prioritize: Because multitasking may be more difficult, planning our time and prioritizing our activities becomes more critical. This may mean that some things simply have to wait. Recognize that “doing it all” may not be realistic, and let yourself off the hook. This can go a long way toward reducing stress and regaining control over your time and your life.





How Aging Alters the Brain

What's going on in the brain that might account for changes in cognitive functioning as we age?

Until recently, all scientists could do was offer educated guesses about the answer to this fundamental question. Today, thanks largely to sophisticated brain-imaging technology, researchers are putting the pieces of the puzzle together. There is much at stake: understanding the neural basis of cognitive decline may point the way to rational pharmacological and other strategies that might slow, stop, or prevent the processes.

Below are some of the central findings. These understandings are based on animal experiments and human brain-imaging studies, and they represent generalizations about brain aging based on what we know today. Specific changes vary considerably from one person to the next.

Brain mass: Beginning in about the sixth or seventh decade of life, overall brain mass may shrink modestly in some people. Certain brain

Brain Aging Myths You Can Forget

You can't change your brain. Your brain is constantly changing in response to your experiences, and it retains this fundamental "plasticity" well into old age. Everything we do and think about is reflected in patterns of activation in our brain. Scientists can see these patterns in brain-imaging scans that show which parts of the brain are functioning during specific tasks. Changing our thinking or changing the way we behave induces corresponding changes in the brain systems involved. This is why psychological therapies that teach people to alter negative patterns of thought and behavior can be effective in treating some mental disorders—there is evidence from brain-imaging studies that the disrupted brain pathways actually change as a result of successful therapy.

We lose thousands of neurons every day. This persistent myth is based on early, flawed efforts to count the number of neurons in various brain regions. Scientists now know that the brain actually loses relatively few neurons with age. What loss there is tends to be concentrated in certain regions deep in the brain, including some that supply important neurotransmitters to other brain areas.

The brain doesn't make new brain cells. This was the prevailing dogma for generations of neuroscientists, but research in the last few years has shot it down. It is now clear that certain areas of the brain, including the hippocampus and the olfactory bulb (the scent-processing center), regularly generate new neurons, many of which go on to become functioning players in brain circuits.

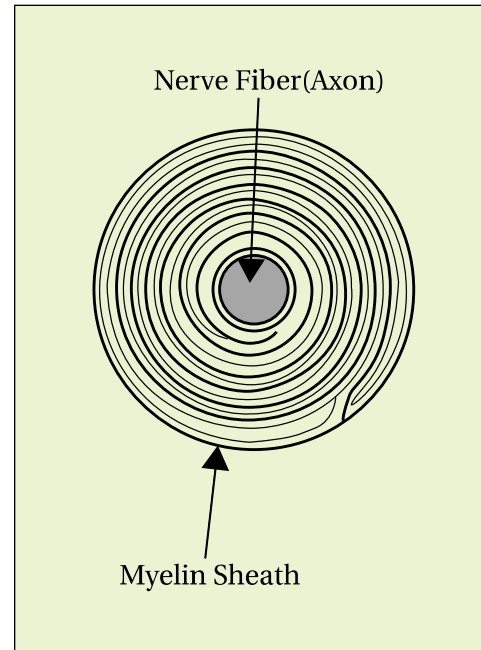
Memory decline is inevitable as we age. There are plenty of people who reach very old age and are still sharp as ever. Genetics clearly plays a role in "successful aging," but how we live our lives on a day-to-day basis is critical. Physical exercise and challenging and intellectually stimulating mental activity, diet, social connections, how we manage stress, and how we view our world and ourselves are all important factors.

areas show more pronounced shrinkage than others, including the frontal lobe (important for higher cognitive functions) and the hippocampus (a key structure for encoding new memories). In addition, the brain's ventricles, the cavities through which cerebrospinal fluid flows, are larger in older people, contributing to lower overall brain mass.

Cortical density: The cortex, the heavily ridged outer surface of the brain, undergoes modest thinning with age. This thinning is not, as scientists once believed, the result of widespread loss of neurons (see “Brain Aging Myths You Can Forget” on page 13). Rather, it is probably due to a steadily declining density of synaptic connections, which begins around age 20.

White matter: Many studies have linked aging with decreases in the brain's white matter, so-called because it consists of myelin-sheathed axons that carry nerve signals between brain regions (myelin is a fatty, white substance). The overall length of white-matter tracts seems to shorten, and the myelin surrounding some axons shrinks. Scientists have correlated these changes with lower cognitive functioning. Since myelin normally enhances the efficiency of nerve transmission, this may help explain the decreased “speed of processing” that commonly occurs with aging.

Neurotransmitter systems: The aging brain both generates fewer of these chemical messengers and has fewer of the receptors that lock onto the chemicals. Decreased availability of neurotransmitters such as dopamine, acetylcholine, serotonin, and norepinephrine may play a role in declining memory.



Synapse density: The thread-like fibers that send and receive nerve signals seem to become less elaborate with aging. The result is a decrease in overall synaptic density, which may underlie cognitive slowing.

Improving With Age

There is good news from brain research: the brain is just as capable of learning in the second half of life as in the first half. We've also learned more, simply because we're older. So in many ways, the brain is not unlike a fine wine, growing richer with each new season.

In normal healthy people, the fundamental mechanics of learning in the brain probably don't change much as we age; it just may take a bit longer for the gears to engage. But once we learn something well, it tends to stick with us just as well as it did in younger years. Skills that we may have acquired earlier in life and have practiced over the years may be at their finest, whether they be mental skills like debating the stock market or procedural skills like playing tennis or a musical instrument. As we age, we also develop a richer and more extensive vocabulary and contextual history in which to use words effectively.

Some types of memory generally hold up well as we age, like short-term memory and recalling events from our past. Our memory for factual and conceptual information, which we use to make inferences about situations and solve problems, also remains well-preserved.

Aging Wisely

“Wisdom,” by many definitions, denotes an enhanced capacity to grasp the essence of complex situations or problems and act accordingly. While wisdom is almost always associated with older age, wisdom may be more a factor of cumulative life experience than of age per se. From the time we are young children, we are gaining experience in all facets of living. By the time we are older, we've been exposed to more situations and, presumably, have learned from past mistakes as well as past successes. We can integrate the learnings of our previous decades and apply them to the challenges and opportunities we face on a daily basis, affording us advantages in judgment and decision making. **Knowledge comes, but wisdom lingers.** — Tennyson, in *Locksley Hall*

“We can make the brain work better simply by accumulating more knowledge, which builds more networks of connections in the brain,” says James McGaugh. “The wisdom that we acquire can compensate for the decline that may be gradually occurring.”

One clue to why we associate wisdom with aging comes from scientific research into how various parts of the brain’s cortex develop throughout life and their varying susceptibility to decline as we age. The prefrontal cortex (PFC), the area of the brain just behind the forehead, is essential to higher-thinking “executive” functions such as planning, reasoning, and judgment. The middle part of the prefrontal cortex (the medial PFC) is involved in the control of cognitive and motor processes and the execution of predictable behaviors. The regions under our temples (lateral PFC) seem to support adaptive thinking. According to neuroscientist Jordan Grafman, Ph.D., chief of the Cognitive Neuroscience Section at the National Institute of Neurological Disorders and Stroke, the medial PFC develops relatively early in childhood, while the lateral PFC may not mature fully until young adulthood. In line with the general rule that areas of the brain that develop latest in life also tend to decline first, the side areas of the PFC typically begin to decline before the middle.

As a result, Grafman says, “the knowledge that we acquire early in life tends to be stored throughout life. As we age, we develop a history of life experiences, and we see the end of processes as well as the beginnings.” In old age, continued access to this wealth of information that began accumulating in our medial prefrontal cortex in childhood affords us advantages in understanding situations and in reacting appropriately.

Think Positive

A positive outlook on life is one of the most important things we can do to keep our brain healthy and ready for learning. How we view ourselves, how we perceive the world around us, and how we interact with others can have profound effects on our overall well-being and on our brain. Best of all, these are things that are completely within our control. No matter what challenges we face, we can choose to start each day by looking at the glass as half full, rather than half empty.

Feeling good about ourselves and having a sense of self-worth and effectiveness in our life—attributes scientists sometimes call “self-efficacy”—are pillars of successful aging, according to the results of large studies that have chronicled lifestyle factors of people who stay mentally sharp into old age. Marilyn Albert, Ph.D., a Dana Alliance member and neuroscientist at Johns Hopkins University who led one of the first and most important of these studies, says self-efficacy entails an ability to adapt to life’s challenges, to maintain a degree of control over our life, and to feel as if we are contributing to our families and society.

Social Networks

Maintaining supportive relationships is one important element of effective aging. The more contact we have with others as we age, the better we may be at retaining mental sharpness. There is even evidence that people who engage in social activities such as learning to play a musical instrument or dancing are less likely to develop dementia.



How can we ensure that strong human connections continue to be an integral part of our lives as we age? Aging experts recommend staying involved in religious and community functions, maintaining a network of friends and family with whom we regularly interact, and volunteering in organizations that get us out and among other people. Pursue social activities, such as wine-tastings, traveling with friends, golfing, or taking yoga classes.

“There’s a lot of evidence that other people are the most unpredictable things you can encounter,” says Lawrence Katz. “So activities that have you engaging with other human beings are a fantastic form of brain exercise.”

Managing Stress

Learning to manage stress so that it doesn’t overwhelm us can go a long way toward improving our outlook on life. While acute, short-term stress can actually improve memory, chronic stress takes a toll on the brain.

Exercise and positive social interactions can help us cope with stress, as can proven techniques such as biofeedback, meditation, and relaxation or visual imagery therapies. While no one can remove stress entirely from life, if we recognize our limitations and prioritize our activities to spend time on things that really matter and bring us pleasure, we’ll be taking important steps toward gaining control of our lives.

Besides the noble art of getting things done, there is the noble art of leaving things undone. The wisdom of life consists in the elimination of nonessentials.

—Lin Yutang

Tuning Out The Negative

Tuning into the positive aspects of life may come naturally to older adults, who may perceive their remaining time as limited and therefore want to make the most out of it. A new study by scientists at Stanford University, which used functional magnetic resonance imaging (fMRI) to track patterns of activation in the brain, found that older adults are more responsive to positive images than to negative ones. Compared to younger adults, people aged 70 to 90 showed greater activation in a



brain region that is central to emotional processing (the amygdala) when they looked at pictures of people expressing positive emotions vs. negative ones. Older people, it seems, tend to tune out the negative while focusing on the positive.

This finding demonstrates a neural basis for something psychologists and sociologists have long recognized: older adults experience fewer negative emotions and are less likely to remember negative emotional stimuli than positive stimuli. Stanford psychologist John Gabrieli, Ph.D., a co-author of the report, says this may reflect “a change in what matters to you depending on how old you are and how you see the horizon of your life.” Negative experiences may be seen as a poor investment in the future, prompting a desire to “maximize your positive emotional experiences,” he says. “That’s probably a wise choice of how to allocate your time and effort and attention.”

Engaging Your Brain

The brain's capacity to alter and reorganize itself in response to learning and experience affords a tremendous opportunity to pursue a lifestyle that maximizes "brain power" and keeps the engine of learning revved up as we age. Brain experts are convinced that engaging in "active learning" throughout life will help maintain brain health in our later years.

"The brain wants to learn; it wants to be engaged as a learning machine," says neurobiologist Michael Merzenich, Ph.D., University of California, San Francisco. Merely replaying well-learned skills that you've mastered in life is not enough, he says. "The brain requires active continuous learning. It requires change, and that change requires that you are acquiring new skills and abilities, new hobbies, and activities that require the brain to remodel itself. That's the key."

Katz applies this concept in a program he calls "neurobics," which encourages using your brain in nonroutine ways. He believes that when



we settle into old routines that we repeat almost automatically day to day, the brain activity required for those activities decreases.

"You basically have an eight-cylinder engine running on four cylinders," Katz says. "It's efficient, but it really only utilizes a relatively small percentage of the potential repertoire of pathways in the brain." By approaching established routines in novel ways, he says, "you're activating parts of the brain that you weren't before, and that in turn creates enhanced activity in the brain." Katz believes this may stimulate growth factors that support nerve cells, as well as having other beneficial effects on neural processes.

Think about the route you take to work each day, or to a familiar destination. It becomes so automatic that you do it without even thinking about it. By taking a new route, Katz says, "your brain is forced to use its attention resources to do that very simple task." Finding your keys or picking out coins in a purse by using your sense of touch rather than sight can have the same effect, he says, which is to "focus your brain's attention on what you're doing at the time you're doing it."

Learning to Change Your Brain

Brain scientists are only beginning to understand the degree to which we can influence the state of our brain just by thinking and learning. In the years ahead, brain research will undoubtedly reveal many more surprises about the wondrous mass of synapses and cells encased in our skulls. By putting the good news from neuroscience into practice in our day-to-day lives, each of us can benefit from this knowledge and improve our brain health as we age.

Engaging in active, lifelong learning is essential. What you do today and every day for the rest of your life can make a real difference in keeping the engine of learning tuned up and running smoothly throughout all of your tomorrows. By minding your brain, you can reap the rewards of learning throughout life.

Further Reading

Keep Your Brain Young: The Complete Guide to Physical and Emotional Health and Longevity, by Guy McKhann and Marilyn Albert (John Wiley & Sons, Inc., 2002)

Keep Your Brain Alive: 83 Neurobic Exercises, by Lawrence C. Katz, Manning Rubin, and David Suter (Workman Publishing Company, 1999)

Memory and Emotion: The Making of Lasting Memories, by James L. McGaugh (Columbia University Press, 2003)

Memory: From Mind to Molecules, by Eric R. Kandel and Larry R. Squire (W.H. Freeman & Co., 2000)

The Memory Bible: An Innovative Strategy for Keeping Your Brain Young, by Gary Small (Hyperion Books, 2002)

Memory: Remembering and Forgetting in Everyday Life, by Barry Gordon (Intelligence Amplification, Inc., 2004) Available at Amazon.com

Intelligent Memory, by Barry Gordon and Lisa Berger (Viking, 2003)

Searching for Memory: The Brain, The Mind, and The Past, by Daniel I. Schacter (Basic Books, 1996)

You Learn by Living: Eleven Keys for a More Fulfilling Life, by Eleanor Roosevelt (Westminster John Knox Press, 1960)

Resources

AARP

888-OUR-AARP (888-687-2277) toll-free
www.aarp.org

Alliance for Aging Research

202-293-2856
202-785-8574 fax
www.agingresearch.org

Alzheimer's Association

800-272-3900
312-335-1110 fax
www.alz.org

Alzheimer's Disease Education and Referral Center

800-438-4380
301-495-3334 fax
www.alzheimers.org

National Council on Aging

202-479-1200
202-479-0735 fax
www.ncoa.org

National Institute on Aging

301-496-1752
www.nia.nih.gov

National Sleep Foundation

202-347-3471
202-347-3472 fax
www.sleepfoundation.org

The Dana Foundation

www.dana.org

Special thanks to the following scientists for their insight for this booklet:

- Carl W. Cotman, Ph.D., *University of California, Irvine**
- John Gabrieli, Ph.D., *Stanford University*
- Fred H. Gage, Ph.D., *The Salk Institute for Biological Studies**
- Paul E. Gold, Ph.D., *University of Illinois at Urbana-Champaign*
- Jordan Grafman, Ph.D., *National Institute of Neurological Disorders and Stroke**
- William T. Greenough, Ph.D., *University of Illinois at Urbana-Champaign**
- Eric R. Kandel, M.D., *Columbia University College of Physicians and Surgeons**
- Lawrence C. Katz, Ph.D., *Duke University Medical Center**
- Robert Katzman, M.D., *University of California, San Diego**
- Claudia H. Kawas, M.D., *University of California, Irvine**
- Arthur F. Kramer, Ph.D., *University of Illinois at Urbana-Champaign*
- James L. McGaugh, Ph.D., *University of California, Irvine**
- Guy M. McKhann, M.D., *Johns Hopkins University**
- Michael M. Merzenich, Ph.D., *University of California, San Francisco*
- David P. Salmon, Ph.D., *University of California, San Diego*
- Larry R. Squire, Ph.D., *University of California, San Diego**

**Members of The Dana Alliance for Brain Initiatives*

NRTA: AARP's Educator Community

601 E Street, NW
Washington, DC 20049
202-434-2380
202-434-6457 fax
www.aarp.org/nrta

Director

Annette Norsman

National Coordinator

Megan Hookey

Membership Manager

Michael C. Patterson

Senior Legislative Representative

Nancy H. Aronson

Field Consultants

Bill Latham
Sharon Smith

Community Service Consultant

Rebecca Villarreal

Program Assistant

Genaro (Gene) Ruiz

Executive Secretary

LaDonna Johnson

Editor: Brenda Patoine
Project Manager: Laura Reynolds
Design: AARP Brand Management

Images

Alamy Images; page 1
The News Office, Dana Foundation, November 2000; page 3, 4
Maureen Keating; page 5
Paul Fetters; page 17, 21
Chamberlain Photography; page 19

The Dana Alliance for Brain Initiatives

Chairman

William Safire

President

Edward F. Rover

Vice Chairmen

Eric R. Kandel, M.D.
James D. Watson, Ph.D.

Executive Committee

Marilyn S. Albert, Ph.D.
Nancy C. Andreasen, M.D., Ph.D.
Colin Blakemore, Ph.D., Sc.D., F.R.S.
Floyd E. Bloom, M.D.
Dennis Choi, M.D., Ph.D.
Leon N. Cooper, Ph.D.
Joseph T. Coyle, M.D.
Fred H. Gage, Ph.D.
Zach W. Hall, Ph.D.
Kay Redfield Jamison, Ph.D.
Joseph B. Martin, M.D., Ph.D.
Guy M. McKhann, M.D.
Herbert Pardes, M.D.
Steven M. Paul, M.D.
Fred Plum, M.D.
Carla Shatz, Ph.D.

Executive Director

Barbara E. Gill

745 Fifth Avenue, Suite 900
New York, NY 10151
212-223-4040
212-593-7623 fax
E-mail: dabiinfo@dana.org
Web site: www.dana.org