A HARVARD MEDICAL SCHOOL
SPECIAL HEALTH REPORT

A Guide to Cognitive Fitness

6 steps to optimizing brain function and improving brain health

PRICE: $29

Harvard Health Publications
HARVARD MEDICAL SCHOOL
Trusted advice for a healthier life

Copyright Notice

Here's what you **CAN** do

- Print out one copy and route this "original" to family.
- You are permitted to have one copy of this publication on your computer at any time (you can't put it on a network unless you purchased a license to do so). If you have paid for more copies, then you may have that many copies on computers at any time.
- Copy, on an occasional basis, a couple of pages to give to friends, family members, or colleagues.
- We are registered with the Copyright Clearance Center (CCC). You can comply with the copyright laws by paying a royalty on copies you make of passages. But not even the CCC can authorize cover-to-cover photocopying or wholesale electronic forwarding.
- If you want to distribute copies of this publication, either in print or electronic form, to others on a regular basis, ask us about bulk discounts or licensing opportunities. You may be able to negotiate an agreement, for a single fee, that would enable you to legally distribute photocopies or electronic copies to others.

Here's what you **CAN'T** do (without prior permission)

- Make or forward email copies of an entire publication. The law provides for a very limited amount of copying, commonly referred to as "fair use." However, cover-to-cover photocopying is forbidden.
- Electronic transmission of a copyrighted work is the legal equivalent of photocopying it (and so is posting it on the Internet or in an electronic database), and is therefore not allowed.
- Routinely copy and distribute portions.
- Republish or repackage the contents.

Some publishers must resort to lawsuits to protect their publications. Harvard Health Publications would like to eliminate the need for such suits by helping to educate customers. We hope this outline has helped explain what is legal and what is not.

For more information

Permissions Requests
Harvard Health Publications
www.health.harvard.edu/permissions

For Licensing, Bulk Rates, or Corporate Sales
HHP_licensing@hms.harvard.edu, or visit us at www.content.health.harvard.edu

Harvard Health Publications
Harvard Institutes of Medicine, 4th Floor
4 Blackfan Circle
Boston, MA 02115
www.health.harvard.edu

A GUIDE TO COGNITIVE FITNESS
SPECIAL HEALTH REPORT

Medical Editor
Alvaro Pascual-Leone, MD, PhD
Professor of Neurology, Harvard Medical School
Chief for the Division of Cognitive Neurology and Director of the Berenson-Allen Center for Noninvasive Brain Stimulation, Beth Israel Deaconess Medical Center

Executive Editor
Anne Underwood

Writer
Stephanie Watson

Copy Editor
Robin Netherton

Creative Director
Judi Crouse

Production/Design Manager
Susan Dellenbaugh

Illustrators
Scott Leighton, Matthew Holt

Published by Harvard Medical School
Gregory D. Curfman, MD, Editor in Chief
Urmila R. Parlikar, Senior Content Editor

IN ASSOCIATION WITH

Belvoir

Belvoir Media Group, LLC, 535 Connecticut Avenue, Norwalk, CT 06854-1713. Robert Englander, Chairman and CEO; Timothy H. Cole, Executive Vice President, Editorial Director; Philip L. Penny, Chief Operating Officer; Greg King, Executive Vice President, Marketing Director; Ron Goldberg, Chief Financial Officer; Tom Canfield, Vice President, Circulation.

Website
For the latest information and most up-to-date publication list, visit us online at www.health.harvard.edu.

Customer Service
For all subscription questions or problems (rates, subscribing, address changes, billing problems), email HarvardProd@StrategicFulfillment.com, call 877-649-9457 (toll-free), or write to Harvard Health Publications, P.O. Box 9308, Big Sandy, TX 75755-9308.

Ordering Special Health Reports
Harvard Medical School publishes Special Health Reports on a wide range of topics. To order copies of this or other reports, please see the instructions at the back of this report, or go to our website: www.health.harvard.edu.

For Licensing, Bulk Rates, or Corporate Sales:
email HHP_licensing@hms.harvard.edu,
or visit www.content.health.harvard.edu.

ISBN 978-1-61401-129-3

Contents

Cover Image: © Stockbyte | Thinkstock

Harvard Health Publications
HARVARD MEDICAL SCHOOL
Trusted advice for a healthier life

Dear Reader,

We are living longer than ever before. Human life expectancy has grown spectacularly over the past few decades, thanks to advances in public health and medicine. With maturity comes a wealth of experience and knowledge. Yet age also brings an increasing risk for major medical conditions. Brain problems are a particular concern as we grow older. According to the World Health Organization, Alzheimer's and other brain diseases will affect one out of every five people at some point in life, and these conditions are the main cause of lifelong disability worldwide.

The good news is that declining brain health and cognitive loss are not inevitable. Drawing on decades of research, this report highlights six pillars of brain health that can help you sustain good brain function and cognitive fitness (the ability to learn, reason, remember, and adapt your thinking processes) into old age.

Maintaining cognitive fitness requires far more than a simple "train your brain" program or diet, as some quick-fix online programs suggest. Research confirms that retaining mental sharpness requires certain lifestyle interventions, working in concert—specifically, adjusting what and how you eat, how much you exercise, how you deal with life's challenges, and how you interact with others. If you turn these behaviors into habits that you can sustain over the long term, that will have dramatic effects not only on your cognitive fitness, but also on your overall health.

The earlier you start, the better. Evidence suggests that the more cognitively fit you are throughout your life, the better armed your brain will be against the assaults of aging—including illness and any stressful events you might face. You may even be able to prevent certain brain problems from occurring in the first place, rather than having to combat them when they arise.

Good brain health is more than the absence of disease. It's optimizing your brain function as you age. In the process, you not only lower your risk for age-related cognitive decline and brain diseases, but also improve your overall health and well-being.

Sincerely,

Alvaro Pascual-Leone, M.D., Ph.D.
Medical Editor

Cognitive fitness: Your No. 1 health goal

In January 2016, just a week before her 94th birthday, actress Betty White made an appearance on the CBS talk show "The Late Late Show with James Cordon." When Cordon asked how White planned to spend her birthday, she joked that she was going to celebrate it with Robert Redford. "He doesn't know that, and I think he's out of the country," she quipped, as Cordon chuckled.

White has often been asked the secret to her enduring quick wit and youthful intellect. She attributes her cognitive longevity to the fact that she's stayed mentally and physically active over the years. White still makes regular TV appearances, which keeps her socially connected, and she says she's obsessed with doing crossword puzzles.

Many of us know someone like Betty White who has managed to maintain his or her mental faculties well into the golden years. And we aspire to be as with-it when we reach the same age. As we contemplate growing older, the goal isn't simply to reach our 80s or 90s, but to remain mentally sharp throughout the aging process. The question is how to do that.

This report centers on six pillars, or cornerstones, of cognitive fitness. Each one involves taking certain steps to change your lifestyle—not just by working crosswords, but by staying involved, nourishing your social networks, dealing with stress, getting enough sleep, and, as Betty White says, staying mentally and physically active. Though it may not be obvious, a healthy diet and exercise are also part of the equation. As doctors often say, "What's good for the heart is good for the brain," since the brain depends on vital supplies of oxygen and nutrients that are delivered through the bloodstream. In short, you cannot achieve optimal brain health without doing everything possible to optimize your general health. However, the opposite is also true—a healthy brain is important for a healthy body. So, if you focus on keeping your brain healthy, your general health will inevitably improve. That's why we call cognitive fitness your No. 1 health goal.

© Digital Vision | Thinkstock

Working crossword puzzles helps with word recall, when you want to remember the name of a flightless Australian bird, for example. But cognitive fitness includes many more mental skills than that.

It's never too soon to start working on cognitive fitness. Ideally, you should get started as early in life as possible. Research shows, for example, that the more physically active you are in childhood and adolescence, the more fit your brain will be in middle age and beyond. But if you've slacked off over the years, that's no cause for despair. Regardless of your age, health, or current level of cognitive fitness, our program can help strengthen your intellectual prowess and protect against any further decline.

Before we start, one caveat is in order: Because the demands of life change with age, your brain changes accordingly over the course of your life span. You would not expect the brain of a healthy 70-year-old to be the same as that of a healthy 17-year-old—and this program won't give you the brain of a 20-year-old again. But it *will* help you attain the best brain performance possible for you at your stage of life, whatever that may be.

There's no better time to begin than right now.

Table 1: Cognitive abilities and what they enable you to do	
COGNITIVE ABILITY	**ASSOCIATED SKILLS**
Perception	Recognizing and interpreting sensory stimuli (smell, touch, hearing, etc.).
Attention	Sustaining concentration on a particular object, action, or thought; managing competing demands in your environment.
Memory	Holding information over the short term while performing a task (working memory); registering new information and storing it for future use (encoding and consolidation); accessing information from storage when needed (retrieval).
Motor skills	Mobilizing your muscles and body; manipulating objects.
Language	Translating sounds into words; generating verbal output.
Visual and spatial processing	Processing incoming visual stimuli; understanding spatial relationships between objects; visualizing images and scenarios.
Executive functions	Carrying out goal-oriented behaviors, such as making a plan and executing it. Executive functions include the following: • flexibility—the capacity to quickly switch to the appropriate mental mode • theory of mind—insight into other people's inner world (their plans, likes, and dislikes) • anticipation—prediction based on pattern recognition • problem solving—defining a problem in the right way to generate possible solutions and pick the right one • decision making—the ability to make decisions based on problem solving, incomplete information, and emotions (your own and others') • emotional self-regulation—the ability to identify and manage your emotions for good performance • sequencing—the ability to break down complex actions into manageable units and prioritize them • cognitive control and response inhibition—the ability to withstand distraction and internal urges.

What is cognitive fitness?

You probably have a general idea of what cognitive fitness means, or you wouldn't have picked up this report. The word "cognitive" relates to thought processes, and "fitness" means just what it says. But you may be surprised to learn just how many skills are included. Obviously, memory is a key component, but cognitive fitness also encompasses a variety of brain-based skills, such as reasoning, learning, problem solving, perceiving the world around you, processing what you see and hear, communicating, and making sound decisions. It includes the ability to focus attention, comprehend new information, use language effectively, interact with others, control impulses, weigh options, and formulate and pursue plans.

These brain-based skills, or cognitive abilities, help you carry out any task, from the simplest to the most complex (see Table 1, above). The skill set required is often much more complex than you would imagine. For example, the simple act of answering the door involves much more than hearing the doorbell and opening the door. It involves a surprising number of cognitive skills, including these:

- perception (hearing the ring)
- memory (remembering that the sound is your doorbell)
- inference making (knowing that someone is at your door and wants to see you)
- decision making (deciding whether or not to open the door)
- visuospatial memory (remembering where the door is)
- orientation (navigating your house to get to the door)
- motor skills (getting up, walking to the door, and unlocking it)
- facial memory (recognizing your neighbor)
- language skills (greeting, talking, and understanding language)
- social skills (interpreting tone of voice and interacting properly with another human being).

Specific parts of your brain, working together, support each one of these cognitive abilities. This means that optimizing cognitive function involves much more than simply boosting those parts of the brain that are involved in memory formation and retrieval. For optimal cognitive fitness, all of your brain needs to be working at its peak—a concept known as brain health.

Your brain is a busy and important organ, and your body devotes an inordinate amount of resources and energy (primarily in the forms of sugar and oxygen) to keep it working. Even though the brain represents only about 2% of the body's weight, it consumes more than 20% of its total energy. Other organs, like the kidneys or liver, will shut down entirely before your body compromises brain function.

In addition to cognitive tasks, your brain also performs many essential functions that do not fall under the category of conscious thought. It monitors your "internal world"—the working of your organs—and warns you when things are malfunctioning—for example, by sending out signals that you may perceive as pain. Your brain regulates your body temperature, heart and breathing rates, sleep and wake cycles, and even the moisture and color of your skin by influencing the function of sweat glands and the state of blood vessels. Though these functions are not considered part of cognitive (thinking) health, they are very much a part of brain health in general, and the steps in this program improve brain health across the board, so that your brain can optimally fulfill the demands of your life, minimize the impact of brain disease, and maintain or restore function in the face of challenges.

Cognitive reserve enables the brain to find alternate ways of carrying out many functions. You build cognitive reserve through a lifetime of education, challenging work, and mental stimulation.

What is cognitive reserve?

There is one more concept that is crucial to the understanding of cognitive health, and that is cognitive reserve. You can think of cognitive reserve as your brain's ability to improvise and find alternate ways of getting a job done. Just like a powerful car that enables you to engage another gear and suddenly accelerate to avoid an obstacle, your brain can change the way it operates and thus make added resources available to cope with challenges and everyday tasks. Cognitive reserve is developed by a lifetime of education, challenging work, mental stimulation, and activities that challenge your brain. It helps your brain to cope better with any failures or declines it faces.

Scientists developed the concept of cognitive reserve in the late 1980s, when they found individuals with no apparent symptoms of dementia who were nonetheless revealed at autopsy to have brain changes consistent with advanced Alzheimer's disease. These individuals did not show symptoms of the disease while they were alive because they had a large enough cognitive reserve to offset the damage and continue to function as usual.

Since then, research has shown that people with greater cognitive reserve are better able to stave off the degenerative brain changes associated with dementia or other brain diseases, such as Parkinson's disease, multiple sclerosis, or a stroke. A more robust cognitive reserve can also help you function better for longer if you're exposed to unexpected life events, such as stress, surgery, or toxins in the environment. Such circumstances demand extra effort from your brain—similar to requiring that car to engage another gear. When the brain cannot cope, you can become confused, develop delirium, or show signs of disease. Therefore, an important goal is to build and sustain your cognitive reserve.

The program outlined in this report will help you boost your cognitive reserve at the same time you are improving your cognitive fitness.

How to test your cognitive fitness

Any program that promises to help you achieve a health goal, whether mental or physical, should start out with a baseline—an initial assessment of your fitness level. Testing your cognitive fitness can give you insight into your current state of brain health and help you identify areas that need improvement. You can then compare future test results against this baseline measurement to see how you're progressing and determine whether you've gained, maintained, or lost cognitive ability with age.

Cognitive fitness tests include measures of your performance in certain tasks: for example, remembering a list of words to assess your verbal memory, responding as quickly as possible every time a given letter is presented on a computer screen to assess your response time and sustained attention, or copying a complex figure to assess your visuospatial abilities. Of course, you can improve your performance on individual tests like these by practicing those specific tests, but this will only make you a good test taker—it won't improve the cognitive skills that might benefit you in everyday life. The goal of the evaluation is to identify which of your cognitive abilities need training, and then prescribe exercises that are different from those tested in the evaluation, but that target the same cognitive skill.

When it comes to testing, you have several options, which range from free Web-based tests you take on your own to more in-depth neuropsychological panels from your doctor. Which option you choose depends on how individualized you want your results to be. A full neuropsychological evaluation has the advantage of being tailored to your level of education and knowledge. You'll get a more precise assessment that can identify areas warranting further testing. More importantly, a good cognitive evaluation does not simply identify difficulties but also includes constructive feedback and recommendations to help you understand, cope with, and ultimately overcome deficits. This is part of what a neuropsychologist would offer.

Neuropsychological evaluation

A neuropsychological evaluation offers your doctor a glimpse inside your brain, revealing how well it is functioning with regard to different aspects of cognition and determining how illness, aging, or injury has affected its function. During this evaluation, which is typically administered by a psychologist or neuropsychologist, you'll go through a battery of tasks and tests to assess mental functions such as problem solving, planning and organization, memory, motor skills, attention, and learning ability. The cost of a complete neuropsychological evaluation can range from $2,000 to $4,000, but it generally is covered all or in part by insurance. In some cases, a neuropsychological exam may be part of a structured brain fitness program (see the box above).

The neuropsychologist will score the results and provide you with feedback. Part of the feedback will include recommendations on how to address weak areas and overcome problems. Your results can give you insight into any functional changes that have already occurred and guide your cognitive fitness program to ensure that you achieve the maximum benefit.

Brain fitness assessments

If you're interested in testing your cognitive fitness on your own, you have a few options. You can try one of the many self-administered tests that are available online. These tests provide a quick and easy way for you to get a general idea of your current cognitive status and identify possible concerns that warrant further evaluation. However, it's important to note that not all online assessments are equally accurate.

Structured brain fitness programs

Several hospitals around the country, including Harvard-affiliated Beth Israel Deaconess Medical Center, provide neuropsychological evaluation as part of a structured cognitive fitness program. The program at Beth Israel Deaconess (founded by Dr. Alvaro Pascual-Leone, the medical editor of this report) is called the Brain Fit Club. Club members start with a thorough evaluation, which includes a battery of cognitive tests, sophisticated imaging scans to assess brain health, gait and balance assessments, a general physical and neurological exam, and nutritional evaluations. That assessment is then used to create a highly customized and individualized brain fitness program.

Call or check the websites of hospitals and clinics in your area to find out if they offer their own brain fitness programs. The "Resources" section of this report (see page 50) lists some examples.

Estimate your cognitive reserve

A number of researchers have developed questionnaires that aim to measure the amount of cognitive reserve amassed throughout a person's lifetime. Researchers at the University of Padova in Italy have developed one called the Cognitive Reserve Index questionnaire (http://cri.psy.unipd.it). This questionnaire captures factors that have been shown in studies to build cognitive reserve—including education, work, and leisure activities, both past and present. Although it doesn't replace an evaluation from a neuropsychologist or brain fitness program, it can give you a general idea of how much cognitive reserve you have and tell you whether you need to stockpile additional stores.

Assign yourself points in each of these areas:

Education

Years of formal education (count 1 point for each year you completed, including elementary, secondary, college, graduate, and postgraduate work) _____ points

Training classes (count 0.5 points for each six-month period of classes) _____ points

Work

Each of the numbered levels below corresponds to a different degree of intellectual involvement. Count the number of years you worked in each type of position; round up the number of years by fives; then multiply the number of years of each type of work by the cognitive level of the work from 1 to 5, in the order they are listed.

1. Low-skilled manual work (farm work, gardener, housekeeper, caregiver, waiter, driver, mechanic, plumber, call center operator, babysitter, etc.) _____ years × 1 = _____
2. Skilled manual work (craftsman, cook, store clerk, tailor, hair stylist, etc.) _____ years × 2 = _____
3. Skilled non-manual work (business owner, white-collar employee, real estate agent, nursery school teacher, etc.) _____ years × 3 = _____
4. Professional occupation (managing director of a small company, lawyer, freelance professional, doctor, teacher, engineer, etc.) _____ years × 4 = _____
5. Highly responsible or intellectual occupation (managing director of a big company, senior manager, judge, university professor, surgeon, politician, etc.) _____ years × 5 = _____

Leisure

These refer to activities you've done regularly throughout your adult life (age 18 to the present). Count the number of activities for which your frequency of engagement would be "often" or "always." Round up the number of years by five—for example, round up 27 years to 30.

Activities with weekly frequency

Only count the number of years in which you did these activities three or more times per week.

1. Reading newspapers and magazines _____ years
2. Domestic chores (cooking, washing, grocery shopping) _____ years
3. Driving _____ years
4. Unpaid leisure activities (sports, hunting, dancing, chess, coin collecting, etc.) _____ years
5. Using new technologies (digital cameras, computer, Internet, etc.) _____ years

Activities with monthly frequency

Only count the number of years in which you did these activities three or more times per month.

1. Social activities (political parties, recreational clubs, associations, etc.) _____ years
2. Movies, theater _____ years
3. Small home repair and maintenance operations _____ years
4. Caring for grandchildren, nieces/nephews, or elderly parents _____ years
5. Volunteer work _____ years
6. Artistic activities (music, singing, performance, painting, writing, etc.) _____ years

Activities with annual frequency

Only count the number of years in which you did these activities three or more times per year.

1. Exhibitions, concerts, conferences _____ years
2. Trips lasting several days _____ years
3. Reading books _____ years

Activities with fixed frequency

1. Children _____ number
2. Pet care _____ years
3. Managing money day-to-day _____ years

TOTALS

Education _____

Work _____

Leisure _____

Overall total _____

RESULTS	COGNITIVE RESERVE
Less than 70	Low
70–84	Medium-low
85–114	Medium
115–130	Medium-high
130 or higher	High

Adapted from Nucci M, Mapelli D, and Mondini S. "Cognitive Reserve Index questionnaire (CRIq): A new instrument for measuring cognitive reserve," Aging Clinical and Experimental Research *(June 2012), Vol. 24, No. 3, pp. 218–26.*

Look for a program that has been validated by scientific research, such as Test My Brain. The Test My Brain website (www.testmybrain.org) offers a number of brain tests that measure attention, focus, puzzle-solving abilities, and other capacities. Each test takes five to 20 minutes to complete. Once you've finished a test, you'll get your results, along with an explanation of what they mean. Your results will not only give you a sense of your own cognitive fitness, but will also let you compare them with the results of other test-takers.

You can also try the Synthetic Aperture Personality Assessment (https://sapa-project.org), another research-oriented online quiz. This 15-minute free test will provide you with a report of your cognitive abilities along with other personality measures such as temperament (for example, whether you're an extrovert or introvert, and how emotionally stable and agreeable you are).

AARP also offers a brain assessment, called Staying Sharp (https://stayingsharp.aarp.org). To join and get personalized recommendations, you'll have to pay a $36 annual fee. However, Staying Sharp not only offers a brain assessment, but also rich and valuable information anchored on scientific evidence, as well as guidance specifically for you.

All of these approaches capture how your brain performs various cognitive tasks, but they don't assess how hard your brain has to work in order to perform that way. It's like measuring a car's speed without knowing the amount of pressure on the gas pedal, how many revolutions the motor generates, or how much gasoline it consumes. Ideally, brain fitness assessments should include measures that capture how hard your brain needs to work to perform cognitive tasks. This is what structured brain and cognitive fitness programs aim to provide. A thorough assessment requires not only a neuropsychological evaluation, but also brain imaging and brain physiology studies to capture how your brain is working, as well as general physical and neurological exams, sometimes with additional laboratory tests.

In addition, it is possible to estimate your cognitive reserve using a home-based test (see "Estimate your cognitive reserve," page 6).

Six steps to cognitive health

So how do you keep your brain healthy, stay cognitively fit, and build your cognitive reserve? It's easier for some people than for others. And though genetics set the stage for your brain health, everyone can do something to improve cognitive fitness.

First it is important to remember that you need a healthy body to have a healthy brain. Therefore, ensuring your brain health depends upon regularly seeing your doctor, following her or his recommendations, and managing any health conditions you have (see "Medical conditions that affect the brain," page 15).

The heart of our cognitive fitness program, however, involves lifestyle changes. Researchers at Harvard Medical School have identified six cornerstones to any effective brain health and cognitive fitness program. Though we refer to them as "steps," they should all be done together rather than sequentially:

Step 1: Eat a plant-based diet.

Step 2: Exercise regularly.

Step 3: Get enough sleep.

Step 4: Manage your stress.

Step 5: Nurture social contacts.

Step 6: Continue to challenge your brain.

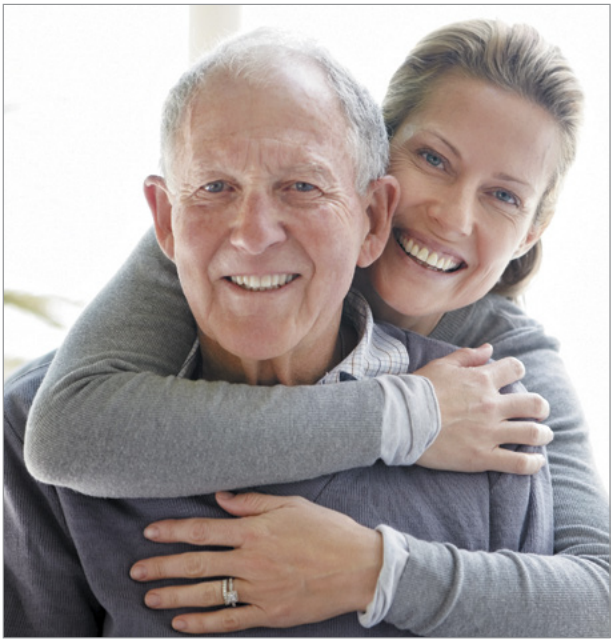
Together, these can yield real results, leading to changes in both your brain's structure and function. But the key word is "together." These factors are equal parts of a cohesive plan—they don't work in isolation. Simply eating more fiber or adding a morning walk to your routine isn't enough to forestall mental decline. Instead, exercise, diet, sleep, stress management, social interaction, and mental stimulation work in concert to yield results.

In this report, we'll show you how to make changes in all of these areas so you can start improving your brain health and cognitive fitness today.

How cognitive function is shaped over a lifetime

Cognition—the ability to think, learn, understand, and remember—stems from the brain. Without the sophisticated network made up of billions of neural connections, you wouldn't be able to read a book, have a conversation, solve a crossword puzzle, talk to friends, drive a car, or do any of the hundreds of tasks that make up your days.

To accomplish all these tasks, the brain must be adaptable. Brain cells known as neurons (a term referring to the type of cell that makes up nerve tissue) are highly specialized, but they are engaged in very flexible and continuously changing networks. Today we know that our brains do, in fact, produce new neurons throughout our lives. However, the brain's capacity to make new cells is much lower than the capacity of other organs—for example, our skin or stomach—to make new cells.



Brain health means different things at different ages. The brain of a healthy 70-year-old is not the same as the brain of a healthy 40-year-old. But that's not necessarily a bad thing.

Although your brain does not regularly replace cells, it is continuously reshaping the connections between cells. Literally thousands of new connections are made—and unused connections are cleared—every fraction of a second. Scientists refer to this ongoing reorganization as brain plasticity. It is an intrinsic property of the brain, and it indicates the nervous system's capacity to be molded by environmental stimuli, physical changes, and experiences. Plasticity plays a fundamental role not only in the brain's ability to learn but also in its response to stress and injury.

However, it is important to realize that not all plasticity is beneficial. Plasticity explains how we learn new information and acquire new skills, and how we can recover from a brain injury. Yet it is also behind symptoms of brain illnesses, like chronic pain or stiff, spastic muscles. The challenge is to guide plasticity, controlling changes that may cause problems, while enhancing those that result in a behavioral benefit.

Researchers now know that, while the nervous system remains plastic throughout life, the efficacy of plasticity mechanisms changes throughout your lifetime. Therefore, assessing these mechanisms and maintaining a plastic brain over the life span are important. Scientists believe that you can sustain your brain's plastic capacity by engaging in activities—like exercise or cognitive tasks—that challenge your brain.

Your brain: A complex organ

To understand how cognitive function works and how it changes over the course of a lifetime, you need to first be familiar with the various parts of the brain and how they interact to help you think, remember, and undertake every other daily activity.

Here's a brief primer.

The cerebrum makes up the largest part of your brain. Its outer surface, called the *cerebral cortex*, is pitted and grooved with wrinkles, which help maximize its surface area and therefore the number of neurons it has available to process information. This part of the

brain is where all higher mental functions—including thinking, planning, reasoning, and understanding language—take shape.

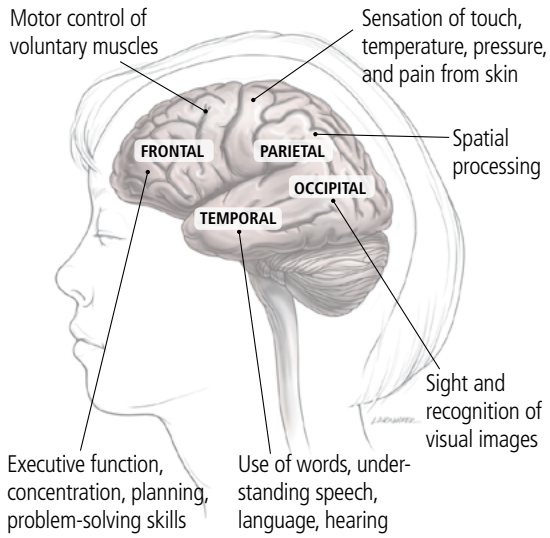
The cerebrum is divided into two sections called hemispheres, which are connected by—and communicate via—a bundle of nerve fibers called the corpus callosum. The cerebrum is further divided into four sections, called lobes (see Figure 1, below right):

- The *frontal lobe* is the center of higher cognitive skills such as thinking, planning, organizing, and problem solving. You might use your frontal lobe when preparing for a big presentation you're giving at a conference, as you decide which topics to include and which to omit. If, in the midst of delivering that presentation, you suddenly feel the urge to cry or say something inappropriate, it's your frontal lobe that helps you control the impulse. The frontal lobe also controls the voluntary muscles, which enable you to move.
- The *parietal lobe* processes sensory information, keeps you oriented, and helps you recognize language. This part of your brain helps you navigate your way to the podium to deliver your presentation and allows you to make sense of the notes you've prepared.
- The *occipital lobe* enables you to make sense of the visual information your eyes take in, including shape, color, movement, etc. With the help of your occipital lobe, you can clearly recognize that the person in the suit sitting in the front row of the audience is your manager.
- The *temporal lobe* processes auditory information—the sounds coming in through your ears. It enables you to understand and respond to questions from the audience during the Q&A portion of your presentation. The temporal lobe also includes highly specialized structures that are crucial to forming and retrieving memories.

The limbic system is the brain's emotional center of operations. It is located deep inside the temporal lobe and contains four structures that control basic emotions as well as human drives such as hunger, anger, and sexual desire.

- The *amygdala* regulates your emotional response to stimuli around you. If one of the conference attendees were to suddenly jump up and yell at you during your presentation, your amygdala would process the image of the angry audience member and produce feelings of fear. Your amygdala also tags memories as being emotionally important, so you're more likely to retain them. When you remember the angry audience member incident a few days or weeks later, your amygdala will call up the feeling of fear that was associated with that memory.
- The *hippocampus* is the part of your brain where information gets coded into memories. When you're introduced to a woman at the cocktail party following your presentation, the hippocampus consolidates all the different aspects of your meeting (the woman's face, the dress she was wearing, the way she said your name) from the various parts of your brain into one memory. If you were paying attention and were interested enough during your meeting, the connections between brain cells will strengthen over time to solidify the encounter into your long-term memory so you can remember it when you meet the same woman a few months later.
- The *thalamus* takes in sensory information from your eyes, ears, taste buds, and skin (and, to some extent, your nose), to help you understand and reg-

Figure 1: Lobes of the brain



The cerebrum is divided into four sections, or lobes. Different parts of the brain specialize in different functions. Also shown in this diagram, but not labeled, is the cerebellum (below the cerebrum).

ister all the different feelings you're experiencing at a given time. Thanks to the thalamus (together with sensory areas of the cerebral cortex), you realize that the woman you've met and are shaking hands with has warm, soft palms, and that an hors d'oeuvre you've been served is too salty. The thalamus also plays an important role in modulating the motor and cognitive functions of the cortex.

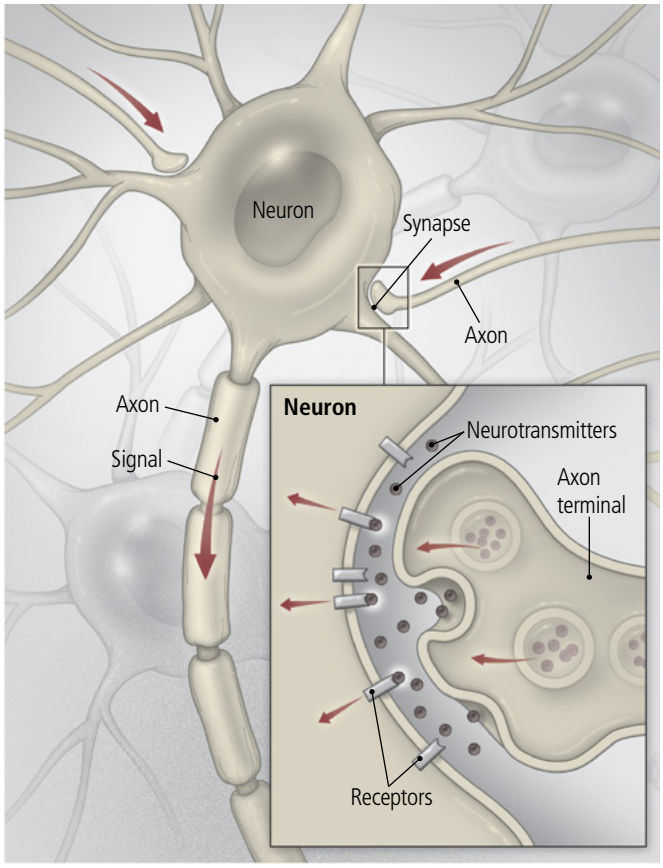
- The *hypothalamus* regulates your body's essential functions. It controls your body temperature, regulates hunger and thirst, mediates emotional responses, and oversees the release of hormones from the pituitary gland.

The basal ganglia are clusters of interconnected neurons found deep inside the cerebrum. They process information on movement and signal your muscles to respond appropriately. For example, if during your cocktail party you noticed a tray of drinks tipping in your direction, your basal ganglia would enable you to jump out of the way.

The cerebellum is sometimes referred to as the "little brain." Like the cerebrum, it is made up of two hemispheres and has a wrinkled surface. The cerebellum collects and interprets sensory information from your eyes, ears, and muscles to coordinate your movements. It is the cerebellum that enables you to remain upright as you walk from the podium back to your seat. The cerebellum also helps you pair motor and sensory information; for example, to execute purposeful movements, such as writing. However, the cerebellum is also critical to nonmotor capacities of the brain, including thinking, planning, learning, and feeling emotions.

The brainstem is a small but essential region at the base of your brain. It helps regulate most of the functions you need to stay alive, including your breathing, blood pressure, and temperature. The brainstem also contains the neurons necessary for waking and regulating sleep. In addition, nerve connections from both the motor and sensory systems pass through the brainstem. This area is also where most of the chemicals called neurotransmitters (for example, serotonin, dopamine, and noradrenaline) for the entire brain originate. These substances control the passage of signals from one neuron to another. Damage to the brainstem can rob the brain of key substances, damping down initiative, motivation, and interest.

Figure 2: A wide web of connections



A vast network of interconnecting neurons (brain cells) delivers messages along neural pathways, primarily in the cerebral cortex, the large, domed outer layer of the brain. Neurons communicate from one to another across spaces called synapses, by way of chemical substances known as neurotransmitters. These neurotransmitters activate the receptors on the neighboring cell.

Getting the message across

The brain is made up of over 100 billion neurons—as many neurons as there are stars in the Milky Way. Each of these neurons makes thousands of connections with other neurons all around the brain. The neurons also send projections called *axons* down the spinal cord and along cranial and spinal nerves to reach all of your organs and body parts. Neurons are therefore linked into high-speed, highly sophisticated networks. These networks generate and transmit the messages that help

you interpret and respond to the world around you.

For example, if a server at the cocktail party were to bump into you and drop a tray of hot mini-quiches onto your arm, nerve endings in your skin would immediately transmit a message to your brain. Even before that part of your brain had made other parts aware that you were in pain, your arm would have moved aside, and you would be jumping away from the offending hors d'oeuvres and getting ready to yell "Ouch!" Other brain regions would be getting the message and preparing a verbal response to the server that you are okay, that accidents happen, but to be more careful. Transmission of that information from neuron to neuron also helps your brain store the memory of that painful incident.

Neurons relay information within the brain and body through a combination of electric and chemical pulses. Information in the form of electric signals travels out of a cell along the axons and is drawn into the cell via other projections called *dendrites*, which also branch off the main body of the cell. For a signal to pass from the axon of one neuron to the dendrite or body of another neuron, complicated machinery inside the cell releases chemicals called neurotransmitters, which bridge the gap between the two neurons (called a *synapse*; see Figure 2, page 10). Neurotransmitters activate specialized structures called receptors on the surface of the next neuron and start a new electric signal. In this way, signals move from one neuron, to another, to another, and so on. Each of the brain's estimated 100 billion neurons can connect with anywhere from 1,000 to 10,000 other neurons, forming up to 1,000 trillion possible synaptic connections in total.

Helping in this process are other cells called *glia* (such as Schwann cells and astrocytes), which support neurons by providing them with nutrients, insulating them, and removing debris from neurons that have died. Schwann cells also form the insulating layer called the myelin sheath that surrounds the axon and helps facilitate nerve signal transmission. Millions of axons, densely packed and surrounded by myelin sheaths, form the brain's *white matter*. (By contrast, *gray matter* refers to the other parts of the neurons—neuronal bodies, dendrites, and the ends of the axons, called the terminals—along with glial cells.)

The brain isn't a static structure. It's a complex piece of circuitry that continually evolves over time. Each time you learn something new—such as a foreign language or a tennis serve—and signals travel from one neuron to another again and again, the connection between those neurons strengthens. The next time you speak that language or serve the ball, those same neurons communicate again and the connections become stronger, forming the foundation of memory. With each new experience and memory you create, your brain essentially rewires itself. On the other hand, connections you don't use become weaker with time. There is therefore some truth to the idea of "use it or lose it."

Neurogenesis and plasticity

When you were born, the basic architecture of your brain was already in place. The billions of brain cells that now communicate on a daily basis were created through a process called neurogenesis while you were still in your mother's womb. In fact, you were born with many more brain cells than you currently have.

Still, the often-held belief that you lose brain cells when you get old is not quite true. The majority of your brain cells are lost—or pruned—in the first few years of life. As you learned language and developed other skills in your youth, your brain formed new neural connections rapidly—at a rate of 700 to 1,000 connections per second. Yet it also lost many more connections and brain cells it didn't use. It is as if your genes designed your brain with all of its possible capacities, and then your brain began the moment you were born to trim the cells and connections it didn't need. Therefore, although your genes were responsible for designing the initial, fundamental structure of your brain, environmental factors shaped its function, and plasticity ultimately reworked its structure—and continues to do so.

At one time, scientists believed neurogenesis was a fixed process—that you were born with all the neurons you'd ever have. Once you reached adulthood, those neurons would gradually die off, leaving you with fewer and fewer of them. As a result, your brain would eventually "shrink," and along with it, your capacity to

learn and remember would decline. Then in the late 1990s, Fred "Rusty" Gage and his research team at the Salk Institute for Biological Studies in northern California found evidence of neurogenesis in the hippocampus of human adults.

During the next two decades, researchers solidified the idea that stem cells in the brain could give rise to new neurons throughout a person's life. In a 2013 study published in the journal *Cell*, researchers at the Karolinska Institutet in Sweden were able to track neurogenesis via a type of carbon dating. Through this method, they discovered that 700 new neurons are created in the adult hippocampus every single day. The researchers also found that this process of neurogenesis continues into your 70s and perhaps beyond.

In recent years, scientists have discovered that certain factors can slow or stop the neurogenesis process, while others stimulate it. For example, stress, sleep deprivation, and aging can all impede the formation of new neurons, while aerobic exercise (such as running) can speed up the process.

Not only is neurogenesis possible long into adulthood, but you also have the ability to form new neural connections as you age. These connections change and adapt—rewiring, in a sense—in response to your experiences. One of the ways they rewire themselves is called neuronal sprouting. For example, when parts of the brain are injured by damage or disease, undamaged neurons sprout new nerve endings that connect with other undamaged nerve endings—forming entirely new pathways. When you stimulate your brain—for example, by listening to complex music or learning a new language—you also promote the formation of these new connections.

As noted earlier, the ability to generate new neurons and establish new neural connections as you grow older is referred to as plasticity, or more specifically, as neuroplasticity. Neuroplasticity allows you to continue learning and gaining new skills, well past what you'd consider to be your mental prime. If you encourage brain plasticity by continuing to stay mentally and physically active and constantly learning new things, you can maintain—or even improve—your ability to perform many cognitive functions with age.

How memory and thinking ability change with age

Scientists used to think that brain connections developed at a rapid pace in the first few years of life, until you reached your mental peak in your early 20s. Your cognitive abilities would level off at around middle age, and then start to gradually decline. We now know this is not true. Instead, scientists now see the brain as continuously changing and developing across the entire life span. There is no period in life when the brain and its functions just hold steady. Some cognitive functions become weaker with age, while others actually improve.

Some brain areas, including the hippocampus, shrink in size. The myelin sheath that surrounds and protects nerve fibers wears down, which can slow the speed of communication between neurons. Some of the receptors on the surface of neurons that enable them to communicate with one another may not function as well as they once did. These changes can affect your ability to encode new information into your memory and retrieve information that's already in storage.

On the other hand, the branching of dendrites increases, and connections between distant brain areas strengthen. These changes enable the aging brain to become better at detecting relationships between diverse sources of information, capturing the big picture, and understanding the global implications of specific issues. Perhaps this is the foundation of wisdom. It is as if, with age, your brain becomes better at seeing the entire forest and worse at seeing the leaves.

Age is also the biggest risk factor for many brain diseases, most of which affect brain structure and function. Alzheimer's and other forms of dementia cause abnormal proteins to clump together and form plaques and tangles that damage brain tissue. Other diseases that are more common in older adults, such as diabetes and heart disease, can also compromise cognitive function (see "Medical conditions that affect the brain," page 15). Medications, poor vision and hearing, sleep deprivation, and depression also can interfere with brain function, and thus cognitive ability.

Table 2: Loss of cognitive abilities: Should you be worried?

If you're not sure whether you have normal, age-related cognitive changes or something more serious, here's a guide.

PROBABLY NORMAL AGING	TALK TO YOUR DOCTOR
You sometimes search for words.	You use the wrong words—"stove" instead of "table," for example.
It takes you a little longer than normal to complete tasks at work, but you can still finish them.	You struggle to perform your job responsibilities. You have trouble following a series of steps or instructions.
You can't find your car keys.	You can't remember how to drive.
You have to focus a little more on conversations in a noisy environment.	You can't follow conversations at all when there is background noise or other distractions.
You lose your temper a little more easily during an argument.	You scream at your partner often, and for no reason.
You misplace your house keys from time to time.	You always seem to be losing your keys and other everyday items, and they turn up in strange places—such as in the refrigerator.
You forget what you ate for dinner last night, but you remember as soon as someone gives you a hint.	You forget what you ate for dinner last night and no reminders can jog your memory.
You have trouble deciding which entree to choose at a restaurant, but ultimately make your choice.	You find it impossible to decide what to eat, choose what to wear, or make other daily decisions.
You drive a little slower than you used to.	You're very slow to react behind the wheel, and you often miss stop signs or red lights.
It takes you a little longer to answer the phone.	You don't recognize when the phone is ringing, and that you need to answer it.

As a result of these changes, you will likely start to notice slight slips in your memory in middle age and beyond. This is why the name of an old friend might be right on the tip of your tongue but you can't quite recall it, or why you can't think of precisely the word you're looking for. You might not be sure whether these slips reflect normal, age-related memory decline or a more serious brain disease like dementia.

Short of a full neurological workup, there are ways to help identify the signs of more serious cognitive loss and determine when to call your doctor (see Table 2, above).

Your brain through the decades

While certain faculties do deteriorate with time, others actually grow stronger with age. In your 20s, you likely had an easier time remembering a phone number or solving a complex math problem. These skills involve short-term memory and problem solving capacities that peak early in life. Yet you are more likely to win against your children or grandchildren in Trivial Pursuit because of the vast knowledge stores you've accumulated throughout the years. This ability to use learned knowledge is called crystallized intelligence, and it improves with age.

Researchers are finding that cognitive abilities over a lifetime are likely far more flexible than once thought. Laura Germine, a faculty member in psychiatry at Harvard Medical School and in neuroscience at McLean Hospital, along with her colleagues, analyzed cognitive tests taken by tens of thousands of people at various ages. In a 2015 study published in the journal *Psychological Science*, they found that various elements of memory and cognition peak at differing times of life.

Following is a general overview of how cognitive abilities wax and wane throughout the years, based on Germine's research and other studies on the subject. Remember that these changes represent a broad spectrum. Peaks and valleys in intellectual capabilities can differ from person to person, depending on education, health, physical fitness level, and other factors.

In your 20s

Your brain development has reached maturity. You should be able to solve problems, reason, learn, process, and remember new information—such as

people's names and faces—as quickly and as easily as you ever will.

In your 30s

Your learning, processing, and reasoning abilities, along with your thinking speed, are starting to gradually decline as your brain begins to lose efficiency in its connections. Yet your working memory—the means by which you quickly call up and manipulate information—is peaking.

In your 40s

Your cognitive function and memory remain strong, although you might start to notice subtle changes in your ability to learn and remember new information, such as the name of a person you've recently met or the details of a TV show you've watched. On the other hand, you are really good at capturing and describing the overall plot, and your reasoning skills are solid. It may get harder for you to perform more than one task at a time—for example, reading a book while the TV is on. However, thanks to your life experiences, other cognitive measures are improving at this age, such as your ability to perceive emotions in others and make moral decisions.

In your 50s

You may start to notice some mild forgetfulness, such as not being able to recall a word or name that once came easily to you. Your memory, processing skills, and other executive functions may be gradually declining. If so, you'll have more trouble learning new information and accessing information you've already learned. It will also become harder to divide your attention among tasks and ignore distractions. On the other hand, you may notice that you perform better than you did in the past in tasks involving vocabulary, comprehension, and general knowledge.

In your 60s

Your memory, processing skills, and other executive functions may continue to decline. However, your comprehension of vocabulary and general knowledge should remain stable.

In your 70s

You'll have more trouble with working memory—the ability to hold information in your mind while using it. For example, it may be harder for you to calculate the tip on a restaurant bill. You'll also have more difficulty recalling information—for example, remembering the names for common objects. You'll respond more slowly to sensory stimulation. If a deer were to run in front of your car, you'd be slower to hit the brakes than you were in years past. You'll continue to have more trouble dividing your attention among tasks. It will become harder for you to formulate concepts and think abstractly. Your risk for Alzheimer's disease and other forms of dementia also rises. You can at least partially offset thinking and memory loss now by continually acquiring new knowledge and experiences.

In your 80s

You will likely experience some difficulty with both short-term and long-term memory retrieval. Sensory and motor skills will also continue to decline. It will be harder for you to find the words associated with everyday objects and people. Your risk for dementia continues to rise. By age 85, nearly one out of every three people will have Alzheimer's disease. However, not everyone will manifest symptoms of the disease. How you withstand these brain changes depends in part on your cognitive reserve. You can continue to improve your cognitive reserve and buffer thinking and memory loss by challenging your brain to learn new skills.

Medical conditions that affect the brain

Your brain does not exist in isolation. It depends on your body to provide it with nourishment and support. To have a healthy brain, you must have a healthy body and avoid the many diseases that are known to compromise cognitive health. While the risk for these conditions typically increases with age, the processes that underlie them often start earlier in life, and can sometimes be set in motion by lifestyle shortcomings like a poor diet and lack of exercise.

Heart disease and stroke

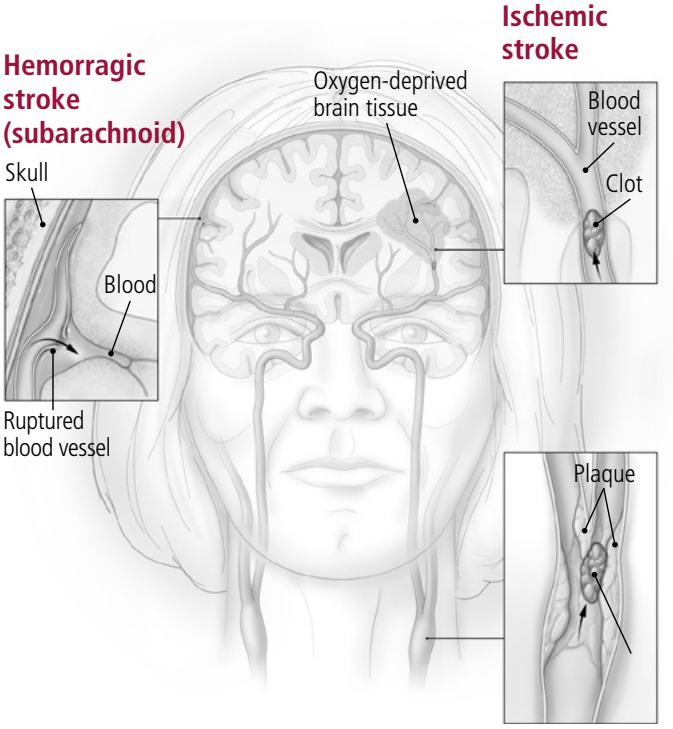
Every minute, your heart pumps five quarts of blood throughout your body. By the end of the day, it has pushed out a total of 2,000 gallons. Though your brain makes up only about 2% of your total body weight (for an average, 150-pound person), it receives 15% to 20% of your body's entire blood supply. Without this continuous flow of oxygen-rich blood, the brain's cells would die and the organ would cease to function.

Any condition that compromises heart health and blood vessel flexibility also compromises cognitive function. A 2013 study published in the *Journal of the American Heart Association* showed that women with heart disease were more likely to develop mild cognitive impairment—declines in cognitive abilities that can precede dementia—than those without heart problems. A 2015 study, published in the journal *Circulation*, linked poor heart function to double or triple the likelihood of developing memory loss.

Heart disease encompasses a number of conditions, including coronary artery disease and heart rhythm problems (arrhythmias). Both can hasten cognitive decline. A hallmark feature of coronary artery disease is the buildup of deposits called plaques—sticky goo made from cholesterol and other material. Plaques make the arteries narrower and stiffer, so it's harder for blood to flow smoothly through them. Sluggish blood flow can cause clots to form. More often, clots are formed by the body's attempt to repair the damage from a ruptured plaque. Either way, if a clot blocks one of the blood vessels that supplies the heart muscle with blood, the result is a heart attack.

But clots can damage the brain, too. If a piece of plaque or a blood clot travels to the brain and becomes

Figure 3: Two types of stroke



Strokes come in two forms:

Ischemic stroke is the most common type of stroke. It occurs when a clot blocks a blood vessel that supplies the brain with oxygen-rich blood. An ischemic stroke resembles a heart attack, but in the brain. It kills brain cells by starving them of oxygen and nutrients. Roughly 80% of strokes are of this type.

Hemorrhagic stroke occurs when a weakened blood vessel in the brain ruptures. If the bleeding is heavy enough, it creates a mass of accumulated blood called a hematoma, which compresses nearby brain tissue. Under this pressure, oxygen and nutrients can't reach brain cells, which die as a result.

You can also have a series of tiny ischemic strokes (known as lacunar strokes) or small bleeds. These can cause cumulative damage.

lodged in a blood vessel there, it can cut off the blood supply to part of the brain, causing a stroke (see Figure 3, page 15). Without blood, brain cells die, which is why stroke survivors often struggle with the loss of cognitive abilities afterward. Stroke damage also can occur slowly, over time, as a series of tiny strokes (called lacunar strokes) gradually reduce the connections in the brain. Whether damage occurs from one big stroke or several small ones, the destruction of connections in the brain can lead to a condition called vascular dementia, which is the second most common cause of dementia, after Alzheimer's disease.

Arrhythmias such as atrial fibrillation make the heart pump in an uncoordinated way. This chaotic action can cause blood to pool and form blood clots that can lead to a stroke. Research shows that people who have atrial fibrillation in middle age are at greater risk for developing dementia over the next two decades.

If there is any bright side to this doom-and-gloom scenario of poor cardiovascular health leading to cognitive decline, it is that many risk factors for heart disease—and thus dementia—are preventable. In a 2016 study in the *Journal of the American Heart Association*, researchers from the University of Miami found that the same lifestyle factors that protect the heart have a measurable effect on cognitive ability. People in the study who followed all the rules—kept their weight within the recommended limits, didn't smoke, exercised regularly, ate a well-balanced diet, and controlled their blood pressure, blood sugar, and cholesterol levels—performed better on tests of brain processing and memory than those who'd let their habits slip.

Life's Simple 7

Following these seven lifestyle strategies from the American Heart Association can lower your risk for heart disease and protect your brain in the process:

1. **Manage your blood pressure** with diet, exercise, weight loss, and medicine.
2. **Control your cholesterol levels** with diet, physical activity, and weight loss.
3. **Reduce blood sugar** by losing weight, eating healthfully, and increasing your physical activity.
4. **Get active** by doing at least 150 minutes per week of moderate exercise, or 75 minutes of vigorous exercise.
5. **Eat better**—more fruits and vegetables, whole grains, low-fat dairy, skinless poultry, fish, nuts, and vegetable oils.
6. **Lose weight** by burning more calories than you take in each day.
7. **Stop smoking** by using nicotine replacement, medicines, or other strategies.

The American Heart Association calls these lifestyle factors Life's Simple 7 (see the box below). Following them can lead to significant improvements in the health of your heart—and brain.

Diabetes

Doctors now refer to diabetes as an epidemic, and with good reason. Nearly 10% of the American population—some 29 million people—have type 2 diabetes, the most common form of the disease. More than one-third of them do not even know they have diabetes. If blood sugar levels continue to soar unchecked, the prevalence of type 2 diabetes could rise to one in three Americans by 2050. That's especially disturbing news, considering the strong association between diabetes and dementia.

Diabetes is a disease of high blood sugar. In people with type 2 diabetes, the body's cells become resistant to the effects of insulin. (By contrast, type 1 diabetes is an autoimmune condition in which the body attacks and destroys the pancreas' insulin-producing cells.) Insulin normally ferries sugar (glucose) from food into the cells for energy production or storage. When the cells don't respond appropriately, the pancreas churns out even more insulin to get the job done. Over time, the pancreas can no longer keep up with the body's demand for insulin. As a result, blood sugar soars.

Blood sugar levels that are consistently high over time wreak havoc on the body's tissues, damaging the eyes, heart, kidneys, nerves, and blood vessels. The brain is not spared. High blood sugar affects blood

vessels that nourish brain tissues. High blood sugar has also been linked to structural changes in the brain, including reductions in both white and gray matter. One consequence of this is shrinkage of the hippocampus, which plays a central role in memory formation and consolidation.

Damage to the brain and its blood vessels translates into direct, real-world effects. In addition to memory issues, several studies have noted problems with attention and other cognitive skills in people with diabetes. In a 2015 study led by Dr. Vera Novak, associate professor of neurology at Harvard Medical School, older adults with type 2 diabetes scored lower on cognitive tests compared with people who didn't have the condition. Novak attributed her diabetic participants' poor performance to less flexible blood vessels. Damage from diabetes had left these vessels less able to expand to accommodate the brain's blood flow needs. Diabetes might also reduce the effectiveness of brain plasticity mechanisms, thus affecting learning and memory. As evidence, a 2016 study in the *Journal of Alzheimer's Disease* by Peter Fried, instructor of neurology at Harvard Medical School, revealed abnormal plasticity in people with type 2 diabetes that correlated to reduced verbal learning ability.

Abnormal insulin and blood sugar levels may also directly affect neurons. Like other cells in the body, neurons in the brain need insulin to help them absorb glucose for energy. Insulin is also essential for neuronal growth, survival, and function. When insulin stores in the brain are low, cognition suffers.

But just as cells of the body become resistant to the effects of insulin in people with diabetes, the brain's cells can also become resistant. Experts believe that insulin resistance in the brain may play an important role in the development of Alzheimer's disease and other forms of dementia. A lack of insulin has been implicated in the formation of the abnormal beta-amyloid protein clusters that damage brain cells in people with dementia. The connection between insulin and dementia is so strong that some researchers have nicknamed Alzheimer's disease "type 3 diabetes." And some researchers are investigating whether an insulin nasal spray might help treat Alzheimer's by raising levels of the hormone in the brain.

Until medical research comes up with a drug treatment to combat the ill effects of low insulin and insulin resistance in the brain, diabetes prevention remains the best strategy. People with type 2 diabetes are also more likely to have cardiovascular disease, high blood pressure, and high cholesterol. Therefore, the same lifestyle habits that protect the heart and brain—including exercise and a healthy diet—can also stave off diabetes, or at least delay its onset. And in people who already have type 2 diabetes, careful blood sugar control is essential to preventing cognitive damage.

Obesity

One common influence linking heart disease, stroke, and diabetes is obesity. As of 2016, more than one-third of American adults were obese. Carrying too much weight can damage both the body and the brain. In studies, people who are very overweight often score lower on tests of memory and other cognitive abilities than their normal-weight peers.

Obesity contributes to cognitive decline both directly and indirectly. The indirect effects have been better studied. These revolve around the increased risks for diseases such as diabetes and cardiovascular disease, which contribute to strokes and dementia. Yet obesity also appears to have a direct impact on the brain. Magnetic resonance imaging (MRI) scans performed on obese people have revealed reductions in and damage to the myelin sheath that encases and protects nerve cells. This damage could compromise the transmission of nerve signals. Researchers also theorize that obesity contributes to vascular changes that affect blood flow to the brain, and that it triggers the release of chemicals that promote brain inflammation. Inflammation can affect levels of hormones and chemical messengers in the brain, such as serotonin, dopamine, and glutamate. Alterations in levels of these substances can contribute to depression, memory problems, and neuron damage.

One powerful way to counteract the harmful effects of obesity on the brain is with dietary changes. The key to losing weight—and keeping it off over the long term—is to change your eating

habits so that you're lowering the number of calories you consume, but in a way you can sustain. Exercise also plays a role in keeping weight off, helping you control your desire to overeat and making you more goal-oriented.

Dementia

Dementia is the most obvious—and probably most feared—cause of cognitive decline with age. It's not a disease in and of itself, but rather a descriptive term for progressive loss of memory and other cognitive abilities severe enough to disrupt one's daily life. Alzheimer's is the most public face of dementia, with more than five million Americans currently living under the shadow of this condition. Yet dementia comes in several forms, each of which can have a devastating effect on those who have it and on their families.

The hallmarks of Alzheimer's disease are abnormal deposits in the brain of proteins called beta-amyloid and tau. Beta-amyloid congregates into sticky plaques in the spaces between neurons, while tau forms twisted tangles inside them. Researchers are still trying to determine the driving force behind these abnormal deposits and how exactly they contribute to the damage that causes cognitive loss. Yet we do know that as plaques and tangles proliferate in the brain, they gradually cause the death of brain cells that govern memory, visuospatial abilities, word retrieval, personality, and every other cognitive function.

Alzheimer's usually strikes late in life (after age 65), and it's a gradual, progressive disease. When the first signs arrive, they can be hard to pinpoint—missing a few appointments, having trouble recalling a dinner out with friends the previous week, or forgetting the steps to a recipe you once knew by heart. Initially, these early signs may not significantly affect activities of daily living. Physicians refer to this stage as mild cognitive impairment (MCI). MCI can—but doesn't always—evolve into Alzheimer's disease, but it can also be caused by treatable conditions, such as a vitamin B_{12} deficiency or obstructive sleep apnea. By some estimates, 10% to 20% of people ages 65 and older have MCI.

In fact, scientists have found that, by the time people notice the first cognitive symptoms of Alzheimer's or MCI, the disease has already been going on for over a decade without causing memory problems or other cognitive difficulties. There is thus a strong effort within the medical community to find early markers of the disease that can be observed and treated in the preclinical stage (before symptoms become apparent), in order to forestall the progression of dementia and prevent the damage it causes. Dementia prevention isn't yet possible, but researchers are working toward that end.

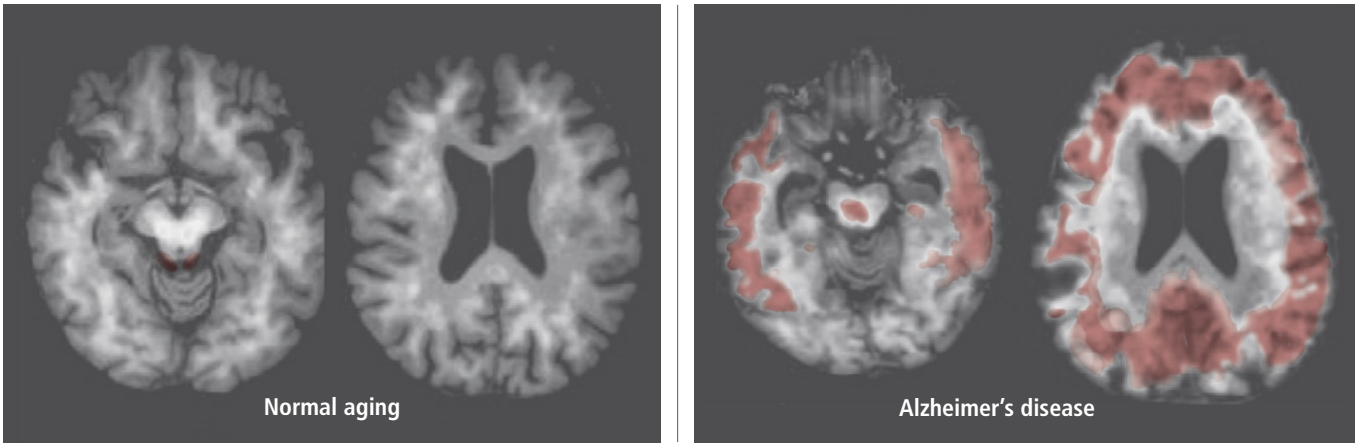
In the early or mild stage of Alzheimer's, a person is still able to live independently, but memory and other mental functions start to slip. Misplacing keys, forgetting what you've just read, or having trouble remembering names are common at this stage. The memory slips may be obvious enough that friends and family start to notice.

By the middle or moderate stage of dementia due to Alzheimer's, forgetfulness becomes more significant. Neglecting personal hygiene, getting confused about the day or place, and having difficulty remembering long-known information like one's address and phone number are common. Even an individual's personality can undergo a dramatic shift during this stage. Someone who was once open and outgoing may become withdrawn, moody, and angry as he or she struggles with mounting frustration.

At the late stage of dementia due to Alzheimer's, a person becomes completely reliant on others. Memory has slipped, and meaningful communication is almost impossible. People with late-stage Alzheimer's require help with even the simplest daily tasks—including dressing, bathing, and toileting.

The decline from an intelligent, thoughtful person with a vast, rich memory trove to someone who is unable to complete even the most basic personal hygiene tasks can occur in as little as four to eight years. It's a terrifying idea to contemplate. In a 2012 survey by the Marist Institute for Public Opinion, Americans said they fear Alzheimer's disease more than any other serious health condition, including cancer, stroke, heart disease, and diabetes. Accentuating the fear is the projection that by 2050, an estimated

Figure 4. Amyloid PET scans to detect Alzheimer's disease



A specialized type of PET scan uses a chemical tracer, which is injected into the arm before the scan. Once the compound enters the brain, it binds to amyloid deposits, a telltale sign of Alzheimer's disease. Other tracers, which are more experimental, can reveal tau.

14 million Americans will be living with Alzheimer's disease—nearly triple today's numbers.

Although Alzheimer's is the most common type of dementia, it's not the only cognitive condition that has a dramatic effect on people's lives. Other forms of dementia exist, too:

Vascular dementia makes up 10% of all dementia cases. It stems from damage to the blood vessels. The most obvious difference between vascular dementia and Alzheimer's is that vascular dementia tends to affect judgment and decision making first, rather than memory. Also, vascular dementia worsens in a stepwise fashion, rather than in a slow, steady decline like Alzheimer's.

Dementia with Lewy bodies involves abnormal formations of a protein called alpha-synuclein in the brain. This protein also forms in the brains of people with Parkinson's disease. In addition to experiencing thinking and memory issues, people with this form of dementia have the same type of awkward gait that's typical in Parkinson's disease.

Frontotemporal dementia is caused by damage to the nerve cells in the frontal or temporal lobes of the brain. This damage leads to problems with personality and behavior as well as trouble with language and motor functions.

Mixed dementia involves brain changes that are common to more than one type of dementia—such as Alzheimer's plus vascular dementia.

Finding a solution to dementia

For the millions of Americans who are at risk for Alzheimer's and other forms of dementia, a cure cannot come soon enough. As of today, only a few drugs are available to treat the disease, and they only help temporarily with memory loss and behavioral symptoms—they do not halt the underlying disease process.

One of the reasons why researchers have been so slow to discover an effective treatment is that until recently, the only way to definitively diagnose Alzheimer's disease was after a person had died, by cutting open the brain postmortem. Today, doctors can see signs of the disease in the brains of living patients in one of two ways—by using a spinal tap to look for amyloid and tau proteins in the cerebrospinal fluid or with a positron emission tomography (PET) scan, which uses a radioactive tracer to bind to and reveal beta-amyloid in the brain (see Figure 4, above). Other, more experimental tracers can reveal tau. Doctors can use these methods to confirm that a patient has Alzheimer's disease and differentiate it from other dementias, so they can initiate treatment earlier in the disease process.

Using PET scans to help identify older adults with the first signs of plaques and tangles, researchers are trying to develop therapeutic approaches that might stall—or even stop—this disease before symptoms become apparent. One major research effort under way is the Anti-Amyloid Treatment in Asymptom-

atic Alzheimer's study (known as A4), which is led by Reisa Sperling, a neurology professor at Harvard Medical School and director of the Center for Alzheimer's Research and Treatment at Brigham and Women's Hospital. The A4 study will test whether an investigational treatment called an anti-amyloid antibody can break up beta-amyloid deposits and slow memory loss in people at risk for Alzheimer's. Other disease-modifying therapies are under investigation at universities and pharmaceutical companies around the world.

Until a treatment is available, the best defense against dementia is a good offense. The preventive strategies outlined in this report—regular exercise, a healthy diet, nourishing sleep, mental stimulation, social interaction, and stress management—may together help the brain compensate for the effects of Alzheimer's, sustain cognitive abilities longer, and perhaps even slow down the damaging effects of this devastating disease.

Traumatic brain injury (TBI)

Anyone who's taken a fall or gotten a hard knock on the head knows the symptoms that may follow, especially headaches and dizziness. The major concern with a head injury is the possibility of a brain injury. Most head injuries don't cause brain trauma, but a more severe injury can. This type of injury is called a concussion, and its symptoms are brief unconsciousness or confusion and trouble remembering the injury and the moments afterward. Neurologists and neurosurgeons refer to an injury with these symptoms as a mild traumatic brain injury (TBI). For a few days, or perhaps weeks, you might have physical symptoms, but cognitive symptoms are the most worrisome. They are, fortunately, transient, fading after a few days or weeks in almost all patients with no more treatment than a brief reduction in activity. While you recover from a mild TBI, your memory might be a little impaired. Your quickness of response and balance might also be diminished. Don't take on important projects until you feel better, and take caution to avoid further injury.

Until treatments for dementia are available, the best defense is a good offense—regular exercise, a healthy diet, plenty of sleep, social interaction, and of course mental stimulation.

There are special concerns about concussions in older adults. The elderly may have less brain reserve because of other illnesses that affect the brain or just from being older. Their recovery can take longer. The most common cause of TBI in the elderly is a fall. When your reaction time is slowed and you feel a little dizzy, your risk of a second fall is higher. It's therefore important for older adults to take precautions to prevent falls. Here are a few tips:

- Have regular eye examinations.
- Get rid of tripping hazards in and around your home. Remove piles of papers, loose cords, and other obstacles that might trip you up.
- Prevent slips outside your home. After a snowstorm, put down a layer of salt or cat litter on sidewalks and outdoor stairs to reduce slickness.
- Wear low-heeled, rubber-soled shoes to put you on more solid footing.
- Place skidproof backs on loose rugs so they don't slide out from under you.
- Add grab bars next to tubs and showers and place nonskid mats on the tub and shower floor so you don't slip while getting out.
- Install lighting in dark stairways and hallways.
- Do balance exercises every day. A simple balance exercise might involve alternately standing on one leg and then the other.

It is also important to realize that sometimes falls are an early sign of cognitive decline. When you walk, you do what scientists call "dual tasking." You not only put one foot in front of the other, but you also enjoy the scenery, talk with another person or listen to a podcast, pay attention to the traffic lights, and so on. This requires the brain to make additional resources available by tapping into its cognitive reserve. When cognitive reserve is too low or the brain is strapped for resources because of an illness, falls can be an early warning sign. If you've had a couple of spills, it may be worth getting your cognitive health, gait, and balance evaluated by a specialized clinic.

There is now much more public awareness about the possible complications of TBI. One mild TBI isn't likely to lead to Alzheimer's years later. However, the connection between severe TBI and Alzheimer's is stronger. It may be that a severe TBI reduces the brain's reserve, allowing other illnesses to emerge. The lesson is to stay active, maintain and build your brain health with an active cognitive life (through reading, music, social contacts, and games), and manage medical risks such as high blood pressure.

People who have multiple concussions and don't take enough time to recover from them can take significantly longer to return to normal cognitive function. For example, there is the very special case of multiple head injuries and concussions in athletes who play contact sports. Studies of the brains of many athletes have revealed abnormalities similar to Alzheimer's disease, but at much younger ages. This finding has been called chronic traumatic encephalopathy (CTE). It's been seen for a very long time in boxers. More recently, it's emerged in football players and other athletes. You typically don't need to be concerned about CTE unless you play contact sports, you've served in the military, or you participate in other activities that have a very high frequency of head injuries.

Physical activity is a very important tool for brain and cognitive health. Don't let a concussion stop you from being active. Give yourself time to recover, but get moving again.

Health problems that can mimic dementia

Memory slips might make you imagine a worst-case scenario like Alzheimer's disease or vascular dementia, but memory loss and other cognitive difficulties can also be symptoms of a treatable medical condition. Here are a few disorders that can cause forgetfulness, confusion, cognitive difficulties, and personality changes:

- alcoholism or substance abuse
- brain infections or tumors
- depression
- diabetes
- exposure to high levels of toxic substances such as lead, iron, or copper
- Lyme disease and other tick-borne diseases
- normal-pressure hydrocephalus (a buildup of fluid in the brain)
- oxygen deprivation (anoxia) from heart or lung problems
- sleep disorders
- subdural hematoma (a collection of blood between the brain's covering and its surface) after a fall
- thyroid disorder
- urinary tract infection
- vitamin B_{12} deficiency.

Alcohol, cigarettes, and illicit drugs

If you've ever indulged in a few too many drinks, you know how excessive alcohol use makes you feel. Drinking slurs your speech, blurs your judgment, slows your reaction time, and impairs your memory. The ethyl alcohol in beer, wine, and liquor is a central nervous system depressant that interferes with thought, memory, and motor control and slows brain activity over all. Depending on how much you drink, you might forget the entire night's events—a phenomenon known as a blackout. And these are only the short-term effects.

Over the long term, heavy drinking (more than two drinks a day for months) can lead to nutritional deficiencies, particularly of thiamine (vitamin B_1). The brain needs this essential nutrient to survive. Long-term alcoholics who are thiamine-deficient can develop a serious brain disorder called Wernicke-Korsakoff syndrome, which causes mental confusion, among other symptoms. In addition, heavy drinking can directly

Table 3: Drugs that affect cognition

All of these medicines can interfere with your cognitive abilities. If you have cognitive problems and you take one of these medications, ask your doctor and pharmacist about lowering the dose or choosing an alternative drug. Also go over your list of medications with your physician at regular intervals—for example, once a year—to make sure you're not taking any medicines you no longer need. However, don't stop taking any drug without first consulting your doctor, because you may need it to manage your health.

DRUG CLASS	EXAMPLES	USED TO TREAT	DRUG CLASS	EXAMPLES	USED TO TREAT
Anticholinergics	oxybutynin (Ditropan XL, Oxytrol) solifenacin (Vesicare) tolterodine (Detrol)	Overactive bladder	Dopamine agonists	apomorphine (Apokyn) pramipexole (Mirapex) ropinirole (Requip)	Parkinson's disease, restless legs syndrome
Antihistamines (first generation)	chlorpheniramine (Chlor-Trimeton) clemastine (Tavist) diphenhydramine (Benadryl)	Cold and allergy symptoms, motion sickness	Narcotic pain relievers (opioids)	fentanyl (Duragesic) hydrocodone (Vicodin) hydromorphone (Dilaudid) oxycodone (OxyContin, Percocet)	Chronic pain
Antiseizure medicines	acetazolamide (Diamox) carbamazepine (Tegretol) gabapentin (Neurontin) lamotrigine (Lamictal) pregabalin (Lyrica) topiramate (Topamax) valproic acid (Depakote)	Seizures, nerve pain, bipolar disorder, mood disorders	Nonbenzodiazepine sedative-hypnotics	eszopiclone (Lunesta) zaleplon (Sonata) zolpidem (Ambien)	Insomnia and other sleep problems
Benzodiazepines	alprazolam (Xanax) chlordiazepoxide (Librium) clonazepam (Klonopin) diazepam (Valium) flurazepam (Dalmane) lorazepam (Ativan) temazepam (Restoril)	Anxiety disorders, muscle spasms, seizures	Statins	atorvastatin (Lipitor) fluvastatin (Lescol) lovastatin (Mevacor) pravastatin (Pravachol) rosuvastatin (Crestor) simvastatin (Zocor)	High cholesterol
Beta blockers	atenolol (Tenormin) metoprolol (Lopressor, Toprol) propranolol (Inderal) sotalol (Betapace) timolol (Timoptic)	High blood pressure	Tricyclic antidepressants	amitriptyline (Elavil) desipramine (Norpramin) doxepin (Sinequan) imipramine (Tofranil) nortriptyline (Pamelor)	Depression, chronic pain, smoking cessation

harm the cerebellum. It can also damage many other organs, which can affect the brain. For example, alcohol-induced liver damage impairs the body's ability to clear toxins that can lead to brain dysfunction.

You don't have to avoid alcohol entirely—in fact, moderate drinking might help improve episodic memory in some people. Just limit yourself to one drink per day if you're a woman or two if you're a man, and check with your doctor if you have any health conditions drinking might worsen.

As for smoking, nicotine may increase cortical activity somewhat, but the harms vastly outweigh this

modest benefit. In addition to increasing your risk for life-threatening diseases ranging from cancer to lung disease, smoking affects memory in a number of ways. It damages the heart and blood vessels, limiting essential blood flow to the brain and increasing your risk for stroke and vascular dementia. Smoking also damages the lungs, which further reduces the oxygen supply to the brain. And it increases levels of homocysteine—a damaging amino acid that contributes to stroke and dementia risk. Cigarette smokers are twice as likely to develop Alzheimer's disease as nonsmokers. Fortunately, quitting can protect your mind and memory.

Also detrimental to the brain are illicit drugs like heroin, cocaine, and amphetamines. These drugs create a pleasurable feeling by triggering a flood of dopamine, a neurotransmitter that makes you feel good. This pleasurable feeling makes you want more and more of the drug, leading to dependence. Over time, drug use can actually rewire the brain, permanently altering areas involved in memory, decision making, and learning.

Over-the-counter and prescription drugs

Drugs bought on the street aren't the only ones that can compromise memory. Many prescription and over-the-counter medications also interfere with the transmission of chemical messengers in the brain and can alter memory and brain function. These include antidepressants, sleeping pills, anti-anxiety drugs, and some antihistamines (see Table 3, page 22).

Older adults are especially vulnerable to cognitive side effects from medication because their metabolism is slower, preventing their bodies from clearing drugs as quickly as they once did. With some drugs, the cognitive decline could be permanent. A 2014 study in *The BMJ* reported that people in their 60s and older who took a benzodiazepine (tranquilizer) drug such as diazepam (Valium, Diastat) or flurazepam (Dalmane, Dalmadorm) were more likely to develop dementia, especially if they stayed on the drug for more than six months. This study doesn't prove that benzodiazepines cause dementia, though. It's possible that people who already have dementia are just more likely to be anxious and therefore to take these drugs.

The best way to avoid drug-related cognitive decline is to go over your list of medications annually with your doctor and pharmacist. Ask whether any of the drugs you take could affect your memory. If so, find out whether you can lower the dose or switch to a medicine that's less likely to affect your cognitive function. And remember to share with your doctor the full list of medications you take—including vitamins and over-the-counter drugs.

When to see a doctor

Disease, drugs, and injury can all take their toll on your cognitive abilities over the years. And when cognitive issues do emerge, they can sometimes be hard to distinguish from normal age-related changes (see Table 2, page 13). You might not have dementia, but rather a medical condition that mimics its symptoms (see "Health problems that can mimic dementia," page 21).

If you're concerned about your cognitive abilities or a relative has expressed worry about your ability to remember, think, make decisions, or communicate, talk with your doctor. You'll likely be referred to a doctor who diagnoses and treats cognitive difficulties, such as a neurologist, geriatric psychiatrist, or other specialist. Cognitive or behavioral neurologists specialize in the diagnosis and treatment of patients with cognitive problems. Often you'll need evaluation from a multidisciplinary team that includes psychiatrists, neuropsychologists, social workers, and neurologists.

To find a cognitive or behavioral neurologist in your area, try the American Academy of Neurology (http://patients.aan.com/findaneurologist). To find a geriatric psychiatrist, visit the website of the Geriatric Mental Health Foundation (www.gmhfonline.org). The doctor will do a range of medical and cognitive tests to identify the cause. Once you have a diagnosis, your doctor can suggest treatments. If dementia is at the root of your cognitive issues, you might consider enrolling in a clinical trial of a new therapy aimed at slowing or even stopping memory loss and cognitive decline.

Now, with these preliminaries out of the way, you are ready to begin our cognitive fitness program.

STEP 1: Eat a plant-based diet

Food may not be the first thing that comes to your mind when you think about starting a cognitive fitness program. But food nourishes your body and your brain alike. The range of foods you choose from day to day can have a enormous impact not only on your weight, heart health, and cancer risks, but also on your mood, your mental sharpness, and your risks of developing dementia. Research shows that a diet that contains abundant fruits, vegetables, legumes, nuts, and whole grains—with limited amounts of animal products—is best for cognitive fitness. As you'll see in the following pages, there is even an eating plan called the MIND diet, so selecting a brain-healthy diet makes a very appropriate first step in any program to boost brain health.

Colorful fruits and vegetables are an important part of a brain-healthy diet.

The weight-brain connection

Obesity rates have skyrocketed, with 600 million adults around the world now considered obese. That's a problem for multiple reasons. Being very overweight increases the risk for diabetes, heart disease, and other conditions that are known to damage the brain. Moreover, obesity itself can cause structural and functional changes in the brain that lead to cognitive decline. Studies have revealed atrophy in the hippocampus—the brain region essential to learning and memory—as well as shrinkage in gray matter in people who are very overweight. Researchers have also observed that a diet high in saturated fat can lead to a reduction in the molecules needed to create and sustain new neurons. This type of unhealthy diet can also damage blood vessels, compromising blood flow to the brain.

Obesity also leads to inflammation throughout the body, including in the brain. Inflammation can be a healthy process—a defense mechanism our immune system uses to destroy molecular invaders like viruses and cancer cells. But when the inflammation is chronic, it can lay waste to healthy cells, including neurons. Researchers have implicated inflammatory processes in hastening—and potentially even causing—cognitive decline and dementia. Chronic inflammation damages neurons and disrupts the circuitry in the hypothalamus and other areas of the brain.

While an excess of weight is undoubtedly bad for the brain, the opposite is true, too. People who are significantly underweight can also suffer mental declines. Weight loss is a common problem in the elderly, as issues like appetite loss, illness, and tooth loss make eating more difficult. Studies of older adults have associated a lower body mass index (BMI) with reduced cognition and a higher risk for dementia. There may be a few reasons for the link. For one thing, people who are underweight might have underlying health conditions that compromise their cognitive function. A lack of body fat can also disrupt the release of hormones the brain needs to function properly. Finally, a diet low in nutrition can deprive the brain of the vitamins and minerals it needs.

To achieve optimal brain health, try to keep your weight within the ideal range for your height. You can determine that "sweet spot" with a combination of two measurements—BMI and waist circumference. To calculate your BMI, go to www.health.harvard.edu/BMI. A BMI of 30 or more is considered in the obese range, while a BMI of 26 or more is overweight. But it's not simply a matter of how much you weigh. It's also how your weight is distributed, since belly fat is more damaging to your health than fat carried in the hips and

thighs. Waist circumference for women should ideally be 35 inches or less. For men, it should ideally be 40 inches or less.

If you're overweight, talk with your doctor about ways to reach your target weight. This may require a combination of nutritional strategies, portion control, and exercise. You can also find dozens of practical suggestions, tips, recipe ideas, tricks for fighting emotional or stress eating, and information about weight-loss drugs and surgery in another Harvard Special Health Report, *Lose Weight and Keep It Off: Smart approaches to achieving and maintaining a healthy weight.* (For ordering information, see page 51.)

Foods linked to better brainpower

Just as there is no magic pill to prevent cognitive decline, no single food can ensure a sharp brain. Nutritionists emphasize that the most important strategy is to follow a healthy dietary pattern that includes a lot of fruits, vegetables, legumes, and whole grains. Protein should come from lean sources, such as fish, and fats should be healthy ones, such as olive oil or canola oil (see "Best diets for cognitive fitness," below right).

That said, certain foods in this overall scheme are particularly rich in healthful components like omega-3 fatty acids, B vitamins, and antioxidants, which are known to support brain health. Incorporating many of these foods into a healthy diet on a regular basis can improve the health of your brain, which could translate into better mental function.

Research shows that the best foods for your brain are the same ones that protect your heart and blood vessels, including the following:

Green, leafy vegetables. Leafy greens such as kale, spinach, and collards are rich in brain-healthy nutrients like vitamin K, lutein, folate, and beta carotene. Research suggests these plant-based foods may help slow cognitive decline.

Fatty fish. Fatty fish are abundant sources of omega-3 fatty acids, healthy unsaturated fats that have been linked to lower blood levels of beta-amyloid—the protein that forms damaging clumps in the brains of people with Alzheimer's disease. Try to eat fish at least twice a week, but choose varieties that are low in mercury, such as salmon, cod, canned light tuna, and pollock. If you're not a fan of fish, ask your doctor about taking an omega-3 supplement, or choose terrestrial omega-3 sources such as flaxseeds, avocados, and walnuts.

Berries. Flavonoids, the natural plant pigments that give berries their brilliant hues, also help improve memory, research shows. In a 2012 study published in *Annals of Neurology*, researchers at Harvard's Brigham and Women's Hospital found that women who consumed two or more servings of strawberries and blueberries each week delayed memory decline by up to two-and-a-half years.

Tea and coffee. The caffeine in your morning cup of coffee or tea might offer more than just a short-term concentration boost. In a 2014 study published in *The Journal of Nutrition*, participants with higher caffeine consumption scored better on tests of mental function. Caffeine might also help solidify new memories, according to other research. Investigators at Johns Hopkins University asked participants to study a series of images and then take either a placebo or a 200-milligram caffeine tablet. More members of the caffeine group were able to correctly identify the images on the following day.

Walnuts. Nuts are excellent sources of protein and healthy fats, and one type of nut in particular might also improve memory. A 2015 study from UCLA linked higher walnut consumption to improved cognitive test scores. Walnuts are high in a type of omega-3 fatty acid called alpha-linolenic acid (ALA), which helps lower blood pressure and protects arteries. That's good for both the heart and the brain.

Best diets for cognitive fitness

The ideal eating plan for a healthy brain incorporates many of the "brain-boosting" foods listed above. A few diets have been promoted specifically for improving cognitive fitness. One of the most rigorously studied of these eating plans, the Mediterranean diet, is also considered one of the healthiest diets over all.

The Mediterranean diet

It's no coincidence that many of the world's longest-lived people inhabit the area surrounding the Medi-

Sample Mediterranean diet plan

If you'd like to try the Mediterranean diet, but you aren't sure how to get started, try these sample menus as a guideline:

Monday

Breakfast: Whole-wheat couscous with low-fat milk, strawberries, and cinnamon

Lunch: Tomato and mozzarella sandwich on whole-grain bread

Dinner: Pasta salad with multigrain farfalle, artichoke hearts, roasted red pepper, peas, and chopped mozzarella cheese topped with olive oil and lemon juice

Tuesday

Breakfast: Plain Greek yogurt with raspberries, blueberries, and granola

Lunch: Tuna salad with capers and olives over a bed of kale

Dinner: Chicken kabobs with roasted Brussels sprouts

Wednesday

Breakfast: Omelet with spinach and feta cheese

Lunch: Quinoa salad with chicken breast cubes, feta cheese, cucumbers, and kalamata olives

Dinner: Turkey burger topped with yogurt and cucumber on a whole-wheat bun, with side of potatoes, eggplant, and bell pepper roasted in olive oil and balsamic vinegar

Thursday

Breakfast: Egg whites, spinach, tomato, and mozzarella cheese on multigrain sandwich thins

Lunch: Tomato, cucumber, and white bean salad dressed with olive oil and lemon juice

Dinner: Baked whole-grain pasta with zucchini and mozzarella cheese

Friday

Breakfast: Avocado with feta cheese and lemon juice on toasted rye bread

Lunch: Hummus with whole-wheat pita and sliced vegetables (carrots, peppers, tomato, cucumber)

Dinner: Grilled tuna with olives, capers, tomatoes, and artichoke hearts

Saturday

Breakfast: Oatmeal topped with chopped walnuts, honey, and bananas

Lunch: Panini with roasted red peppers, black olives, zucchini, provolone cheese, and olive oil on whole-grain bread

Dinner: Whole-grain spaghetti topped with shrimp, capers, lemon juice, and baby spinach

Sunday

Breakfast: Frittata with onion, feta cheese, roasted red peppers, and kalamata olives

Lunch: Salad of spinach, grilled chicken, yellow pepper, and feta cheese

Dinner: Grilled salmon with black olives, tomatoes, and whole-wheat couscous

terranean Sea. Those who make their home along the coasts of Spain, Italy, and France eat a diet rich in fresh fruits and vegetables, fish, beans, nuts, olive oil, and red wine, which are filled with healthful fatty acids and antioxidants that combat disease processes. This diet not only contains an abundance of healthy foods—it also minimizes unhealthy ones, such as packaged snack foods and desserts, which tend to be loaded with ingredients that are not good for cognitive health (see "Brain-draining foods," page 29).

Studies have linked the Mediterranean diet to a number of health benefits, including a reduction in "bad" low-density lipoprotein (LDL) cholesterol, which can contribute to heart disease. The diet has also been shown to reduce the risk of cancer, Parkinson's disease, and premature death. In 2015, Spanish researchers released a rigorous randomized controlled study of the Mediterranean diet's effects on cognitive performance. It was part of a larger five-year investigation of the diet's effects on cardiovascular health, called PREDIMED. Participants were randomly assigned to eat one of the following:

- a Mediterranean diet supplemented with 33 ounces a week of extra-virgin olive oil
- a Mediterranean diet supplemented with an ounce a day of nuts
- a low-fat control diet.

In results published in *JAMA Internal Medicine*, researchers reported that people who ate a Mediterranean diet supplemented with olive oil or nuts had improvements in memory and other cognitive functions compared with those who followed a low-fat diet. The authors speculate that the benefits to cognition likely come from the antioxidant and anti-

inflammatory effects of foods like olive oil and nuts.

The Mediterranean diet is relatively easy to implement because it isn't overly restrictive (see "Sample Mediterranean diet plan," page 26). It's a generally healthy diet that emphasizes plant-based foods and adds a few key components—like the olive oil and nuts in the PREDIMED study. To start adopting a Mediterranean-style eating plan, try these tips:

- **Replace red meat with fish**—especially fish like salmon, pollock, catfish, and canned light tuna, which are high in omega-3 fatty acids but low in mercury—at least twice a week.
- **Cook with an unsaturated fat** like olive oil instead of butter, which consists mostly of saturated fat.
- **Fill half of your plate with fruits or vegetables.** The more colorful the produce you choose, the more antioxidants and nutrients you'll consume. Berries, carrots, broccoli, red peppers, oranges, and spinach are all good choices.
- **Drink wine (in moderation).** A little red wine is good for blood vessels, but moderation is key—one glass a day for women, one or two for men. If you have any chronic health conditions, check with your doctor first to make sure it's safe for you to drink.
- **Make your grains whole grains.** Check the labels to ensure that the pastas, breads, and cereals you buy contain 100% whole grain. This means the manufacturer incorporated the most nutritious part of the grain. Oatmeal, quinoa, barley, and rye are some of the healthiest whole grains.
- **Grab a handful of nuts.** Walnuts, almonds, and other varieties make great snacks because they're packed with hearty protein that fills you up, plus unsaturated fat.
- **Have fruit for dessert.** A bowl of berries will give your meals a sweet finale, without adding a lot of fat and calories. Plus, berries are high in antioxidants.

The MIND diet

The aptly named MIND diet is a research-based eating approach developed by Rush University nutritional epidemiologist Martha Clare Morris. It combines elements of the Mediterranean diet and the DASH diet, which reduces high blood pressure, or hypertension, through a produce-rich diet. (DASH stands for Dietary Approaches to Stop Hypertension, and MIND stands for Mediterranean-DASH Diet Intervention for Neurodegenerative Delay.)

Both of these eating plans reduce cardiovascular and cognitive risks, but Morris and her colleagues fine-tuned their approach based on the latest findings on diet and dementia. For example, like the Mediterranean and DASH plans, MIND emphasizes a plant-based diet with few animal products and saturated fats. But unlike those other diets, MIND recommends eating berries specifically rather than fruit in general, and it emphasizes green leafy vegetables. Studies have shown these fruits and vegetables in particular to be most protective against dementia (see "MIND diet: Foods to include and avoid," below).

One big advantage to the MIND diet is that it's flexible and unrestrictive, making it easy to follow and stick with over time. Even if you don't follow it exactly, you can still see results. A 2015 study published in the journal *Alzheimer's & Dementia* showed the diet helped lower Alzheimer's risk by as much as

MIND diet: Foods to include and avoid

The MIND diet spotlights 10 brain-healthy food groups to include in your daily meals and snacks:

1. green leafy vegetables
2. other vegetables
3. nuts
4. berries, especially blueberries
5. beans
6. whole grains
7. fish
8. poultry
9. olive oil
10. wine.

On the MIND diet, you would typically eat

- ✔ at least three servings of whole grains a day
- ✔ a salad and one other vegetable a day
- ✔ a glass of wine daily
- ✔ a snack of nuts on most days
- ✔ beans every other day
- ✔ poultry at least twice a week
- ✔ berries at least twice a week
- ✔ fish at least once a week.

The diet also spotlights five unhealthy groups to limit or avoid:

1. red meat
2. butter and stick margarine
3. cheese
4. pastries and sweets
5. fried or fast foods.

53% among those who followed it strictly for an average of four-and-a-half years. But even people who were less rigorous in their adherence saw a 35% risk reduction. In other research, Morris's group found that older adults who stuck with the diet experienced slower mental declines, making them the equivalent of 7.5 years cognitively younger than their peers who were following other diets.

One limitation of these studies is that they were observational, meaning the researchers only observed the participants' behaviors—they didn't seek to influence them. The authors say a head-to-

Table 4: Supplements for brain health

Many supplements are touted for cognitive health, but the evidence is not as strong as the marketing might suggest. The same ingredients can be found in healthy foods.

NUTRIENT OR SUPPLEMENT	DOES IT HELP?	POSSIBLE SIDE EFFECTS	FOOD SOURCES
Folic acid	Folic acid is essential to brain function and emotional health. It is a component of DNA and RNA, which are part of the body's genetic material, and is used in cells of the brain and central nervous system. Folic acid also affects the production of neurotransmitters in the brain. It increases nitric oxide in the brain, which protects against oxidative damage. Low folic acid levels have been associated with depression. Supplementation can lower levels of homocysteine—an amino acid linked to heart and blood vessel disease as well as to dementia. Research on whether folic acid supplements improve cognitive function is mixed.	In large doses, folic acid can cause stomach problems, sleep issues, confusion, appetite loss, nausea, and seizures.	Dark leafy greens such as spinach as well as chickpeas, pinto beans, lima beans, asparagus, papaya, avocado, and whole grains.
Ginkgo biloba	Ginkgo biloba has antidepressant effects, and it has been marketed for delaying or preventing cognitive decline. Yet the Ginkgo Evaluation of Memory (GEM) study, the largest randomized controlled dementia prevention trial of the supplement to date, showed that it did not reduce the incidence of dementia or improve memory, language, attention, or other measures of cognitive ability.	Bleeding (especially in people who take blood-thinning drugs or who have bleeding disorders), lowered blood pressure and blood sugar levels, drowsiness.	Ginkgo is not a naturally occurring component of foods.
Omega-3 fatty acids	DHA, an omega-3 fatty acid, is an essential component of brain cells. Low omega-3 levels have been found in people with Alzheimer's disease. Research suggests that diets high in omega-3 long-chain polyunsaturated fatty acids might protect cognitive function. Yet recent studies have concluded that omega-3 supplements don't improve cognitive function in healthy older adults or effectively treat dementia.	Bleeding (especially in people who take blood-thinning drugs or who have bleeding disorders); change in blood sugar, blood pressure, or cholesterol levels; allergic reactions in people who are sensitive to fish or fish oil.	Fatty fish like salmon and tuna, flaxseed, vegetable oils.
Vitamins B_6 and B_{12}	Vitamins B_6 and B_{12} are essential for normal brain function as you age. Deficiencies in these B vitamins have been linked to elevated homocysteine levels, which are associated with an increased risk for dementia. Yet in studies, supplements of these vitamins did not improve cognition in healthy middle-aged and older adults.	Vitamin B_{12} is generally safe. High doses of vitamin B_6 can cause peripheral nerve damage, leading to trouble with touch, sensation, and movement. May also cause skin sores, nausea, vomiting, stomach pain, appetite loss, headache, and fatigue.	Vitamin B_6: chickpeas, beef liver, tuna, salmon, chicken breast, fortified breakfast cereal. Vitamin B_{12}: clams, beef liver, fortified breakfast cereal, trout, salmon, tuna, milk.
Vitamin E	Vitamin E has antioxidant effects, which could potentially combat the oxidative stress linked to cognitive decline and dementia. When taken in supplement form, vitamin E did not affect cognition in healthy middle-aged and older adults, according to one review of studies. However, other research suggests that people who eat a diet high in vitamin E–rich foods are 25% less likely to develop dementia than those with the lowest vitamin E intake.	Increased bleeding risk, skin reactions, changes in cholesterol levels or insulin resistance.	Sunflower seeds and oil, almonds, hazelnuts, peanut butter, corn oil, spinach, broccoli.

head test of the MIND diet against other plans is needed to confirm its benefits to cognition.

Brain-draining foods

While some foods are known for enhancing cognitive fitness, others have the opposite effect. Many of the same foods that are damaging to your heart and blood vessels can also be bad for your brain because they increase your risk for artery clogs that lead to strokes. Therefore, you should limit your intake of these foods:

Red meat, butter, cream, whole milk. All of these animal-based foods are high in saturated fat, which raises blood levels of unhealthy LDL cholesterol. When cholesterol builds up in arteries, it can slow blood flow to the brain or create a blockage that produces a stroke. The link between saturated fat and memory may also relate to a gene called apolipoprotein E, or APOE, which helps control the amount of cholesterol in the blood. People with a variation in this gene called APOE4 are at greater risk for Alzheimer's.

Added sugars. Soft drinks, cookies, cakes, and pies are all loaded with sugar. It's in almost everything we eat, including foods not known for their sweetness, like ketchup and salad dressing. Sugar stimulates the brain's reward center in much the same way addictive drugs do. That's why you may have cravings for sweets. But sugar has also been linked to diabetes and obesity, both of which are detrimental to brain health. Try to cut back on foods with added sugars when possible. Substitute berries for cake, and eat eggs for breakfast rather than a muffin or sweet cereal. To find hidden sources of sugar in packaged foods, check the ingredients list on the package for words like honey, molasses, cane sugar, fruit juice concentrate, brown rice sugar, glucose, corn syrup, invert sugar, and sucrose.

Refined flour. When flour is "refined" or "enriched," that means manufacturers have stripped away the healthiest parts of the grain—the fiber-rich bran and vitamin-rich germ—and then added a few vitamins and other nutrients back in. In the process, they have also created an easy-to-digest foodstuff that quickly floods the bloodstream with glucose. The result is that white flour and products made with it (pasta, bread, crackers, cake) cause blood sugar levels to spike and then plummet, leaving you feeling hungry again soon after you eat them. Eating too many foods made with refined flour can affect your blood pressure and diabetes risk over time. Look for foods labeled "100% whole grain" to maximize the fiber and nutrient content of the grain products you buy.

Trans fat. To increase the shelf life of cookies and other packaged foods, and give fried foods like French fries a satisfying crunch, companies have long added hydrogenated vegetable oils. These fats increase levels of LDL cholesterol and lower levels of healthy HDL cholesterol. By doing so, they raise the risk for heart disease and strokes. In 2015, the FDA took steps to remove artificial trans fat from the food supply for good by taking it off the GRAS ("generally recognized as safe") list. Manufacturers have until 2018 to complete the process. In the meantime, scan the Nutrition Facts label of packaged foods to see if trans fat is listed.

Diet soda. A 2017 study in the journal *Stroke* linked regular consumption of diet soda to a higher risk of strokes and dementia. However, the reasons for the association are not clear, and the study does not prove cause and effect, so the warning is preliminary.

Supplements and the brain

If foods that are rich in nutrients like antioxidants, B vitamins, and omega-3 fatty acids are good for the brain, it would stand to reason that concentrated supplements of these nutrients would be even better. A number of nutritional supplements sold over the Internet and at drugstores embrace this premise, claiming to improve memory, concentration, and focus. They go by names like Brain Shield, Brain Super Boost, and Focus Formula, and they contain blends of supposedly memory-boosting ingredients, many of which are components of the Mediterranean diet.

The trouble with these products is they're largely untested. Without studies to confirm that they work—and with the potential for side effects—brain supplements may be more trouble than they're worth. Table 4 (page 28) lists some of the supplements that have been touted for brain health, the evidence, potential side effects, and foods that may be better sources of these nutrients.

STEP 2: Exercise regularly

Anyone who's taken a long run, pedaled through an intense spin class, or made it through an hour of power yoga will recognize the immediate effects of exercise on the body. As you run, pedal, or twist your body into various poses, your breathing rate intensifies, your heart pounds to circulate more oxygenated blood to your muscles, and you break out in a sweat. You also get an immediate boost in energy and alertness—and research indicates that there are benefits to both mood and cognitive function as well.

The many benefits of exercise

The positive effects of regular exercise on the body have been well documented and are so numerous that some doctors now recommend exercise to their patients for a variety of ills. Among its many benefits, exercise

- helps prevent weight gain and obesity and is especially useful for keeping weight off (provided that you don't offset your exercise sessions with more sedentary time and increased calories in your diet)
- lowers blood pressure and reduces your risk for heart disease, heart attacks, and strokes
- decreases your odds of getting diabetes and certain cancers—including breast and colon cancer
- strengthens your muscles and bones and helps prevent debilitating falls.

Exercise is also a powerful tool to protect the brain against the detrimental effects of aging, thanks to a number of positive changes it exerts on both brain structure and cognitive abilities. Among other things, it

- rushes oxygenated blood to nourish brain cells and fosters the growth of new blood vessels in the hippocampus, cerebellum, and other brain regions
- increases levels of brain-derived neurotrophic factor (BDNF), a molecule that encourages the growth of new neurons and maintains the health of existing ones
- preserves and even improves volume in regions of the brain that tend to shrink with age, such as the prefrontal areas and hippocampus
- maintains the integrity of white matter, which is fundamental for the transmission of information
- enhances neurogenesis and reverses normal age-related declines in new nerve cell generation
- enhances cognitive control and reduces impulsivity, promoting better decision making
- improves sleep and mood
- may help clear the plaques that contribute to Alzheimer's disease (this possible effect of exercise is still under investigation).

As a result, exercise has been found to improve a variety of cognitive functions that tend to decrease with age and the onset of dementia. For example, active older adults are able to focus better and process information more quickly than those who are sedentary, which enables them to perform tasks and complete challenges more effectively.

A number of observational studies have shown that people who are more physically active have a lower risk for Alzheimer's disease and other forms of dementia. One study, reported several years ago in *Annals of Internal Medicine*, looked at 1,740 people over age 65. Researchers found that people who exercised more than three times a week were 34% less likely to be diagnosed with dementia than those who were less active. Fit individuals also score higher on tests of attention, verbal fluency, verbal memory, and other cognitive abilities. More recent randomized controlled trials suggest that exercise is particularly helpful for improving executive functions like planning, scheduling, and multitasking.

Exercise is especially potent when partnered with a brain-healthy diet and the other steps outlined in this report. A 2015 study published in *The Lancet* was one of the first trials to look at the combined effects of exercise plus diet, cognitive training, and management

of cardiac risk factors among a group of older adults who were at risk for dementia. The study, called the Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability (FINGER), assigned a group of participants to a multipronged program that included the following:

- an exercise program combining strength training (one to three times a week), aerobic exercise (two to five times a week), and balance training
- a diet low in saturated fat, salt, and sugar and high in polyunsaturated and monounsaturated fats, fiber, and fish
- computer-based and psychologist-led cognitive training sessions, plus social activities
- management of risk factors such as high blood pressure, weight, BMI, and waist circumference.

After two years, participants who had engaged in these healthy lifestyle interventions had improved or maintained cognitive outcomes like executive functioning, memory, and processing speeds by 25% to 150% compared with the control group.

To gauge whether you're active enough, try using the International Physical Activity Questionnaire (see page 32). If you've been sedentary in the past, don't be discouraged. It's never too late to begin reaping the many benefits of a more active lifestyle. Start incorporating more physical activity into your day, but do so gradually. You never want to dive straight from inactivity into intense exercise. And if you've had surgery recently or have any existing health conditions like heart disease or diabetes, talk with your doctor before starting to exercise (see "Safety first," page 33). Your doctor and a physical therapist can help you structure an exercise program that's safe and realistic for you. Harvard Medical School also has published a number of Special Health Reports on core exercises, strength and power training, stretching, balance exercises, and walking for health (see "Resources," page 50).

What type of exercise is best for your brain?

As you get ready to start an exercise program, remember always to exercise within your budget, interests, and comfort zone. Choose a routine you enjoy and are likely to stick with—whether it's playing tennis, walking, dancing, or attending a formal fitness class. You don't have to invest thousands of dollars in a gym membership. If you're budget conscious, buy fitness DVDs and follow them at home, or simply walk outside.

That said, you should make an effort to have a well-rounded program that includes more than one type of exercise. As the FINGER study illustrates, the ideal brain fitness program includes both aerobics and weight training. Research suggests that each kind of exercise exerts a slightly different effect on cognitive function. Mind-body activities, such as yoga and tai chi, also seem to have cognitive benefits. The key with any form of exercise is that you work to the very limit of your ability, pushing yourself as hard as you can. It seems that extra push translates into real cognitive benefits.

Here's a look at the best-studied fitness programs for cognitive health, and how much of each exercise you need to engage in to see results. In any case remember that some exercise is always better than none.

Aerobic exercise

Aerobic exercise, also known as "cardio," is any activity that makes your heart beat faster to pump additional oxygen to your muscles and brain, and that causes your body to burn fat stores for energy. A brisk walk, bike ride, swim, and dance class all count as aerobic activities.

In addition to burning fat, aerobic exercise exerts a profound influence on brain structure and activity. It's been shown to increase both gray and white matter, which could prevent age-related cognitive loss, and it counteracts brain volume declines in people who already have dementia. As evidence, people with early-stage Alzheimer's who are more aerobically fit show less brain atrophy than those who are less fit.

Arthur Kramer, a psychology professor at Northeastern University, has been researching the effects of exercise on brain plasticity for the better part of two decades. Over the years, his studies have noted the benefits of aerobic exercise on executive functions like attention and working memory. He's found that as little as six months of exercise is enough to produce visible functional changes in the brain. Even people who have

International Physical Activity Questionnaire

The questions below were adapted from the International Physical Activity Questionnaire (IPAQ), which was developed by an international group of experts in the late 1990s. It has been validated in several countries as an accurate measure of physical activity level. Your goal is to be moderately to highly active on most—if not all—days of the week.

When answering these questions, think about the activities you did while at work, at home, and during travel and recreation.

Vigorous activities

Count activities that took a good deal of physical effort and made you breathe harder than usual for at least 10 minutes at a time.

1. During the last seven days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ days per week

   ❏ No vigorous physical activities—skip to question 3

2. How much time did you usually spend doing vigorous physical activities on one of those days?

   _____ hours per day _____ minutes per day

   ❏ Don't know / not sure

Moderate activities

Count activities that took moderate physical effort and made you breathe harder than usual for at least 10 minutes at a time.

3. During the last seven days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or playing doubles tennis? (Walking, which is addressed below, doesn't count.)

   _____ days per week

   ❏ No moderate physical activities—skip to question 5

4. How much time did you usually spend doing moderate physical activities on one of those days?

   _____ hours per day _____ minutes per day

   ❏ Don't know / not sure

Walking

Think about the time you spent walking at work and at home, to travel from place to place, and for recreation or exercise.

5. During the last seven days, on how many days did you walk for at least 10 minutes at a time?

   _____ days per week

   ❏ No walking—skip to question 7

6. How much time did you usually spend walking on one of those days?

   _____ hours per day _____ minutes per day

   ❏ Don't know / not sure

Sitting

Consider how much time you spent sitting at work, home, and elsewhere. This includes time spent lying down.

7. During the last seven days, how much time did you spend sitting on a typical weekday?

   _____ hours per day _____ minutes per day

   ❏ Don't know / not sure

Calculate your score

To determine your activity level, weight each type of activity by the amount of energy you expend on it in a typical week, using the formulas provided below. (MET stands for "metabolic equivalent" and measures energy expenditure during activity versus energy expenditure at rest.)

Walking: 3.3 × _____ minutes spent walking × _____ days you walked = _____ MET-minutes per week

Moderate activity: 4 × _____ minutes spent doing moderate-intensity activity × _____ days you performed moderate exercise = _____ MET-minutes per week

Vigorous activity: 8 × _____ minutes spent doing vigorous-intensity activity × _____ days you performed vigorous exercise = _____ MET-minutes per week

_____ Walking × _____ Moderate _____ + Vigorous = _____ MET-minutes/week

You're moderately active if you do

- three or more days a week of vigorous activity at least 20 minutes a day, OR
- five or more days of moderate-intensity activity or walking for at least 30 minutes a day, OR
- five or more days of any combination of walking, moderate-intensity, or vigorous-intensity exercise that totals at least 600 MET-minutes/week.

You're highly active if you do

- vigorous-intensity activity on at least three days a week that totals at least 1,500 MET-minutes/week, OR
- seven days of any combination of walking, moderate-intensity, or vigorous-intensity activities that total at least 3,000 MET-minutes/week.

Your physical activity levels are low if you don't meet either of these two categories. Start incorporating more moderate- and high-intensity exercises into your routine—and try to spend less time sitting.

already begun to see the effects of cognitive decline show improvements as they become more active.

How much aerobic exercise should you do? The Physical Activity Guidelines for Americans, issued by the U.S. Department of Health and Human Services, recommend that you do at least two-and-a-half hours of aerobic exercise a week. Doubling that amount seems to provide additional benefits.

Resistance training

Aerobic exercise becomes an even more powerful tool to combat brain aging when it's coupled with resistance training, also called strength training.

This type of exercise uses weights, exercise bands, and other forms of resistance to build muscles and increase endurance. Research shows that twice-weekly strength training sessions improve brain plasticity, attention, and associative memory (the ability to learn new information, such as the name of someone you've just met). A resistance training program might also help stabilize white matter and prevent it from shrinking.

How much resistance training should you do? You should aim for two 30-minute sessions each week (in addition to aerobic exercise), working all major muscle groups—chest, arms, legs, back, and abdominals. Allow 48 hours between sessions to give your muscles a chance to recover.

Mind-body exercises

Aerobics and resistance training are undoubtedly the pillars of an exercise program for improving cognition, yet mind-body techniques are also a worthwhile addition to any comprehensive cognitive fitness routine. Yoga and tai chi are based on the principle of focusing body, mind, and breath to achieve physical fitness and mental relaxation. Though their movements are slow and deliberate compared with aerobic activities like walking or cycling, mind-body exercises exert effects on the body similar to moderate-intensity exercise, including better lung function and lower blood pressure.

When researchers in Hong Kong assessed the relationship between exercise and memory in 140 older adults, they found people who did both cardiovascular and mind-body exercises improved their ability to acquire, retain, and retrieve information. Both types of exercises offered a similar memory boost. That's good news for anyone with health issues that make vigorous exercise difficult. Tai chi and slower forms of yoga are gentle on the body, easy to perform, and even possible to do from a wheelchair.

How much mind-body exercise should you do? Perform one session a week, which can replace one aerobics training session.

Reduce sedentary time

A formal exercise program is only one part of improving your overall fitness. If you exercise an hour a day but spend the other 14 hours sitting at a desk or in front of the TV, you defeat much of the purpose of your fitness routine. Excessive sedentary time is linked to an increased risk for obesity, type 2 diabetes, heart disease, and premature death—even in people who exercise regularly.

Engage in an hour or more of daily exercise, but aim to get more active over all. Stand up from your desk once an hour and walk around your office. Bike to work instead of driving. Walk around the mall before you shop. And walk in place while you watch TV.

Safety first

The goal of starting an exercise program is to improve your overall health. Yet if you're already living with a chronic condition like heart disease, type 2 diabetes, osteoporosis, arthritis, or chronic obstructive pulmonary disease (COPD), you could end up hurting yourself if you don't tailor your fitness program to your condition. The best way to assess your readiness for exercise is to see your doctor. Your provider, with the help of a physical therapist or exercise physiologist, can help you structure a program that suits your health and ability level. If you have any doubt about whether you should talk with a doctor before starting, fill out the Physical Activity Readiness Questionnaire for Everyone, PAR-Q+; you can find it at www.health.harvard.edu/PAR-Q. If you have any of the following chronic conditions, your doctor might suggest modifi-

cations like these to make your exercise safer:

Heart disease. Avoid exercises that involve heavy lifting, because they can raise blood pressure. Use lighter weights instead, and do more repetitions of each exercise. Remember to breathe, since holding your breath while weight lifting can also cause blood pressure to spike. Skip isometric exercises that strain muscles against other muscles (such as sit-ups and push-ups). Don't do outdoor activities in especially hot, humid, or cold weather because temperature extremes can affect blood circulation.

Diabetes. Exercise makes your body more insulin sensitive and helps control blood sugar. But before diving in, you should see your doctor, who can offer the best advice for you after checking your heart, blood vessels, eyes, kidneys, feet, and nervous system. You may need special footwear to protect your feet, for example. Or if you have diabetic retinopathy, you may not want to participate in high-impact activities, which can cause bleeding into the eye. Once you get the go-ahead, try to exercise one to three hours after eating, when your blood sugar level is likely to be higher. Carry a carb snack like fruit juice or hard candy when you work out, in case your blood sugar drops too low. Drink plenty of water during and after exercise. Wear a medical alert bracelet indicating that you have diabetes and whether or not you take insulin.

Osteoporosis. Incorporate weight-bearing exercises like walking, stair climbing, and dancing, which help maintain bone strength. Avoid high-impact exercises like jogging or jumping that could lead to fractures. Be careful not to bend or twist your spine, as this could lead to spinal compression fractures. You might need to avoid activities like yoga and bowling, which incorporate twisting motions.

Arthritis. Don't run or jump, as these high-impact activities can be hard on your joints. Instead, do gentle, low-impact exercises such as walking, bicycling, and swimming. Exercise within a comfortable range of motion. There are programs specifically designed for people with arthritis. Examples include Fit and Strong, a program targeted to older adults with osteoarthritis; the Arthritis Foundation's Exercise Program (AFEP); and its Walk with Ease program. There are also water-based therapy programs, such as the Arthritis Foundation's Aquatic Program.

COPD. During exercise, inhale through your nose, keeping your mouth closed, to warm and filter the air. Exhale slowly and gently through pursed lips to improve lung action. If you ever feel short of breath, stop exercising right away. Stay hydrated, but don't drink more fluid than your doctor recommends. Seek indoor options when it is very cold or hot and humid outside.

No matter what condition you have, ease into any new exercise program slowly. You might walk for only a few minutes at first, gradually increasing the duration and intensity of your strolls. Lift light weights (1 or 2 pounds) to start, and gradually increase by a pound at a time as you get more comfortable with the weight. If you ever feel any discomfort or symptoms such as shortness of breath, chest pain, dizziness, or rapid heartbeat, stop exercising right away and consult your doctor.

Is exercise boosting your cognitive fitness?

With any intervention, lifestyle or medical, results are the real measure of success. While you can easily quantify the weight loss from your exercise program with a scale or tape measure, cognitive gains may not be as easy to measure.

The best way to determine how much your mental fitness has improved with exercise is to test your cognitive fitness over time. Refer back to the assessment you did earlier, whether it was from your doctor, a brain fitness club, or a validated online tool like Test My Brain (see "How to test your cognitive fitness," page 5). Use your initial results as a baseline. Retake the test to see whether your results have changed, and if so, by how much. You should see an improvement in certain aspects of memory and other cognitive abilities within six months of starting your exercise program.

Note, however, that repeating a test too often may be misleading. Sometimes you'll improve simply because you've learned the test, rather than because you improved the cognitive ability being evaluated. Using validated measures and following the instructions carefully can help prevent these false results.

STEP 3: Get enough sleep

Sleep is essential for good health. You've likely sensed its importance whenever you've slept poorly. A lack of sleep leaves you physically drained and mentally foggy. Sleep affects virtually every aspect of your health, from immune function to metabolism and memory. Sleep deprivation impairs attention, concentration, working memory, long-term memory, reasoning, and decision making, all of which are essential for acing a test or impressing a roomful of work colleagues. People who drag through their days heavy-lidded pose a danger to themselves and others on the roads, function poorly at work, and are more likely to suffer from depression. What's more, research has linked chronic sleep deprivation to an increased risk for conditions like obesity, diabetes, high blood pressure, and heart disease.

Sleep is also essential for memory. To learn new information, you must be able to pay attention, which you can't do if you're nodding off. It's also harder to hold on to memories and retrieve information you've learned previously if you're poorly rested, because the process in which you cement new information into your memory banks (called consolidation) occurs while you sleep.

Despite all the evidence to support the benefits of getting a good night's rest, Americans continue to be chronically sleep deprived. According to the CDC, more than a third of adults are not getting the minimum seven hours of uninterrupted rest recommended for optimum health. "Uninterrupted" is the key word. While many adults do accumulate the recommended sleep totals nightly, the rest they get is sporadic. Their slumber is continually interrupted as they're jarred awake by the stress of an upcoming work project, the need to use the bathroom, or the disruptions of a condition like sleep apnea or restless legs syndrome.

Sleep stages and memory

To fully grasp the importance of sleep to cognition, you need to understand what happens in your body and brain during the various stages of sleep, which alternate throughout the night in a fairly predictable pattern.

- **Stage 1.** You are in between being awake and falling asleep. Your sleep at this stage is light and easily interrupted.
- **Stage 2.** This is the first stage of true sleep. Your heart rate and breathing slow, and you start to become unaware of your surroundings.
- **Stage 3 (slow-wave sleep).** In this phase of sleep, which is also referred to as deep sleep, your breathing and heart rate have slowed. Your blood pressure has dropped. Your muscles are relaxed. During this phase, your tissues regenerate and your body releases essential hormones. If someone were to try to rouse you now, you'd have a hard time awakening and would feel groggy.
- **Rapid-eye-movement (REM) sleep.** Dreaming occurs in REM sleep, during which your body is paralyzed but your eyes dart back and forth behind closed eyelids. Your blood pressure increases, and your heart rate and breathing speed up to daytime levels.

Of these phases, the one that is most important for memory is REM. During the heightened brain activity of REM sleep, you process and consolidate new information you've learned. When you first acquire new memories, they're flimsy and easily forgotten. Your brain needs to process them to make them stick. Sleep helps shuttle information from the brain's temporary storage—the hippocampus—into its permanent memory troves in the frontal cortex. While you rest, you also merge existing information you've learned with new knowledge, a process that is instrumental to problem solving.

During REM sleep in particular, your brain processes complex, fact-based—or *declarative*—memories. For example, if you learned on TV that the artistic term "Impressionist" was first used as an insult, your

memory would solidify that information during REM sleep so you could recall it during an art talk a few months later. In REM sleep, you also reinforce *procedural* memories—the ability to perform tasks, like playing the piano, for example. In addition, your brain processes *emotional* memories—like an argument you've had with your partner—to help you make better sense of what happened. This is why people often recommend that you "sleep on it" when you're dealing with a problem. While you sleep, your brain prioritizes memories—shoring up the more important ones while marking the less useful ones for deletion.

That's not to say that REM is the only sleep phase that plays a role in memory. Researchers say declarative memories are also processed during slow-wave sleep, and both slow-wave and REM sleep influence visual learning—the ability to learn new ideas by associating them with images.

How much sleep is required to cement existing information into memory? Robert Stickgold and his colleagues at the Center for Sleep and Cognition at Harvard-affiliated Beth Israel Deaconess Medical Center have studied the role of sleep in learning and memory consolidation. According to Stickgold, for every hour you're awake during the day, you need a full half-hour of sleep time to process the new information you've learned. By contrast, he's found that a lack of sleep can impair the ability to remember and make sense of what you've learned. In one of his studies, students who were taught a new task and then deprived of sleep for a night were less able to remember how to do that task for up to three days afterward.

There is limited evidence that we may also learn some types of information that we're exposed to during sleep. For a 2012 study published in *Nature Neuroscience*, researchers exposed participants to a variety of scents—some pleasant, others unpleasant. They matched the scents to sounds. When the subjects awoke, they sniffed in response to the sounds alone, suggesting they'd learned a new association between sound and smell while they slept.

Researchers are still trying to fully understand the role of sleep in memory. What they learn could one day lead to new treatments or strategies to help preserve memories, especially as we age.

Sleep and inflammation

Inflammation is the body's natural response to disease and injury. When you come down with a respiratory infection or cut yourself, your immune system activates white blood cells, which in turn release cytokines and other inflammatory molecules that attack invaders and protect the body's tissues. When this response is temporary, it serves as an effective defense mechanism. But when inflammation doesn't let up, it can contribute to the development of heart disease, diabetes, stroke, cancer—and Alzheimer's disease.

When Janet Mullington of the Harvard Medical School Division of Sleep Medicine and her colleagues at Beth Israel Deaconess Medical Center studied the effects of sleep deprivation on inflammation, they found increases in inflammatory molecules—including cytokines, interleukin-6 (IL-6), C-reactive protein (a marker that's elevated in people at risk for heart disease and diabetes), and others—among people who weren't sleeping well. While these signs of inflammation could be attributed to other factors—stress, smoking, or obesity, for example—they do suggest that sleep deprivation plays a role in the inflammatory process. And they could help explain why people who sleep poorly are at risk for cardiovascular disease, high blood pressure, and diabetes, among other chronic conditions.

How does a lack of sleep contribute to inflammation? One theory focuses on blood vessels. During sleep, blood pressure drops and blood vessels relax. When sleep is restricted, blood pressure rises, which could trigger cells in blood vessel walls that activate inflammation. A lack of sleep might also alter the body's stress response system.

The beta-amyloid–sleep connection

Researchers are increasingly recognizing a connection between a lack of sleep and Alzheimer's disease. People with Alzheimer's often have difficulty sleeping through the night, but in a chicken-and-egg fashion, it's not clear whether the disease leads to sleep issues or whether a lack of sleep contributes to Alzheimer's development.

In recent years, studies have discovered elevated levels of beta-amyloid—the destructive protein that

accumulates in the brains of Alzheimer's patients—in people whose sleep is interrupted or of poor quality. A 2013 study published in the journal *Sleep* suggested that people who slept fitfully or too little in midlife were more likely to develop dementia decades later.

The brain has a remarkable housecleaning process that should prevent beta-amyloid buildup, and it happens while we sleep. In the deepest sleep phases, cerebrospinal fluid rushes through the brain, sweeping away beta-amyloid protein before it can congregate and destroy brain cells. Without a good night's sleep, this housecleaning process is less thorough, allowing the protein to accumulate. Then, a vicious circle sets in. Beta-amyloid buildup in the brain's frontal lobe starts to impair deeper, non-REM slow-wave sleep. This damage makes it harder both to sleep and to retain and consolidate memories.

How sleep changes as you age

Age launches a double assault on cognition. As you naturally start to lose volume in your brain's storage and retrieval centers, you also have more difficulty sleeping through the night, which compromises memory even more.

Contrary to what you might have heard, your sleep needs don't change as you reach your seventh decade and beyond. You still need seven to nine hours nightly, but you might find it harder to log those hours. That's because the structure and pattern of sleep—a concept that experts term "sleep architecture"—shifts with age. You go to asleep and wake up earlier. You have a harder time falling asleep and staying that way throughout the night. You do not have as much deep sleep. Your sleep is more fragmented, broken up by bathroom visits and ailments that become more prevalent with age, such as arthritis or reflux. A number of medications you may take to treat these and other conditions can also keep you up at night (see Table 5, page 38).

Older adults who don't sleep well are groggier and less attentive during the day. A lack of alertness can contribute to falls, which are more likely to lead to a fracture in someone whose bones have been made brittle by osteoporosis. Seniors who don't sleep well have more trouble remembering what they've learned, compounding the problems of mild cognitive impairment or various forms of dementia.

Sleep issues can also be symptoms of a condition like Parkinson's, Alzheimer's, or depression. Let your doctor know if you consistently have trouble falling or staying asleep, so you can find the treatment or solution that best fits the cause.

Poor sleep isn't something you have to resign yourself to living with. Strategically placed and timed daytime naps can help you recoup some of the sleep you're missing and be more alert during the day as a result. Experts typically recommend a 20- to 30-minute power nap to help rejuvenate you without causing grogginess or keeping you from falling asleep at night. Yet for the purpose of enhancing memory, longer naps might be better. Research from Robert Stickgold at Beth Israel Deaconess Medical Center suggests that a 60- to 90-minute nap, which provides enough time to cycle through both slow-wave and REM sleep, can help you learn a new task as effectively as a full night's sleep. You can extend the time, provided the longer nap doesn't keep you awake at bedtime.

Strategies for better sleep

If you're having trouble falling asleep and you toss and turn during the night, the problem could lie in your sleep routine. Don't wait until bedtime to implement changes. Improving sleep is a daylong process that should start as soon as you wake up in the morning.

Early in the day:

- Wake up approximately at the same time every morning, even on weekends. You want to get your body into a sleep-wake routine. Coordinate bedtime and wake time to give yourself at least seven to nine hours of sleep nightly.
- Get outside. The sunlight will help regulate your sleep-wake cycle. If the weather is too cold for outdoor excursions, sit by the window or in a well-lit room (you can even buy special light boxes that mimic outdoor light in stores or on the Internet) for a few minutes each morning.
- Keep up with your exercise program (see "Step 2: Exercise regularly," page 30). A daily walk, bike ride, or other fitness session can improve the qual-

Table 5: Medicines that can make you lose sleep

Here are some of the medications known to cause insomnia. If you're on one of these drugs and are having trouble sleeping, ask your doctor whether it's worth switching to another medicine. However, don't just stop taking a drug without first consulting your doctor, because you may need it to control health problems.

DRUG CLASS	EXAMPLES	USED TO TREAT
Alpha blockers	doxazosin (Cardura) prazosin (Minipress) terazosin (Hytrin)	high blood pressure, enlarged prostate (BPH)
Angiotensin-converting enzyme (ACE) inhibitors	benazepril (Lotensin) captopril (Capoten) enalapril (Vasotec) ramipril (Altace)	high blood pressure
Angiotensin-receptor blockers (ARBs)	candesartan (Atacand) losartan (Cozaar) telmisartan (Micardis)	high blood pressure, heart failure
Antihistamines (newer generation)	cetirizine (Zyrtec) fexofenadine (Allegra) loratadine (Alavert, Claritin)	colds, allergies
Beta blockers	atenolol (Tenormin) metoprolol (Lopressor, Toprol-XL) propranolol (Inderal LA, InnoPran XL)	high blood pressure, glaucoma, migraines
Cholinesterase inhibitors	donepezil (Aricept) galantamine (Reminyl) rivastigmine (Exelon)	Alzheimer's disease
Corticosteroids	methylprednisolone prednisone	asthma, rashes, lupus, rheumatoid arthritis, and other inflammatory conditions
Selective serotonin reuptake inhibitors (SSRIs)	citalopram (Celexa) escitalopram (Lexapro) fluoxetine (Prozac) paroxetine (Paxil) sertraline (Zoloft)	depression
Statins	atorvastatin (Lipitor) lovastatin (Mevacor) pravastatin (Prevachol) rosuvastatin (Crestor) simvastatin (Zocor)	high cholesterol
Thyroid hormone	levothyroxine sodium (Synthroid)	underactive thyroid

ity of your sleep and help you feel less drowsy during the day. Some studies have pinpointed morning as the best time to exercise, but later in the day is fine, too, as long as it's not within two hours of bedtime. Exercise is energizing and can interfere with sleep if done too late in the day.

In the evening:

- Eat a small, light dinner. A large meal can make you feel too full to sleep comfortably. Big nighttime meals can also contribute to heartburn.
- Avoid foods and drinks that could keep you awake. This includes caffeine, alcohol, and spicy foods.

- Avoid nicotine, which is a stimulant.
- Resist the temptation to lie in bed and read or watch TV. Your brain learns to associate the bed with the activities you typically do there. Go to bed only when you are ready to sleep.

Before bed:

- About an hour before bedtime, turn off all electronics—including your laptop, phone, TV, and e-reader. Many electronic devices emit a particular type of blue light that activates your brain and keeps you awake. Some e-readers and other devices today will filter out this light for you. Better yet, read a book instead.
- Check your room. To maximize sleep, the environment should be dark, quiet, cool, and comfortable. If it's too bright, close the shades. If your partner snores or street noises keep you awake, turn on a white noise machine or fan, or put in earplugs.
- About 30 minutes before bedtime, start your sleep routine. Do the same set of activities every night, so your mind and body will know it's time for sleep. Your routine should involve calming activities, like taking a warm bath, listening to soft music, doing some stretches, breathing deeply, or getting a massage from your partner.

At bedtime:

- Give yourself time to ease into sleep. Turn off the light and settle in when you just start to feel sleepy.
- If you can't fall asleep within 30 minutes, get out of bed. Go into another room and do something calming—like knitting or reading—for 15 to 20 minutes. Wait until you get sleepy, and then climb back into bed.

Nondrug approaches

If these techniques don't help you fall asleep and stay asleep, talk to a doctor or see a sleep specialist. You might also try one of these nondrug treatments for insomnia:

Relaxation techniques can calm an overexcited or stressed mind and help you fall asleep. With progressive muscle relaxation, you systematically tighten and then relax the muscles from your head to your feet. During meditation, you close your eyes and slowly breathe in and out while clearing your mind or focusing on a word. Guided imagery has you imagine a soothing scene—such as a beach—to bring you into a more relaxed state.

Cognitive behavioral therapy for insomnia (CBT-i) targets "insomniaphobia"—sleep-related anxiety that can keep you awake. CBT-i helps to foster calming thoughts that are more conducive to sleep. It may include relaxation techniques, such as the ones described above.

Can sleep aids help?

Good sleep hygiene outlined in the steps above is the best way to improve sleep. But what if you've tried everything and you're still sleeping fitfully or not at all? A number of sleep aids are available over the counter or with a prescription from your doctor, but they come with some pretty big cautions.

Many of the over-the-counter sleep aids (such as Unisom and ZzzQuil) contain ingredients like diphenhydramine—an older-generation antihistamine that makes you feel drowsy, so you fall asleep more easily. Benzodiazepines like lorazepam (Ativan), diazepam (Valium), and alprazolam (Xanax) are anti-anxiety drugs that also make you feel drowsy, but they can be addictive. Both benzodiazepines and first-generation antihistamines have been linked to an increased risk for dementia with long-term use (see "Over-the-counter and prescription drugs," page 23). Newer sleep aids such as zolpidem (Ambien), eszopiclone (Lunesta), and zaleplon (Sonata) avoid the daytime hangover and are less habit-forming than benzodiazepines, but they can cause strange and alarming side effects like sleepwalking, nighttime eating, and driving while asleep. And although these sleep aids may improve your slumber, they, too, could also impair your cognitive abilities.

If you want to try a sleep aid, it's best to use it at the lowest effective dose for the shortest period of time possible. These drugs are most appropriate for short-term problems that disrupt sleep, such as traveling across time zones or coping with a death in the family. If you've tried one for a few months and still can't sleep without it, ask your doctor for other treatment options. Some people find that supplements such as valerian, chamomile, or melatonin help, but research backing them is scant.

STEP 4: Manage your stress

Stress is an ever-present and inescapable part of life in the modern world. Our triggers are varied and numerous—a difficult job, relationship troubles, traffic, money issues, health concerns. Though the human body was built to withstand a certain degree of stress—and some people seem to thrive on it—stress can take a real toll on your health when it becomes constant or overwhelming.

When your body is under duress, the sympathetic nervous system launches a cascade of physiologic events known as the "fight or flight" response, which prepares your body to either stand your ground and fight or else flee to safety. Your pulse quickens. Breathing speeds up. Muscles tense. Your liver releases more glucose (sugar) into your bloodstream to give you energy. Platelets become stickier, to aid clotting and minimize bleeding from any potential injuries. Immune system activity picks up to combat infection from any wounds you might suffer. Body systems not needed for the immediate emergency are suppressed in order to focus energy where it's needed. A series of stress hormones such as cortisol, epinephrine, and norepinephrine help orchestrate the response.

The stress response is extremely helpful when a tornado or a mugger is headed your way, because it enables you to spring into action. After the threat has passed, your parasympathetic nervous system takes over, bringing hormone levels, along with breathing, heart rate, and blood sugar levels, back to normal. It is only when this fight-or-flight system fires repeatedly in response to everyday stressors that it can become detrimental to both body and mind.

What happens to your brain when you're stressed?

Short-term stresses, like an upcoming work presentation or final exam, can actually be good for the brain, challenging it to perform at its peak. Some people thrive on this type of stress, and they do better when they're tested in this way.

However, when stress is intense or continues unabated, it begins to produce changes to the brain's structure and function. Long-term exposure to cortisol and other stress hormones can have real, measurable effects on the brain—particularly in the areas of the hippocampus, amygdala, and prefrontal cortex.

Researchers have learned much of what they know about the effects of stress on the brain from studying people with post-traumatic stress disorder (PTSD), a condition that develops in someone who's lived through an especially harrowing experience. Normally, after a traumatic event like the loss of a loved one, you suffer for a time. Though you may never forget the painful event, it eventually recedes into memory. Yet when stress is extreme or prolonged, such as that experienced by combat veterans and survivors of childhood abuse, the brain undergoes structural and functional changes that can permanently alter it.

For example, a constant flow of stress hormones can slow or even halt the production of new neurons in the hippocampus—the part of the brain that helps encode memories. As evidence, researchers have noted that people with PTSD have a reduction in hippocampal volume, which correlates to greater difficulty learning new information and to more fragmented memories. Chronic stress can also lead to shrinkage in the prefrontal cortex—the part of the brain involved in planning, judgment, and decision making. At the same time, stress hormones *increase* the number and activity level of neurons in the amygdala—the region that perceives threats and processes fears. Long after the traumatic situation has passed, someone with PTSD will continue to relive and respond to the event as if it were ongoing.

While most of us will never develop PTSD, the experience of people with this devastating condition illustrates the detrimental and far-reaching effects of

stress on the brain. And many of these same effects can occur, to a lesser degree, in someone with lower but constant levels of stress. Over time you may have more trouble remembering, and you may be less adept at responding to stress in the future. (To determine your current stress levels, see "How stressed are you?" on page 42.)

The effects of stress on the brain can be significant, but they are reversible to some extent. Building cognitive reserve with the techniques outlined in this report can help you compensate. Exercise and relaxation techniques such as deep breathing can build back lost hippocampal volume, while simultaneously helping you better cope with any future stress you encounter.

Ways to manage stress

We know stress is detrimental to both body and mind. Yet you can't simply wipe away a difficult job, trying relationship, or financial troubles. The key is not to rid your life of stress, but rather to learn how to manage it more effectively so that it exerts less of a damaging influence. Here are a few tested methods that can help. Included prominently among them are most of the six foundational elements of this cognitive fitness program.

Exercise

While it tones your muscles, burns fat, and enhances brain activity, exercise also improves your mood and relieves stress. When you jog, swim, dance, or play tennis, your brain releases natural painkilling chemicals called endorphins, which give you the immediate good feeling sometimes termed a "runner's high." At the same time, working out focuses your mind—on the feel of your arms slicing through the water, or the angle of your shot as you aim the ball at the basket. The preoccupation steers your thoughts away from the day's stressors. Regular exercise also helps you sleep better, which itself can combat stress.

When designing your routine, aerobic exercise and muscle conditioning are essential, but also consider adding yoga. This ancient practice combines a series of poses that strengthen and stretch muscles with deep breathing that calms the mind and reduces stress and anxiety.

Practice deep breathing

Has anyone ever told you to take a deep breath when you were upset? That advice is firmly rooted in science. Whenever you breathe deeply, the incoming rush of oxygen signals your brain to reduce its production of stress hormones. Your heart rate steadies, and your blood pressure slows. As a result of these physiological effects, you feel calmer and more focused.

Deep breathing, particularly at a moment of stress, can be challenging, but with practice you will be able to master it. You simply sit or lie down in a quiet room. Inhale deeply through your nose, letting your abdomen slowly expand. Hold the breath for a few seconds, and then exhale through your nose. You don't need to devote much time to deep breathing. Just a few minutes a day is enough.

Meditate

Meditation takes deep breathing one step further. Although its foundation is simple—breath coupled with mental focus—its application can take several forms. In mindfulness meditation, you shift your attention to the inward and outward flow of breath. When negative thoughts or concerns enter your mind, you simply let them pass, without judgment, through your mind. During mantra meditation, you repeat a word or sound, like "om," to keep your mind anchored in the moment. Yoga and tai chi combine poses and gentle movements, respectively, with deep breathing and inward-focused thoughts.

Meditation is simple and safe to try, and research suggests it can produce both structural and functional changes to the brain with as little as eight weeks of practice. Brain scans are giving researchers clues as to why this might be. MRI images taken after an eight-week meditation program reveal an apparent shrinkage in amygdala volume, which could correlate to better regulation of the stress response. Normally, shrinkage of the brain corresponds to poorer cognitive outcomes. But with the amygdala, smaller can be better, because a larger amygdala has been linked to higher levels of stress and anxiety.

Harvard neuroscientist Sara Lazar was one of the first researchers to discover the brain benefits of meditation. She found that, compared with nonmedita-

tors, meditators had a thicker cortex—a region of the brain essential to executive functions like planning and decision making. In fact, the cortex in the meditators resembled that of individuals 20 years younger, suggesting meditation may help compensate for age-related shrinkage in this region. In later research, Lazar and her colleagues also noted an increase in gray matter volume in the hippocampus—an area involved in learning and memory.

If you're new to the practice and aren't sure where to start, you can try one of the free downloadable meditations offered by Harvard psychologist Ronald Siegel at his website, www.mindfulness-solution.com.

Eat well

Stress can have two opposite effects on appetite. In the short term, the release of epinephrine and other stress hormones dampens your desire to eat. Over the long term, the production of cortisol stimulates hunger. In particular, stress increases your desire for so-called "comfort foods" like pizza, cake, and macaroni and cheese. These foods *are* comforting, at least momentarily. When you bite into a burger or chocolate bar, you get an initial pleasurable rush, as the fat and sugar make their way into your system and cause your blood sugar to spike. At the same time, comfort foods inhibit activity in brain areas where you process stress. The happy feeling is only temporary, however. After the blood sugar rush plunges into an inevitable crash, you're left feeling lethargic—not to mention hungry again.

When you're stressed, fruits and vegetables are much better options than comfort foods. A nutrient- and fiber-dense diet that's high in fresh fruits and vegetables increases serotonin production in the brain, which boosts mood. These foods are also high in antioxidants, which buffer the harmful effects of stress on the immune system.

Sleep

Anyone who's tried to fall asleep after a particularly trying day knows it's not easy to drift off when your mind is preoccupied with worry. When stress hormones course through your body and brain, they produce a state of arousal that prevents restful sleep. A lack of sleep in turn ratchets up stress levels even more. To escape this cycle and get more rest, follow the sleep hygiene tips outlined in the previous chapter (see "Strategies for better sleep," page 37). In particu-

How stressed are you?

It's not always clear to people how much stress they're under. This test will help you gauge your stress level. Remember that what counts is your *perceived* level of stress—for example, not necessarily the amount of work you have to do, but whether it leaves you feeling energized or exhausted.

To assess your stress level, choose the most appropriate answer for each of the following statements.

HOW OFTEN DO YOU...	ALMOST NEVER (1 POINT)	SELDOM (2 POINTS)	OFTEN (3 POINTS)	ALMOST ALWAYS (4 POINTS)
1. Find yourself with too little time to do things you really enjoy?				
2. Wish you had more support/assistance?				
3. Lack enough time to finish your work most effectively?				
4. Have trouble falling asleep because you have too much on your mind?				
5. Feel people expect too much from you?				
6. Feel overwhelmed?				
7. Become forgetful or indecisive because you have too much on your mind?				
8. Believe you're in a high-pressure situation?				
9. Feel you have too much responsibility?				
10. Feel exhausted at the end of the day?				

Add up your points. A score of 25 to 40 indicates that you have a high stress level. See a doctor or therapist to discuss ways to reduce your stress.

Adapted from Girdin DA, Everly GS, and Dusek DE, Controlling Stress and Tension *(Allyn and Bacon, 1996).*

lar, give yourself enough time to wind down before bed with a relaxing activity like a warm bath.

If the day's worries weigh heavily on your mind at bedtime, free yourself from them by writing them down. Keeping a journal or simply making a list of things you have to do tomorrow is an effective way to release your concerns so you can concentrate on getting a good night's rest.

Listen to music

A simple melody can be an incredibly powerful tool for combating stress. Music can mentally transport you to another time and place, calm frayed nerves, and even exert physiologic changes on your body—like slowing heart rate and lowering blood pressure. Studies suggest that listening to music during a challenging situation can reduce levels of anxiety and perceived stress, and improve your ability to cope. Music also touches areas of the brain associated with memory and emotion. This may be why some people with late-stage Alzheimer's disease perk up when they hear songs from their youth, and are able recall every word.

Which type of music is most soothing? Songs with a slower rhythm exert a calming effect on brain waves, putting the mind into an almost meditative state. Celtic, Native American, and Indian music that features flutes, strings, and the sounds of rain, thunder, and rippling water are particularly soothing, which is why you'll often hear these types of songs played at spas. On the other hand, music with faster beats can increase alertness and promote concentrated thinking, which can also help you cope with and reduce stress. Listen to whatever type of music you find helps you relax the most.

Laugh

The old saying "laughter is the best medicine" has more than a kernel of truth to it. Chuckling at a comedy or sharing a joke with a friend is a potent stress reliever. Each time you laugh, a rush of oxygen-rich air fills your lungs, nourishing your heart and brain. Your muscles and blood vessels relax. Production of feel-good chemicals like dopamine increases, while stress hormone production decreases. Even the anticipation of having a good laugh is enough to lower levels of cortisol and other stress hormones, according to one study.

If you want to harness the joint benefits of laughter and exercise, try laughter yoga. This program, which was developed in India, follows the premise that the body benefits from laughter, whether it's spontaneous or induced. The program incorporates exercise with a generous dose of belly laughs, and it's taught in thousands of centers around the world.

Stop multitasking

Though you might feel more efficient as you simultaneously talk on the phone, answer emails, and fill out a spreadsheet, by diluting your focus you're reducing your ability to do any one of these tasks well. Your brain was designed to focus on one thing at a time. In fact, you never really multitask. Instead, your brain uses additional resources to allow you to switch quickly back and forth between different tasks. Research shows that when you try to do too much at once, you not only increase your stress levels, but you also create a sort of mental "bottleneck" that reduces your efficiency and your ability to successfully complete any one of the tasks.

Stay positive

Keeping an upbeat attitude, even in the face of adversity, can undo many of the health-damaging effects of stress and other negative emotions. In the Nun Study of Aging and Alzheimer's Disease, nuns who had a positive, cheerful attitude in their youth lived an average of a decade longer than their less positive peers. The happier nuns also seemed to be protected against the damaging cognitive effects of Alzheimer's disease. Even nuns who were found to have Alzheimer's plaques and tangles in their brain after their death showed no signs of the disease in life, as if their positive spirit had enabled them to somehow overcome their condition.

Maintain social connections

A strong social support network can be your anchor during turbulent times. Just having a friend to call and vent to about your day is incredibly comforting. The act of connecting with another human being lowers stress hormones and decreases the perception of stress. Having accessible friends and family combats loneliness, improves feelings of self-worth, and increases your ability to cope with life's challenges.

STEP 5: Nurture social contacts

Humans are, by nature, social creatures. We cluster in family units and groups of friends, searching for companionship, comfort, support, and familiarity in a big and sometimes overwhelming world. Having solid social ties offers more than someone to call when you want to go out to dinner or see a movie. Social interaction can also have profound effects on your health and longevity. In fact, there's evidence that strong social connections may be as important as physical activity and a healthy diet.

Strong social interactions also protect your memory and cognitive function as you age. Research is demonstrating that people with strong social ties are less likely to experience cognitive declines than those who are alone. For example, in a study of more than 2,200 women published in the *American Journal of Public Health*, women with a large social network were less likely to develop dementia than women with fewer connections.

The opposite is also true. People who are socially isolated may face more rapid cognitive losses. Dr. Nancy J. Donovan of Harvard's Brigham and Women's Hospital studied the effects of loneliness on cognitive function among more than 8,300 adults ages 65 and older. After 12 years of follow-up, Dr. Donovan and her colleagues found that participants who reported loneliness experienced faster cognitive declines, according to results published in 2016 in the *International Journal of Geriatric Psychiatry*. Depression, which often goes hand in hand with loneliness, also correlated to faster cognitive decline.

How social connections affect cognition

Whether you're having a conversation or playing a game of tennis with friends, social contact stimulates and challenges your brain. Social activities require you to engage several important mental processes, including attention and memory. Frequent engagement helps strengthen neural networks, slowing normal age-related declines. It may also help delay the onset of dementia, in part by strengthening cognitive reserve.

Various studies have hinted at the ways different types of social engagement may enhance cognitive function:

- Playing chess, mah-jongg, or a card game like bridge improves episodic memory—your ability to remember specific events.
- Volunteering in an educational capacity—for example, by teaching children how to read—may slow age-related atrophy in brain regions needed for planning and organizing. Children's unexpected reactions and questions also force you to think on your feet.
- Conversations with friends and family not only expose you to new information, but also force you to frame your thoughts in different ways.
- Ballroom dancing, group exercise classes, and team sports combine the cognitive benefits of physical activity with social interaction.

Having a strong network of people who support and care for you can also help lower your stress levels. As discussed in the previous chapter, stress affects cognition in multiple ways. People with strong social networks not only tend to say they are less stressed—a subjective measure—but they also show less stress on objective measures. For example, people with many close relationships tend to have lower levels of stress-triggered inflammatory chemicals such as interleukin-6, which has been implicated in cardiovascular disease, osteoporosis, rheumatoid arthritis, and Alzheimer's disease.

People with stronger social networks also tend to have better physical health, including lower rates of heart disease and other conditions that compromise brain health. There are multiple reasons for this. Friends and family can encourage you to maintain better habits—for example, urging you to get more

exercise, see a doctor when you're sick, and eat better. And if you do get sick, having people to care for you—both emotionally and physically—can improve your odds of survival. In a study in the *Journal of Health and Social Behavior*, unmarried people were nearly twice as likely to die after heart surgery than those who were married, indicating the importance of having a loving caregiver by your side during recovery.

On the flip side, a 2010 meta-analysis published in *PLOS Medicine* looked at nearly 150 studies and concluded that people with a network of friends, family members, neighbors, and work colleagues were 50% more likely to live longer than those who were more isolated. According to the study, loneliness is as detrimental to health as smoking 15 cigarettes a day, being obese, or never exercising.

How to widen your social network

Ironically, just as your health begins to decline and you need social connections the most, they become more difficult to find and maintain. As your children leave home for college or other opportunities, you may lose touch with the other parents you used to see on a regular basis. With increasing age, you retire from the workplace, further reducing your daily network of contacts. Later, mobility issues and chronic health conditions may keep you housebound. Older family members and friends start to pass away, while children and grandchildren start independent lives of their own.

Yet growing older needn't prevent you from making new connections. Here are a few ideas to help you forge new friendships, whatever your age or stage of life.

Say hello. Introduce yourself to a new neighbor, or start up a conversation while in line at the grocery store. During the course of your conversation, you might discover common interests that could launch a new friendship. If you're shy, you might find that a simple smile quickly broadens your social horizons. When you smile, you give others the impression that you're friendly and approachable, and someone else just might walk up and start a conversation with you.

Join a group or club. Do you like to play golf or tennis? Are you fond of photography, crafting, or chess? Look for a club, class, or group in your area made up of people who share your interest. Check with universities, the YMCA, community centers, and your local library. Or search online for a program near you. You'll get even more of a cognitive boost if you take part in an intergenerational program that includes people of all ages.

Reach out. Friends come and go over a lifetime, and it's common to lose touch with people as you move, change jobs, or enter another stage of life. Search through your address book or Facebook to find former connections. Then, reach out by phone or email to see if you can rekindle an old relationship.

Volunteer. Donating your time to a good cause offers double benefits: you get to meet a whole new circle of contacts while doing something to help others. Choose your volunteer position based on your interests and skills. For example, if you used to be a teacher, you might teach inmates in a youth prison or help underprivileged children learn to read.

Get a part-time job. If you're retired, see if you can find opportunities for part-time work. Use your lifetime of experience to find a job in your previous field. Or simply do something you enjoy, whether it's working part-time in an art gallery or teaching continuing education classes. No matter what job you take, you'll make new social connections while earning money.

Try something new. Take part in an activity you've never done before. Learn a new language, take ballroom dance classes, or try pottery making. You'll meet a whole new group of people while simultaneously challenging your brain (see "Step 6: Continue to challenge your brain," page 47). You might even go back to school to study a topic that interests you, but that you never had time to study—like archaeology or 20th-century literature.

How many relationships do you need to protect your health? There is no specific number—and the answer is not a simple "the more, the better." What's crucial is to feel that you have sufficient social connections and a supportive social environment. To figure out whether you need more social connections, see "How lonely are you?" on page 46.

Staying connected in the digital age

There was a time when, if you wanted to connect with a friend or family member, you either had to go to his or her home, or pick up the phone and call. Today, computers and the Internet have expanded our social world exponentially. With the help of Skype or FaceTime, you can now see loved ones while you talk to them. Sites like Facebook, LinkedIn, and Classmates.com enable you to keep up with your high school friends and former work colleagues, many of whom you likely would have lost touch with otherwise. And Pinterest lets you share recipes, craft ideas, and other interesting tidbits with people from around the world.

Older adults are turning to social media in increasing numbers. In fact, the fastest growing segment in social networking is users ages 74 and older, according to a 2010 Pew Research Center report. For elderly people who are homebound because of mobility issues or who live far away from family and friends, the Internet can provide a lifeline—a way to reduce social isolation, loneliness, and depression.

It's not clear how online socializing affects the brain compared with in-person interaction. Research suggests that positive online interactions target the brain's reward centers. For example, in a 2016 UCLA study, seeing "likes" on a social media page triggered the same reward circuitry in teenagers' brains as eating chocolate. Social media and other online channels also benefit cognition by continually presenting your brain with new learning challenges.

However, a quick comparison suggests that time spent online does not provide the rich experience that in-person contact does. You can't cover as much territory in a series of messages as you can in a real conversation, nor do you reap all the rewards of human contact—a smile, a light touch on the arm, the joy of a shared experience. In fact, some research indicates that the more time people spend on social media sites like Facebook, the more unsatisfied they are with their lives. This may be because some people turn to social media to counteract feelings of sadness or social isolation, or because they become envious when they compare their friends' accomplishments with their own, but it suggests the medium may not be the cure-all for loneliness. By all means, spend time on social media, but also make time for real-world interactions—like book clubs and dinners out with friends.

How lonely are you?

Are you in need of new social connections? Take this quiz to find out whether you feel lonely, and if so, how lonely you are. For each question, indicate how often you feel the way described.

HOW OFTEN DO YOU...	NEVER (1 POINT)	RARELY (2 POINTS)	SOMETIMES (3 POINTS)	ALWAYS (4 POINTS)
1. Feel unhappy doing so many things alone?				
2. Feel you have no one to talk to?				
3. Feel you cannot tolerate being so alone?				
4. Feel as if no one understands you?				
5. Find yourself waiting for people to call or write?				
6. Feel completely alone?				
7. Feel unable to reach out and communicate with those around you?				
8. Feel starved for company?				
9. Feel it is difficult for you to make friends?				
10. Feel shut out and excluded by others?				

Add up your points. If you scored 25 or higher on this quiz, you have a high level of loneliness. A score of 30 or higher suggests a very high level of loneliness. Follow the tips in this chapter to widen your social network.

Source: UCLA Loneliness Scale, Dr. Daniel Russell.

STEP 6: Continue to challenge your brain

You've likely seen the phrase "train your brain" many times. A number of websites offer brain-training activities, which some of them claim are scientifically proven to make you smarter and sharper. But do they work?

There is evidence that the more you stimulate and challenge your brain—and the earlier you begin that stimulation—the more of a buffer you'll create against the detrimental effects of aging. Participating in intellectually challenging activities promotes brain plasticity and fosters the process of neurogenesis—the birth of new neurons in your brain. People who have led more intellectually robust lives thanks to their education, work, and leisure activities have more cognitive reserve and appear to face a lower risk of developing dementia as they age. Although they may still develop Alzheimer's plaques and tangles in their brains, they are better able to cope with and compensate for the disease's effects.

The cardinal rules of mental stimulation

Although you ideally want to start stockpiling cognitive reserve in your youth and continue the process throughout your lifetime, regardless of your age, educational level, or career, you can still build that reserve today by constantly learning new things and challenging yourself. As in the case of physical exercise, mental stimulation and mentally engaging activities do not need to be costly. Everything you do can become mental exercise if you pay attention to it and try to get better at it. For your brain-training program to be successful, consider doing the following:

Try something new. Continually expand your horizons by trying new experiences that fall outside your comfort zone. If you're a literature buff, do not just read, but also try something different, like a painting class. If you've never been much of a cook, enroll in a culinary class. Particularly helpful can be learning a new skill, such as gardening, a new language, or a musical instrument. Each time you expand your expertise by learning a new skill, you forge new neural networks.

Challenge yourself. If you have a favorite activity, continue to increase the level of difficulty. If you do a daily crossword puzzle, choose progressively harder puzzles. If you're taking language classes, try to read entire books in that language or engage in conversation with a fluent speaker. Only by continually challenging your mind will you build cognitive reserve.

Vary your cognitive workouts. Whether you're training your brain or exercising at the gym, you will benefit the most by cross-training. Just as the ideal physical training program combines aerobic activity for your heart with strength training for all the major muscle groups—arms, legs, back, and abs—you want brain training to work all parts of your brain. To do this, you need to vary your cognitive workout. Instead of doing crossword puzzles every day, play bridge one day and attend an art class the next. See a play, visit a museum, and take music lessons. Keep introducing new activities to maximize your mental workout.

Low-tech brain-training activities to try

If you're looking for some easy ideas to help kick-start your cognitive training routine, try these activities. For the greatest mental boost, mix and match them, and combine them with the other strategies (exercise, diet, sleep, stress relief, and social interaction) outlined in this report.

Puzzles. One of the easiest ways to flex your mental muscles is by filling in the daily newspaper crossword puzzle or working on a Sudoku. A study in the *Journal of the International Neuropsychological Society* that looked at nearly 500 older adults showed that regularly working crossword puzzles slowed the onset of

memory decline by as much as two-and-a-half years. For the best results, however, remember the cardinal rules of mental stimulation (see page 47). Do different kinds of puzzles—a crossword one day, Sudoku the next, and a word jumble the next day. As you master one type of puzzle, increase the difficulty level. And make puzzles part of a broader brain-stimulating routine. While puzzles do stimulate your brain, they hone only one ability—your crossword puzzle–solving skills—and will not help you remember a shopping list or where you left your keys.

Card and board games. Games that require you to retrieve information from your memory stores (such as Trivial Pursuit or Jeopardy!) or to think strategically (like Monopoly or Stratego) are good games for improving cognitive fitness. Checkers and chess also require you to strategize, as you continually have to figure out your next move in relation to your opponent. Bridge is particularly useful for improving mental fitness, because it requires you to harness a variety of mental skills, including memory, visualization, and sequencing. Playing with friends—for instance, in a weekly card game—adds a social component. There is evidence that regular game playing might have an impact on future memory. A study presented at the 2014 Alzheimer's Association International Conference showed that playing checkers, cards, or board games correlated to larger volume in the hippocampus—an area typically damaged by Alzheimer's disease.

Travel. Visiting a new place can yield many rewards. You have the chance to interact with and befriend people from different cultures, gain new experiences, and visit sites you've previously seen only in books or on television. Exposure to new sights, sounds, and even smells also enhances neuroplasticity, forming new connections in your brain. Travel abroad is especially beneficial, because you have the added challenges of communicating in another language and trying to immerse yourself in a different culture. To maximize your travel experience, stray away from your hotel and the big tourist attractions and try to engage with the local community. Set off on side streets. Simply exploring an unfamiliar area can produce changes in the brain. A study in *Proceedings of the National Academy of Sciences* showed that taxi drivers, whose jobs require a great deal of spatial navigation, have greater gray matter volume in certain areas of the hippocampus. This finding suggests that even in adulthood, the brain can rewire itself in response to new challenges.

If you can't go overseas, don't despair. Drive the back roads of a town you've never been to before. Visit a museum in a neighboring state. As long as you interact with people and have new experiences, you'll have something to gain cognitively.

Plays, films, concerts, and museums. Cultural activities are both enriching and intellectually stimulating, especially when you incorporate learning into the experience. For example, as you walk through a museum, read the descriptions next to each painting to learn about the artist, medium, and style. Take a tour led by an experienced museum guide, or participate in a question-and-answer session with an artist. When choosing an event, pick something that requires a little more effort on your part. For example, get tickets for a Shakespeare play instead of the most popular musical on Broadway. See a foreign film, and try to discern what the characters are saying without reading the subtitles. Or go to the symphony to hear a particularly complex classical composition. If there is a pre-concert lecture, sign up.

Music. Regardless of whether your preference is for country, rock, jazz, or classical, you've likely experienced the uplifting effect of music. Listening to a favorite song can immediately improve your mood and increase your energy level. Certain songs can transcend time and space, transporting your mind back to when you first heard them. Music even has the power to reach areas of the brain damaged by dementia, as evidenced by the "awakening" some Alzheimer's patients experience when they listen to music from their youth.

Listening to classical music and learning how to play an instrument are two ways to challenge your mind through music. For a more formal approach, a few programs are trying to harness the power of music to improve cognitive function and ward off dementia. For example, Baycrest Health Sciences, a geriatric residential living and research facility at the University of Toronto,

offers a music therapy program that incorporates singing, playing instruments, dancing, songwriting, and improvisation. The program is designed to enhance seniors' mental, physical, and emotional health.

Computer-based brain-training games

Simply participating in a range of online activities that are fun, engaging, and challenging can help you build cognitive strength and agility, so long as you are challenging your brain with new learning and tasks, rather than simply performing something you already know how to do.

What about brain-training programs, like Lumosity, BrainHQ, or Cogmed, that promise to boost I.Q. and improve measures of cognition like memory and processing speed? Many of these programs claim to be backed by scientific research. According to BrainHQ's website, its method is "proven to work—dozens of published papers (and counting) show real benefits from using exercises in BrainHQ." But in January 2016, the Federal Trade Commission sued the makers of another brain-training program, Lumosity, alleging they deceived consumers with false claims about the games' cognitive benefits.

While these programs do seem to offer a short-term boost in working memory, they mainly improve your ability to perform the specific task in the game—not your broader ability to learn and solve problems, which is the ultimate goal. The same can be said for the effects of video games, some of which have also been touted for brain-training purposes. For example, NeuroRacer, which was developed by scientists at the University of California, San Francisco, yielded improvements at multitasking in one study—and especially at playing NeuroRacer—but there was no evidence this improvement carried over into other real-world skills.

What's more, the gains of computer-based brain-training games do not appear to be sustained over the long term—and the games' cost is something else to take into consideration. These games can cost $15 or more per month. In 2014, the Stanford University Center on Longevity and the Max Planck Institute for Human Development in Berlin released a strongly worded consensus statement about brain-training games, which was signed by more than 70 of the world's leading psychologists and neuroscientists. It read: "We object to the claim that brain games offer consumers a scientifically grounded avenue to reduce or reverse cognitive decline when there is no compelling scientific evidence to date that they do. The promise of a magic bullet detracts from the best evidence to date, which is that cognitive health in old age reflects the long-term effects of healthy, engaged lifestyles." The experts concluded that "exaggerated and misleading claims exploit the anxieties of older adults about impending cognitive decline," and they called for more research.

More research is indeed necessary, but that does not mean that cognitive training does not offer promise and help. For example, results of a study called Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE), presented at the 2016 Alzheimer's Association annual meeting, were positive. The study, which began in 1998, recruited more than 2,800 older adults with normal cognitive health. Participants were divided into four groups: one group received no brain training, two got classroom instruction on memory and reasoning improvement, and the fourth group received 10 hours of computer-based speed-of-processing training (in which participants see a rapid series of images and are asked to identify them). Ten years later, people who had completed the computer-based speed-of-processing training, along with four hours of "booster" training a year after the first sessions, were 48% less likely to be diagnosed with dementia than the control group that received no training. In addition, they showed better performance in everyday activities, such as driving. This program is now part of the training offered by BrainHQ.

The bottom line is that brain-training games can offer a degree of help. But for maximum effect, they should be just one arm of a multipronged brain fitness program like the one described in this report—a program that also includes optimal nutrition, exercise, stress reduction, social interactions, sleep, and stimulating activities. Only a holistic approach can fully protect both your body and brain as you age.

Resources

Organizations

Alzheimer's Association
225 N. Michigan Ave., Floor 17
Chicago, IL 60601
800-272-3900 (toll-free 24-hour help line)
www.alz.org

The Alzheimer's Association, one of the nation's leading nonprofit organizations, promotes Alzheimer's care and research. Its 24-hour help line provides support, referrals, and information.

Alzheimer's Disease Education and Referral Center
National Institute on Aging
Building 31, Room 5C27
31 Center Drive, MSC 2292
Bethesda, MD 20892
800-438-4380 (toll-free)
www.nia.nih.gov/alzheimers

This website from the National Institute on Aging (part of the National Institutes of Health) provides information about Alzheimer's disease, including legal and financial planning and clinical trials.

American Academy of Neurology
201 Chicago Ave.
Minneapolis, MN 55415
800-879-1960 (toll-free)
www.aan.com

The American Academy of Neurology is an association that represents thousands of neurologists and neuroscientists throughout the country. Its website includes a section for patients and caregivers on a variety of neurological diseases.

CDC Center for Healthy Aging
1600 Clifton Road
Atlanta, GA 30329
800-CDC-INFO (800-232-4636) (toll-free)
www.cdc.gov/aging

The Centers for Disease Control and Prevention's age-related website has a section on cognitive health, including Alzheimer's disease.

Geriatric Mental Health Foundation
6728 Old McLean Village Drive
McLean, VA 22101
703-556-9222
www.gmhfonline.org

The Geriatric Mental Health Foundation increases public awareness of mental health disorders that affect older Americans and promotes access to quality mental health care for this population.

NIH SeniorHealth
www.nihseniorhealth.gov

This website, a combined effort of the National Institute on Aging and the National Library of Medicine, offers information on common health issues that affect older adults.

Senior Corps
Corporation for National and Community Service
250 E St. SW
Washington, DC 20525
800-942-2677 (toll-free)
www.nationalservice.gov/senior-corps

This federal agency connects adults 55 and over with volunteer opportunities that match their interests and skills.

U.S. Administration for Community Living
330 C St., SW
Washington, DC 20201
202-401-4634
Eldercare Locator: 800-677-1116 (toll-free)
www.acl.gov and www.eldercare.gov

This agency, part of the U.S. Department of Health and Human Services, offers several programs to help older adults stay healthy and active.

Cognitive fitness assessments

Staying Sharp
https://stayingsharp.aarp.org

Take AARP's brain health assessment and get personalized recommendations to improve your cognitive fitness.

Synthetic Aperture Personality Assessment
https://sapa-project.org

Get an in-depth report of your cognitive abilities and learn how your personality compares to that of the hundreds of thousands of other people who've taken this test.

Test My Brain
www.testmybrain.org

Find free tests that assess your cognitive function, while helping researchers learn more about the human brain.

Cognitive fitness programs

Brain Fit Club
Beth Israel Deaconess Medical Center
330 Brookline Ave., Boston, MA
617-667-2507
www.brainfitclub.org

Northwestern School of Communication Cognitive Fitness Program
2315 Campus Drive
Evanston, IL 60208
847-491-3165
www.communication.northwestern.edu/clinics/speech_language/cognitive_fitness

Penn Memory Center Cognitive Fitness Program
3400 Civic Center Blvd., South Pavilion, 2nd Floor
Philadelphia, PA 19104
215-662-4523
www.pennmemorycenter.org/programs-services/cognitive-fitness

Other helpful resources and programs

AARP Games
www.aarp.org/Games/Online

The AARP offers a wide variety of free brain-stimulating games on its website.

Dalcroze Society of America
www.dalcrozeusa.org

Dalcroze Eurythmics is an approach to music education that combines music and movement, and it may offer cognitive benefits, research suggests. The Dalcroze Society offers classes throughout New England, the mid-Atlantic, Northwest, and Rocky Mountain regions.

Laughter Yoga International
https://laughteryoga.org

This program, which was developed by Madan Kataria of India, combines exercise and laughter in a holistic approach to improving health and happiness. Free laughter clubs are available around the United States and the world.

The Mindfulness Solution
781-259-3434
www.mindfulness-solution.com

Ronald D. Siegel, Harvard Medical School assistant professor of psychology, offers a series of free meditations to help calm the mind.

Sharp Brains
www.sharpbrains.com

This website offers free brain teasers and games that were developed based on scientific research.

Smokefree.gov
877-44U-QUIT (877-448-7848) (toll-free)
800-QUIT-NOW (800-784-8669) (toll-free)
https://smokefree.gov

If you smoke, this website offers tips and tools to help you quit.

Harvard Special Health Reports

A number of other Special Health Reports from Harvard Medical School shed light on various aspects of mental health. You can order them online at www.health.harvard.edu or call 877-649-9457 (toll-free).

Better Balance: Easy exercises to improve stability and prevent falls
Suzanne Salamon, M.D., and Brad Manor, Ph.D., Medical Editors, with Michele Stanten, Fitness Consultant
(Harvard Medical School, 2017)

Poor balance can lead to falls. This report explains the many age-related declines, medical conditions, and medications that play a role. It includes safe, effective exercises to help improve balance, a set of stretches for better range of motion, and checklists for home safety to help prevent falls.

Core Exercises: 5 workouts to tighten your abs, strengthen your back, and improve your balance
(Harvard Medical School, 2016)
Lauren E. Elson, M.D., Medical Editor, with Michele Stanten, Fitness Consultant

Core exercises have received a lot of publicity for helping to flatten bellies and build washboard abs. But strong core muscles underlie almost everything you do. This report offers five workouts to help you improve your posture and balance, boost sports performance, and sidestep low back pain.

A Guide to Coping with Alzheimer's Disease
Scott McGinnis, M.D., Medical Editor
(Harvard Medical School, 2014)

This Special Health Report gives in-depth information on diagnosing Alzheimer's disease and treating its symptoms. It includes help for family members and caregivers as well as for individuals with Alzheimer's.

Healthy Eating: A guide to the new nutrition
Teresa Fung, Sc.D., R.D., L.D.N., Faculty Editor
Sharon Palmer, Nutrition Editor
(Harvard Medical School, 2016)

This report explains how to put together a healthy diet, relying on minimally processed foods and "good" versus "bad" carbs, fat, and protein. It includes information on healthy snacking, meal planning, and finding sneaky sources of sugar.

Improving Memory: Understanding age-related memory loss
Kirk R. Daffner, M.D., Medical Editor
(Harvard Medical School, 2015)

This guide outlines 17 steps you can take to improve your memory—along with practical tips and tricks to help you recall everyday things, like names, dates, and lists. It includes information on professional memory-training programs.

Improving Sleep: A guide to a good night's rest
Lawrence Epstein, M.D., Medical Editor
(Harvard Medical School, 2015)

This report explains the causes of insomnia and the techniques and sleep aids that can help you get to sleep more quickly. It includes information on sleep apnea, restless legs syndrome, and other sleep stealers.

Lose Weight and Keep it Off: Smart approaches to achieving and maintaining a healthy weight
W. Scott Butsch, M.D., M.S.C., Medical Editor
Karen Ansel, M.S., R.D.N., C.D.N., Nutrition Consultant
(Harvard Medical School, 2017)

This report provides step-by-step guidance for weight loss—from selecting a satisfying diet to learning tips and tricks that will help you outwit cravings, sidestep temptation, and control comfort eating. It also includes information on additional lifestyle changes that will help you shed pounds. For those who need further help, there is guidance on weight-loss programs, weight-loss medications, and weight-loss surgery.

Positive Psychology: Harnessing the power of happiness, mindfulness, and inner strength
Ronald D. Siegel, Psy.D., Medical Editor
(Harvard Medical School, 2016)

This report is a guide to the concepts that can help you find well-being and happiness, based on the latest research in positive psychology. It includes self-assessment tests and step-by-step advice and exercises to help you maximize the positive emotion in your life.

Starting to Exercise
Lauren E. Elson, M.D., Medical Editor, with Michele Stanten, Fitness Consultant
(Harvard Medical School, 2015)

This report answers many important questions about physical activity, from how exercise changes your body to what diseases it prevents. It will guide you through starting and maintaining an exercise program that suits your abilities and lifestyle, and help you track your progress as you go.

Strength and Power Training for All Ages: 4 complete workouts to tone up, slim down, and get fit
Elizabeth Pegg Frates, M.D., with Michele Stanten, Fitness Consultant
(Harvard Medical School, 2017)

Strength training isn't just for bodybuilders with bulging biceps. It's important for everyone. This report provides a program that takes you from easy to advanced exercises to help build strength as well as power—the boost that adds speed to strength to help you move faster when walking, for example, or react more quickly, so that a trip doesn't become a fall.

Stress Management: Approaches for preventing and reducing stress
Greg Friccione, M.D., Medical Editor
(Harvard Medical School, 2016)

This report will help you identify the warning signs of stress. It will alert you to the dynamic roles of nutrition and social support and give you tips for coping with caregiver stress, work-related stress, and stress from conflict with others.

Understanding Depression: The many faces of depression—and how to find relief
Michael Miller, M.D., Medical Editor
(Harvard Medical School, 2017)

This guide distinguishes between sadness and depression and helps to sort through a variety of treatments and medications. It includes strategies for living with depression.

Walking for Health: Why this simple form of activity could be your best health insurance
Lauren E. Elson, M.D., with Michele Stanten, Fitness Consultant
(Harvard Medical School, 2015)

You've been walking since you were a toddler, so what could you possibly need to learn? This report introduces you to information on what shoes to wear, safety tips, proper gait, different walking styles, walking for weight loss, and staying motivated.

Glossary

Alzheimer's disease: A condition in which abnormal proteins build up and clump together in the brain, destroying brain tissue and leading to progressively worsening problems with learning, thinking, and memory.

amygdala: A part of the limbic system involved in emotions and the development of memories.

axon: A branching projection extending from a neuron, across which nerve impulses travel from one nerve cell to another.

beta-amyloid: A protein that accumulates and forms damaging plaques inside the brains of people with Alzheimer's disease.

brainstem: A small region at the base of the brain that regulates essential functions such as breathing, heartbeat, and blood pressure.

cerebellum: A structure located near the back of the brain that collects and interprets sensory information from the eyes, ears, and muscles to coordinate movements.

cerebral cortex: The outer layer of the cerebrum, which is made up of gray matter. It is divided into the frontal, parietal, temporal, and occipital lobes. Each lobe processes a different kind of sensory information.

cerebrum: The largest part of the brain, which surrounds most other brain structures. It is divided into two halves called the right and left hemispheres. The cerebrum is involved with higher-level functions, including thinking, reasoning, processing language, motor functions, planning, and organization.

cognitive reserve: The ability to cope with and compensate for age- and disease-related changes to the brain.

corpus callosum: A band of nerve fibers that connects the right and left hemispheres of the brain.

crystallized intelligence: The ability to use previously learned information; for example, to answer a trivia question or complete a vocabulary quiz.

declarative memory: A type of long-term memory that is made up of remembered facts and events.

dendrite: An extension of a neuron along which nerve impulses are received.

frontal lobe: One of four lobes that make up the cerebral cortex, the frontal lobe carries out higher-level cognitive skills such as thinking, planning, organizing, and problem solving.

gray matter: One of two types of tissue (the other is white matter) that make up the central nervous system. Gray matter is primarily made up of neuron cell bodies, dendrites, and axon terminals. It is involved in memory, emotions, speech, hearing, decision making, and other functions. A higher gray matter volume correlates to better ability in some of these functions.

hippocampus: An area of the brain that's involved in the consolidation of short-term memory into long-term memory.

hypothalamus: The part of the brain that regulates the body's essential functions, such as temperature, hunger, and thirst. The hypothalamus also mediates emotional responses and oversees the release of hormones from the pituitary gland.

limbic system: A group of structures in the brain (the amygdala, hippocampus, thalamus, and hypothalamus) that are involved with memory and emotions.

mild cognitive impairment (MCI): A decline in cognitive ability that can—but doesn't always—precede Alzheimer's and other forms of dementia.

myelin: A fatty substance that surrounds the axon of certain nerve cells. Myelin both insulates the axons and helps facilitate the transmission of impulses from one neuron to another.

neurogenesis: The process by which nerve cells (neurons) are created.

neurons: Cells of the brain and nervous system that transmit information via chemicals and electrical impulses.

neuroplasticity: The ability to regenerate neurons and establish new neural connections as we grow older.

neurotransmitter: A chemical messenger that facilitates communication between neurons.

occipital lobe: One of four lobes that make up the cerebral cortex, the occipital lobe processes visual information.

parietal lobe: One of four lobes that make up the cerebral cortex, the parietal lobe processes sensory information related to taste, touch, and temperature.

procedural memory: The remembered ability to do something, such as riding a bike or tying your shoe.

synapses: Connections between neurons, across which information passes.

tau: A protein that accumulates and forms damaging tangles in the brains of people with Alzheimer's disease.

temporal lobe: One of four lobes that make up the cerebral cortex, the temporal lobe processes sound information (hearing).

thalamus: An area of the brain that's involved in sensory perception and movement.

vascular dementia: A form of dementia caused by a blockage in blood flow to the brain.

white matter: One of two types of tissue (the other is gray matter) that make up the central nervous system. It contains nerve fibers called axons that form the connections between nerve cells. Axons are wrapped in a protective coating, called myelin.

Harvard Health Publications

Trusted advice for a healthier life

Receive *HEALTHbeat*, Harvard Health Publications' free email newsletter

Go to: **www.health.harvard.edu** to subscribe to *HEALTHbeat*. This free weekly email newsletter brings you health tips, advice, and information on a wide range of topics.

You can also join in discussion with experts from Harvard Health Publications and folks like you on a variety of health topics, medical news, and views by reading the Harvard Health Blog (**www.health.harvard.edu/blog**).

Order this report and other publications from Harvard Medical School

online | **www.health.harvard.edu**

phone | **877-649-9457** (toll-free)

mail | **Belvoir Media Group**
Attn: Harvard Health Publications
P.O. Box 5656
Norwalk, CT 06856-5656

Licensing, bulk rates, or corporate sales

email | **HHP_licensing@hms.harvard.edu**

online | **www.content.health.harvard.edu**

Other publications from Harvard Medical School

Special Health Reports *Harvard Medical School publishes in-depth reports on a wide range of health topics, including:*

Addiction
Allergies
Advance Care Planning
Aging Successfully
Alzheimer's Disease
Anxiety & Stress Disorders
Back Pain
Balance
Caregiving
Change Made Easy
Cholesterol
COPD
Core Workout
Gentle Core Workout
Depression
Diabetes
Diabetes & Diet
Energy/Fatigue
Erectile Dysfunction
Exercise
Exercise Your Joints
Eye Disease
Foot Care
Grief & Loss
Hands
Headache
Hearing Loss
Heart Disease
Heart Disease & Diet
High Blood Pressure
Incontinence
Knees & Hips
Living Longer
Memory
Men's Health
Neck Pain
Nutrition
Osteoarthritis
Osteoporosis
Pain Relief
Positive Psychology
Prostate Disease
Reducing Sugar & Salt
Rheumatoid Arthritis
Sensitive Gut
Sexuality
Six-Week Eating Plan
Skin Care
Sleep
Strength Training
Stress Management
Stretching
Stroke
Thyroid Disease
Vitamins & Minerals
Walking for Health
Weight Loss
Women's Health
Workout Workbook
Yoga

Periodicals *Monthly newsletters and annual publications, including:*

Harvard Health Letter
Harvard Women's Health Watch
Harvard Heart Letter
Harvard Men's Health Watch
Prostate Disease Annual

ISBN 978-1-61401-129-3
SW34000

COG0517