

The Human Brain

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Renew - Exercise

Intro

Your brain is a thinking organ that learns and grows by interacting with the world through perception and action. Mental stimulation improves brain function and actually protects against cognitive decline, as does physical exercise.

The human brain is able to continually adapt and rewire itself. Even in old age, it can grow new neurons. Severe mental decline is usually caused by disease, whereas most age-related losses in memory or motor skills simply result from inactivity and a lack of mental exercise and stimulation. In other words, use it or lose it.

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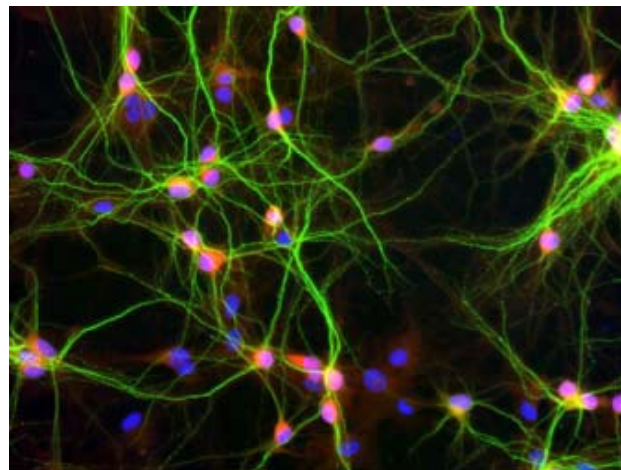
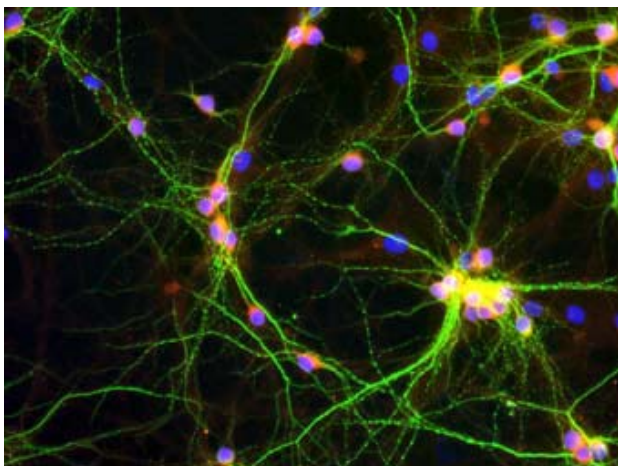
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Journey of the Developing Brain

Only recently have scientists been able to learn how the neural network of the brain forms. Beginning in the womb and throughout life this vast network continues to expand, adapt, and learn. Take a look inside the brain at a cellular level to find out how our three pound universe forms and even how we learn.



Hippocampal Neurons

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Evolving Brains Inspired Movement

Step back a half-billion years ago, to when the first nerve cells developed. The original need for a nervous system was to coordinate movement, so an organism could go find food, instead of waiting for the food to come to it. Jellyfish and sea anemone, the first animals to create nerve cells, had a tremendous advantage over the sponges that waited brainlessly for dinner to arrive.

After millions of generations of experimentation, nervous systems evolved some amazing ways of going out to eat. But behind all the myriad forms of life today, the primary directive remains. Movement. In fact, a diminished ability to move is a good measure of aging. Inflexibility heralds death, while a flexible body and fluid mind are the hallmarks of youth.

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Elasticity and Plasticity

Elastic comes from the Greek word for "drive" or "propulsion." It is the tendency of a material to return to its original shape after being stretched.

Elasticity is the basic animal drive that powers your muscles, giving you strength and balance – flexibility, mobility, and grace.

Plastic derives from the Greek word meaning "molded" or "formed." It is the tendency of the brain to shape itself according to experience.

Plasticity is the basic mental drive that networks your brain, giving you cognition and memory – fluidity, versatility, and adaptability.

Elasticity is the basic animal drive that powers your muscles, giving you strength and balance – flexibility, mobility, and grace.

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The Growth of Your Amazing Neural Network

Before birth you created neurons, the brain cells that communicate with each other, at the rate of 15 million per hour! When you emerged into the world, your 100 billion neurons were primed to organize themselves in response to your new environment – no matter the culture, climate, language, or lifestyle.

Until your early teens, various windows of opportunity opened when you could most easily learn language and writing, math and music, as well as the coordinated movements used in sports and dance. But, at any age you can – and should – continue to build your brain and expand your mind.

During infancy, billions of these extraordinary cells intertwined into the vast networks that integrated your nervous system. By the time you were four or five years old, your fundamental cerebral architecture was complete.

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Expanding Your Amazing Neural Network

Throughout life, your neural networks reorganize and reinforce themselves in response to new stimuli and learning experiences. This body-mind interaction is what stimulates brain cells to grow and connect with each other in complex ways. They do so by extending branches of intricate nerve fibers called dendrites (from the Latin word for "tree"). These are the antennas through which neurons receive communication from each other.

A healthy, well-functioning neuron can be directly linked to tens of thousands of other neurons, creating a totality of more than a hundred trillion connections – each capable of performing 200 calculations per second! This is the structural basis of your brain's memory capacity and thinking ability.

As a product of its environment, your "three pound universe" is essentially an internal map that reflects your external world.

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Learning at the Cellular Level

Many neuroscientists believe that learning and memory involve changes at neuron-to-neuron synapses. Such changes, called long-term potentiation (LTP), make it easier for connected neurons to communicate with each other, and therefore to form memories. LTP involves patterns of synaptic strengthening and weakening that can last for weeks.

Because receptor aggregation may contribute to LTP – and dispersal may contribute to the reverse scenario, long-term depression – the discovery that receptors can scurry in and out of synapses strengthens the synaptic hypothesis of learning.

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Learning Uses Long-Term Potentiation Study

A study by neuroscientists at Brown University provided further evidence that learning uses long-term potentiation LTP to produce changes in the synaptic connections between brain cells that are necessary to acquire and store new information

When the researchers taught rats a new motor skill, scientists found that the animals' brains had also changed. The strength of synapses between neurons in the motor cortex of their brains had increased through a process consistent with the use of LTP.

Previously, "the link between LTP, synaptic modification and learning was tentative," said senior author John Donoghue, professor of neuroscience. "This latest study provides strong evidence that learning itself engages LTP in the cerebral cortex as a way to strengthen synaptic connections."¹

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The Science of the Mind-Body Connection

You may have heard the term "mind-body connection" as it applies to remarkable stories of healing without surgery or stress management, but did you know there is actually a physical connection between the brain and muscles? It is called the neuromuscular junction and chemical exchanges that happen at this junction are the key to your ability to move.

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Where Mind Meets Body – The Neuromuscular Junction

Brain chemistry reveals an essential unity of mind and body. Neurons not only contact other neurons, they also connect with skeletal muscles, at a specialized structure called the neuromuscular junction. There the brain uses acetylcholine – its primary chemical neurotransmitter for memory and attention – to communicate with muscles. Another of the brain's key chemical messengers, dopamine, helps regulate fine motor movement.

The role of these neurotransmitters in regulating movement underscores the intimate relation between body and mind, muscle and memory. In fact, many bodyworkers find that deep massage can trigger the release and awareness of powerful, long-held emotional memories.

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Muscles Activate Brain Receptors

When acetylcholine is released at a neuromuscular junction, it crosses the tiny space (synapse) that separates the nerve from the muscle. It then binds to acetylcholine receptor molecules on the muscle fiber's surface. This initiates a chain of events that lead to muscle contraction.

"So muscle activity is a cue to keep a synapse stable, and synaptic inactivity is a cue to disassemble a synapse," says Lichtman, a professor of neurobiology. "So if you lose activity, you lose receptors. But if you regain activity, you get those receptors back."²

Scientists have shown that muscle fiber contains a scaffold made of special proteins that hold these acetylcholine receptors in place. Research led by Jeff

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W. Lichtman, M.D., Ph.D., at Washington University School of Medicine in St. Louis, indicates that a loss of nerve signals – due to inactivity – actually disassembles this scaffold and causes a loss of acetylcholine receptors. When the muscle becomes active again, however, the scaffold tightens its grip and catches any receptors that come by.

Mental Exercise for a Better Brain

When we are young the world seems filled with curious wonders, delightful discoveries, and daunting challenges. Our brains are taking in countless bits of information and we are developing lifetime skills. This burst of learning is like the brain Olympics of our human journey. Yet unlike the Olympic athletes who have a limited time to demonstrate their peak performance, the human brain can continue to grow and improve with exercise.

Here you will find a variety of suggestions and research that can help keep you mentally fit.



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A Brain Exercise You Can Do Right Now

This is an exercise that can strengthen neural connections and even create new ones.

Switch the hand you are using to control the computer mouse. Use the hand you normally do NOT use.

What do you notice?

Is it harder to be precise and accurate with your motions?

Do you feel like you did when you were first learning to tie your shoelaces?

If you are feeling uncomfortable and awkward don't worry, your brain is learning a new skill.

Try other neural building and strengthening exercises with everyday movements. Use your opposite hand to brush your teeth, dial the phone or operate the TV remote.

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Imagine Increased Muscle Strength!-Experiment

In a fascinating experiment, researchers at the Cleveland Clinic Foundation discovered that a muscle can be strengthened just by thinking about exercising it.

For 12 weeks (five minutes a day, five days per week) a team of 30 healthy young adults imagined either using the muscle of their little finger or of their elbow flexor. Dr. Vinoth Ranganathan and his team asked the participants to think as strongly as they could about moving the muscle being tested, to make the imaginary movement as real as they could.

Compared to a control group – that did no imaginary exercises and showed no strength gains – the little-finger group increased their pinky muscle strength by 35%. The other group increased elbow strength by 13.4%.

Engage Your Brain

It is important to challenge your brain to learn new and novel tasks, especially processes that you've never done before. Examples include square-dancing, chess, tai chi, yoga, or sculpture. Working with modeling clay or playdough is an especially good way for children to grow new connections. It helps develop agility and hand-brain coordination, (like controlling the computer mouse with your opposite hand).

What's more, brain scans taken after the study showed greater and more focused activity in the prefrontal cortex than before. The researchers said strength gains were due to improvements in the brain's ability to signal muscle.³

Pay attention to your breathing. Is it slow and deep, or quick and shallow? Is your belly expanding and contracting, or is your chest doing all the work?

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Travel Stimulates Your Brain

Travel is another good way to stimulate your brain. It worked for our ancestors, the early Homo sapiens. Their nomadic lifestyle provided a tremendous stimulation for their brains that led to the development of superior tools and survival skills. In comparison, the now-extinct Neanderthal was a species that for thousands of years apparently did not venture too far from their homes. (Maybe they were simply content with their lives – in

Early humans gained a crucial evolutionary edge from the flexibility and innovation required by their strategic lifestyle, which also led to a more diverse diet that allowed their brains to rapidly evolve.

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contrast to the seldom-satisfied sapien.)

Neurobics™

Neurobics™ is a unique system of brain exercises using your five physical senses and your emotional sense in unexpected ways that encourage you to shake up your everyday routines. They are designed to help your brain manufacture its own nutrients that strengthen, preserve, and grow brain cells.

Created by Lawrence C. Katz, Ph.D., a professor of neurobiology at Duke University Medical Center, neurobics can be done anywhere, anytime, in offbeat, fun and easy ways. Nevertheless, these exercises can activate underused nerve pathways and connections, helping you achieve a fit and flexible mind.

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Neurobic Exercises

Try to include one or more of your senses in an everyday task:⁴

Get dressed with your eyes closed
Wash your hair with your eyes closed
Share a meal and use only visual cues to communicate.
No talking.

Break routines:

Go to work on a new route
Eat with your opposite hand
Shop at new grocery store

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Combine two senses:

Listen to music and smell flowers
Listen to the rain and tap your fingers
Watch clouds and play with modeling clay at the same time

Reading and Bingo

Consider your brain a muscle, and find opportunities to flex it. "Read, read, read," says Dr. Amir Soas of Case Western Reserve University Medical School in Cleveland. Do crossword puzzles. Play Scrabble. Start a new hobby or learn to speak a foreign language. "Anything that stimulates the brain to think." Also, watch less television, because "your brain goes into neutral," he said.

Challenging the brain early in life is crucial to building up more "cognitive reserve" to counter brain-damaging disease, according to Dr. David Bennett of Chicago's Rush University. And, reading-habits prior to age 18 are a key predictor of later cognitive function.

A cognitive psychologist in England found that when elderly people regularly played bingo, it helped minimize their memory loss and bolster their hand-eye coordination. Bingo seemed to help players of all ages remain mentally sharp.⁵

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What's Thought-Provoking is Brain-Promoting-Research

Research on the physical results of thinking has shown that just using the brain actually increases the number of dendritic branches that interconnect brain cells. The more we think, the better our brains function – regardless of age. The renowned brain researcher Dr. Marian Diamond says, "The nervous system possesses not just a 'morning' of plasticity, but an 'afternoon' and an 'evening' as well."

Dr. Diamond found that whether we are young or old, we can continue to learn. The brain can change at any age. A dendrite grows much like a tree – from trunk to limbs to branches to twigs – in an array of ever finer complexity.

In fact, older brains may have an advantage. She discovered that more highly developed neurons respond even better to intellectual enrichment than less developed ones do. The greatest increase in dendritic length occurred in the outermost dendritic branches, as a reaction to new information.

As she poetically describes it: "We began with a nerve cell, which starts in the embryo as just a sort of sphere. It sends its first branch out to overcome ignorance. As it reaches out, it is gathering knowledge and it is becoming creative. Then we become a little more idealistic, generous, and altruistic; but it is our six-sided dendrites which give us wisdom."

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Stimulating Environment Protects Brain-Study

Animal studies show that intellectual enrichment can even compensate for some forms of physical brain damage. For example, a mentally stimulating environment helped protect rats from the potentially damaging effects of lead poisoning.

Neuroscientists at Jefferson Medical College compared groups of rats given lead-laced water for several weeks in two different environments. Rats living in a stimulating environment showed a better ability to learn compared to the animals that were isolated. "Behaviorally, being in an enriched environment seemed to help protect their brains," says Jay Schneider, Ph.D., professor of pathology, neurology, anatomy and cell biology.

"The magnitude of the protective effect surprised me," he says. "This might lead to an early educational intervention for at-risk populations." It suggests a way to diminish the damage that lead does to kids: by manipulating their socio-behavioral environment.⁶

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Physical Exercise for a Better Brain

Most of us know that physical exercise is good for our general health, but did you know that physical exercise is also good for your brain? If you think you're going to get smarter sitting in front of your computer or watching television, think again. Here scientists present the evidence that a healthy human being is a human doing.

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Our Sedentary Society

Not too long ago, futurists envisioned humans evolving giant thumbs in response to a push-button world. They did not foresee humanity's real response to all its labor-saving conveniences – a sedentary, inactive society with a deteriorated vascular system and consequent decline in physical and mental health.

Nearly half of young people ages 12 to 21 do not participate in vigorous physical activity on a regular basis. Fewer than one-in-four children report getting at least half an hour of any type of daily physical activity and do not attend any school physical education classes.⁷

In June 2001, ABC News reported that school children spend 4.8 hours per day on the computer, watching TV, or playing video games.

The impact of computers, video games, school funding cuts, and public apathy have combined to leave Illinois as the only state that still requires daily physical education in first through 12th grades. This is a far cry from the 1960s, when President John F. Kennedy made physical fitness a priority for Americans of all ages.

These sedentary tendencies represent a real health crisis. And, not just for couch-potatoes. Deep vein thrombosis (DVT) occurs when blood circulation slows, allowing clots to form and then, eventually, break free, causing death. DVT has been nicknamed “economy class syndrome,” because airplane passengers who sit throughout a long flight in the close quarters of economy class have become victims of DVT.⁸

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About Physical Exercise

The word exercise derives from a Latin root meaning "to maintain, to keep, to ward off." To exercise means to practice, put into action, train, perform, use, improve.

Exercise is a natural part of life, although these days we have to consciously include it in our daily routine. Biologically, it was part of survival, in the form of hunting and gathering or raising livestock and growing food. Historically, it was built into daily life, as regular hours of physical work or soldiering. What is now considered a form of exercise – walking – was originally a form of transportation.



Patterson, Kearney, Nebraska

Photograph courtesy of Nebraska State Historical Society, Digital ID: nbhips 12346

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Walking Benefits Brains

Walking is especially good for your brain, because it increases blood circulation and the oxygen and glucose that reach your brain. Walking is not strenuous, so your leg muscles don't take up extra oxygen and glucose like they do during other forms of exercise. As you walk, you effectively oxygenate your brain. Maybe this is why walking can "clear your head" and help you to think better.

Movement and exercise increase breathing and heart rate so that more blood flows to the brain, enhancing energy production and waste removal. Studies show that in response to exercise, cerebral blood vessels can grow, even in middle-aged sedentary animals.

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Walking Improved Memory-Study

Studies of senior citizens who walk regularly showed significant improvement in memory skills compared to sedentary elderly people.

Walking also improved their learning ability, concentration, and abstract reasoning. Stroke risk was cut by 57% in people who walked as little as 20 minutes a day.⁹

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Women Who Walk Remember-Study

When the cognitive abilities of elderly women were compared, those who walked regularly were less likely to experience age-related memory loss and other declines in mental function.

University of California at San Francisco researchers measured the brain function of nearly 6,000 women during an eight-year period. The results were correlated with the women's normal activity level, including their routine walking and stair-climbing.

"In the higher-energy groups, we saw much less cognitive decline," said neurologist Kristine Yaffe, MD. Of the women who walked the least (a half-mile per week), 24% had significant declines in their test scores, compared to only 17% of the most active women (17 miles per week).

It wasn't a matter of all or nothing. "We also found that for every extra mile walked per week there was a 13% less chance of cognitive decline," said Yaffe, who is Chief of Geriatric Psychiatry at the San Francisco Veterans Administration Medical Center. "So you don't need to be running marathons. The exciting thing is there was a 'dose' relationship which showed that even a little is good but more is better."

"In the higher-energy groups, we saw much less cognitive decline" – a protective effect amounting to as much as 40% – according to Yaffe. "This is an important intervention that all of us can do and it could have huge implications in preventing cognitive decline."¹⁰

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Wake Up Your Brain in the Morning Exercise

In the morning, while you're still in bed, slowly begin to move your toes – any way that feels good. Wiggle, scrunch, and stretch. Move all your toes up and down several times, or work just your big toes. Wiggling your toes activates nerves that stimulate your brain and internal organs.

Do this exercise first thing each morning or after sitting for an extended period of time. It will help you to wake-up and become alert more quickly. Your whole body may feel pleasantly energized. Most important, your first steps – and those throughout the day – will be safer ones. (Falls are the second leading cause of spinal cord

and brain injury among people over 65 years old.)

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Foot Note

The human foot is one of the body's most complex engineering marvels. The eight arches in your feet do a remarkable job of evenly distributing the weight of your body, while 200 ligaments coordinate 40 different muscles that control the 56 bones in your feet – one fourth of all the bones in your body!

An intricate system of blood vessels and nerves connect the feet with the rest of the body. Your feet are good barometers of the aging process; inflexible toes, cold feet, and poor circulation are signposts of time.

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Run for More Brain Cells-Study

Ongoing animal studies at The Salk Institute show that running can boost brain cell survival in mice that have a neurodegenerative disease with properties similar to Alzheimer's.

Furthermore, the miles logged correlated directly with the numbers of increased cells, she said. "It's almost as if they were wearing pedometers, and those that ran more grew more cells."

When these mice are sedentary, "it appears that most newly born brain cells die. We don't understand that fully, but it probably has something to do with an inability to cope with oxidative stress," said Carolee Barlow, a Salk assistant professor and lead author of the study. "Running appears to 'rescue' many of these cells that would otherwise die."

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Running is a Brain Boost-Study

Running's brain-boosting effects were in the hippocampus, a region of the brain linked to learning and memory and known to be affected by Alzheimer's disease, Barlow said. "The results suggest that exercise might delay the onset and progression of some neurodegenerative diseases."

This study builds on work directed by Salk Professor and co-author Fred Gage, showing that running also leads to increased brain cell numbers in normal adult mice, elderly "senior citizen" mice, and a genetically "slow-learning" strain of mice. Gage's studies have shown that new cell growth occurs in human brains, too. Therefore, this suggests that the boosting effects of running may occur in people as well.¹²

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Exercise for Aging Brain Studies

Antioxidants attract and gather the free radicals that are associated with many brain maladies. Find out how antioxidants protect your brain and how specific micronutrients benefit your brain. You can also learn how the lack of specific micronutrients can increase the risk of stroke and cognitive decline.

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Physical Exercise Protects Your Brain as it Ages - Statistics

Physical exercise has a protective effect on the brain and its mental processes, and may even help prevent Alzheimer's disease. Based on exercise and health data from nearly 5,000 men and women over 65 years of age, those who exercised were less likely to lose their mental abilities or develop dementia, including Alzheimer's.

Furthermore, the five-year study at the Laval University in Sainte-Foy, Quebec suggests that the more a person exercises the greater the protective benefits for the brain, particularly in women.

Inactive individuals were twice as likely to develop Alzheimer's, compared to those with the highest levels of activity (exercised vigorously at least three times a week). But even light or moderate exercisers cut their risk significantly for Alzheimer's and mental decline.¹³



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Intelligence at Any Age-Study

Since 1956, the Seattle Longitudinal Study has tracked more than 5,000 people, aged 20 to 90 years old. When participants began to experience cognitive decline, they were given a series of five one-hour training sessions designed to improve inductive reasoning and spatial orientation.

As a result, half of them improved significantly – demonstrating that mental enrichment increases fluid intelligence at any age. Lead researcher of the study, Dr. K. Warner Schaie, concluded: "The results of the cognitive training studies suggest that the decline in mental performance in many community-dwelling older people is probably due to disuse and is consequently reversible."

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Mental Challenge Protects Brain From Cognitive Decline-Study

Contrary to popular myth, you do not lose mass quantities of brain cells as you get older. "There isn't much difference between a 25-year old brain and a 75-year old brain," says Dr. Monte S. Buchsbaum, who has scanned a lot of brains as director of the Neuroscience

Certain areas of the brain, however, are more prone to damage and deterioration over time. One is the hippocampus, which transfers new memories to long-term storage elsewhere in the brain. Another vulnerable area is the basal ganglia, which coordinates commands

PET Laboratory at Mount Sinai School of Medicine.

Cognitive decline is not inevitable. When 6,000 older people were given mental tests throughout a ten-year period, almost 70% continued to maintain their brain power as they aged.

to move muscles. Research indicates that mental exercise can improve these areas and positively affect memory and physical coordination.

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Intellectual Activity Fends off Alzheimer's-Study

Numerous studies show that better-educated people have less risk of Alzheimer's disease. In a Case Western Reserve study of 550 people, those more mentally and physically active in middle-age were three times less likely to later get the mind-robbing disease.

Increased intellectual activity during adulthood was especially protective. Examples included reading, doing puzzles, playing a musical instrument, painting, woodworking, playing cards or board games, and performing home repairs.

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Physical Exercise as an Antidepressant-Study

Blumenthal and a team of researchers at Duke University Medical Center found that an aerobic exercise program decreased depression and improved the cognitive abilities of middle-aged and elderly men and women.

To the surprise of the researchers, after 16 weeks, all three groups showed statistically significant and identical improvement in standard measurements of depression, implying that exercise was just as effective as medication in treating major depression.

They followed 156 patients between the ages of 50 and 77 who had been diagnosed with major depressive disorder. They were randomly assigned to one of three groups: exercise, medication, or a combination of medication and exercise. The exercise group spent 30 minutes either riding a stationary bicycle or walking, or jogging three times a week.

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An Active Life Fuels an Active Brain- Study

In a study of 193 people believed to have Alzheimer's disease, researchers found that people who participated in fewer leisure activities between the ages of 20 and 60 were 3.85 times more likely to develop Alzheimer's.

Most beneficial was spending time in intellectual pursuits. "A passive life is not best for the brain," said Dr. Robert P. Friedland at University Hospitals of Cleveland.¹⁴

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"Elderobics" – Pedestrian Power-Study

In a sedentary group of people aged 60 to 75, University of Illinois researchers introduced them to a fitness regime. For six months the elders had either an aerobic or non-aerobic workout for up to 90 minutes, three times

"We see selective cognitive benefits which accompany improvement in aerobic fitness," says Kramer. Although benefits were not obvious in every type of test, improvements were clearly attributable to the aerobics

a week.

"We chose couch potatoes," said the study's lead author, cognitive neuroscientist Arthur Kramer. The 214 healthy adults hadn't been involved in any physical exercise for the previous 5 to 10 years. "Indeed most of our subjects hadn't done any formal exercise for more like 30 or 40 years."

One group took long walks three times a week, and the other only did gentle toning and stretching exercises using weights. Walkers, who completed an hour-long loop around the university, improved significantly in the mental tests, as well as being fitter. An improvement of only 5-7% in cardio-respiratory fitness led to an improvement of up to 15% in mental tests. The non-walkers, however, did not gain any benefits for their brains.

workout.

Even beyond age 70, cardiovascular exercise can improve memory and reasoning skills. "People who have chosen a lifetime of relative inactivity can benefit mentally from improved aerobic fitness. It's never too late."¹⁵

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Why Older Women Have Better Memory-Study

By improving cardiovascular health, exercise increases the flow of oxygen-rich blood to the brain. Over a lifetime, this makes a big difference to brain function. In fact, cardiovascular health appears to be the primary biological reason why elderly women tend to have better cognitive function than men.

When Dutch researchers tested 600 people aged 85 and over, they found that the odds of having a better memory were 80% higher in women, even after considering factors such as formal education and depression. "Good cognitive speed was found in 33% of the women and 28% of the men," they reported.

Women at age 85 are known to be relatively free from cardiovascular disease, compared to men, and this relative absence of atherosclerosis is a likely biological explanation, according to Dr. A. J. M. de Craen of Leiden University Medical Center.¹⁶

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Blood Flow to Brain and Cognitive Decline-Theory

Psychologist James Blumenthal also points out the long-term importance of exercise for brain function. "We know that in general, exercise improves the heart's ability to pump blood more effectively, as well as increases the blood's oxygen-carrying capacity," he says.

"It is thought that one of the reasons why the elderly – especially those with coronary artery disease or hypertension – tend to suffer some degree of cognitive decline is in part due to a reduction in blood flow to the brain."