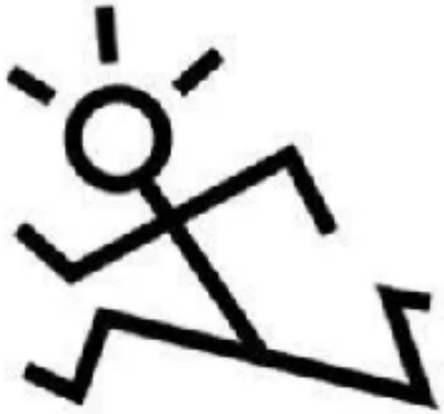
this is your brain on exercise

SPARK

THE REVOLUTIONARY NEW SCIENCE OF EXERCISE AND THE BRAIN



Supercharge Your Mental Circuits to Beat Stress, Sharpen Your Thinking, Lift Your Mood, Boost Your Memory, and Much More

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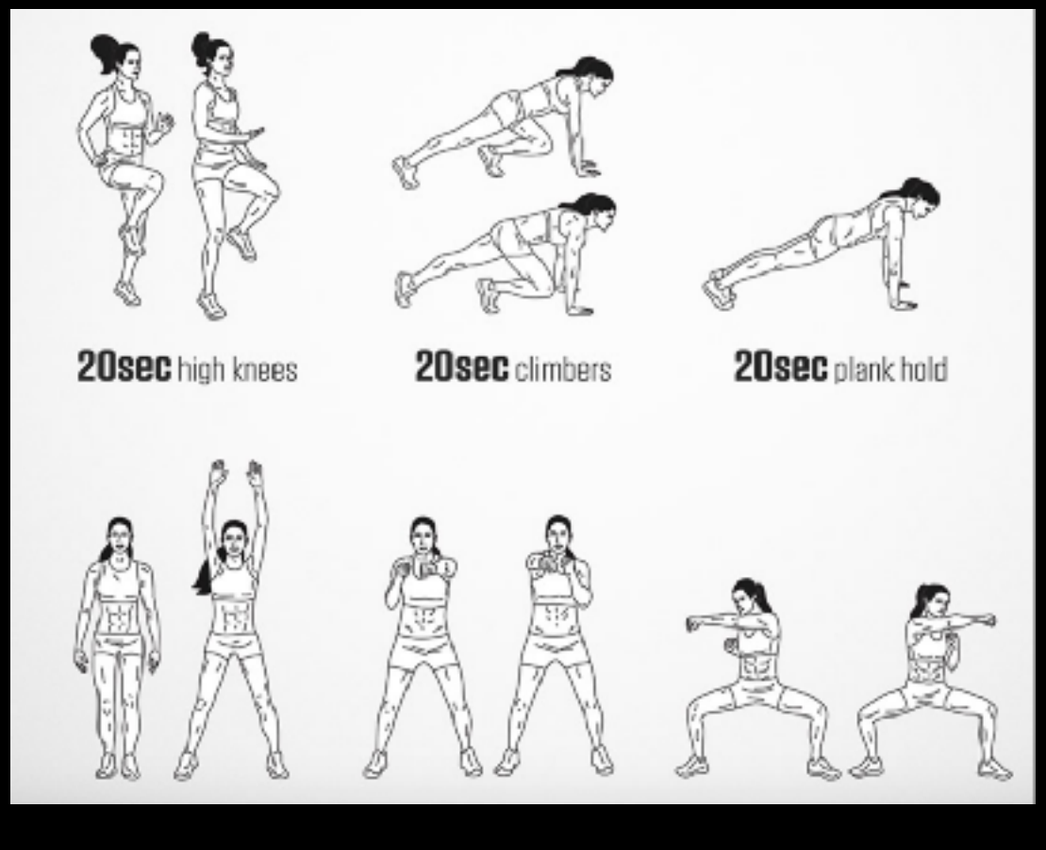
with **ERIC HAGERMAN**

Different types of exercise:

aerobic cardiovascular exercise
resistance training
coordination dominant (sports)
physical activity of daily life

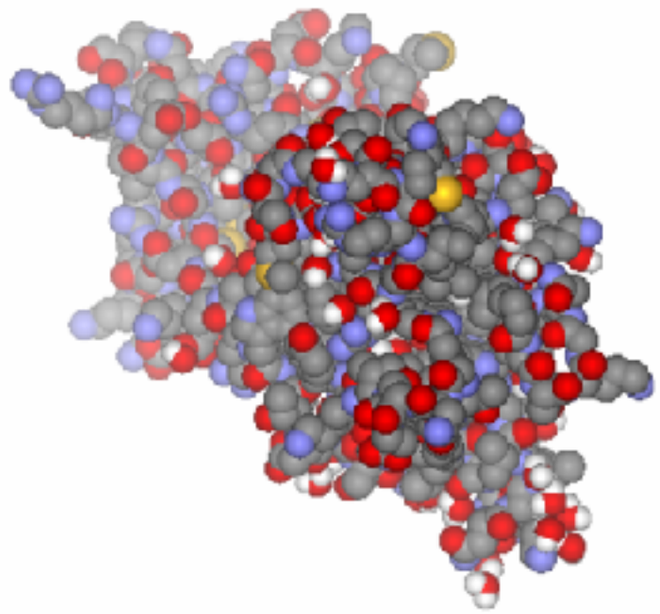
complex movement (strength and skill based):
requires engagement in the process
cognitive load~ working memory, problem solving, concentration,
skill sequence, process of learning with building blocks
(dopamine, reward)

examples:
dance
martial arts
gymnastics



HIIT anaerobic exercise: stimulates neurotrophic growth facors
example: BDNF

BDNF



Brain-derived neurotrophic factor

From Wikipedia, the free encyclopedia

Brain-derived neurotrophic factor, also known as **BDNF**, is a protein[5] that, in humans, is encoded by the *BDNF* gene.[6][7] BDNF is a member of the neurotrophin family of growth factors, which are related to the canonical nerve growth factor. Neurotrophic factors are found in the brain and the periphery. BDNF was first isolated from pig brain in 1989 by Yves-Alain Barde and Hans Thoenen.[8]

Function [edit]

BDNF acts on certain neurons of the central nervous system and the peripheral nervous system, helping to support survival of existing neurons, and encouraging growth and differentiation of new neurons and synapses.[9][10] In the brain, it is active in the hippocampus, cortex, and basal forebrain—areas vital to learning, memory, and higher thinking.[11] BDNF is also expressed in the retina, kidney, saliva, prostate, motor neurons and skeletal muscle.[12][13]

BDNF itself is important for long-term memory.[14] Although the vast majority of neurons in the mammalian brain are formed prenatally, parts of the adult brain retain the ability to grow new neurons from neural stem cells in a process known as neurogenesis. Neurotrophins are proteins that help to stimulate and control neurogenesis, BDNF being one of the most active.[15][16][17] Mice born without the ability to make BDNF suffer developmental defects in the brain and sensory nervous system, and usually die soon after birth, suggesting that BDNF plays an important role in normal neural development.[18] Other important neurotrophins structurally related to BDNF include NT-3, NT-4, and NGF.

BDNF is made in the endoplasmic reticulum and secreted from dense-core vesicles. It binds carboxypeptidase E (CPE), and the disruption of this binding has been proposed to cause the loss of sorting of BDNF into dense-core vesicles. The phenotype for BDNF knockout mice can be severe, including postnatal lethality. Other traits include sensory neuron losses that affect coordination, balance, hearing, taste, and breathing. Knockout mice also exhibit cerebellar abnormalities and an increase in the number of sympathetic neurons.[19]

Certain types of physical exercise have been shown to markedly (threefold) increase BDNF synthesis in the human brain, a phenomenon which is partly responsible for exercise-induced neurogenesis and improvements in cognitive function.[13][20][21][22][23] Niacin appears to upregulate BDNF and tropomyosin receptor kinase B (TrkB) expression as well.[24]

Before we get into the building materials, let's discuss the directors of the show: neurotrophins. There are at least four neurotrophins that we know of so far. **The two most well researched neurotrophins are Nerve Growth Factor (NGF), and Brain Derived Neurotrophic Factor (BDNF).**

NGF deals mainly in sensory, and sympathetic neurons which can make our perception seem more crisp, and vibrant, but it can make us overly sensitive to environmental influences if we over do it.

BDNF has been nicknamed "fertilizer for the brain" by many researchers and doctors, and it may even has antidepressant-like effects in humans.

We believe that living a healthy and balanced lifestyle leads to a healthy balanced brain, and there are many simple lifestyle changes that have been shown in studies to increase levels of BDNF.

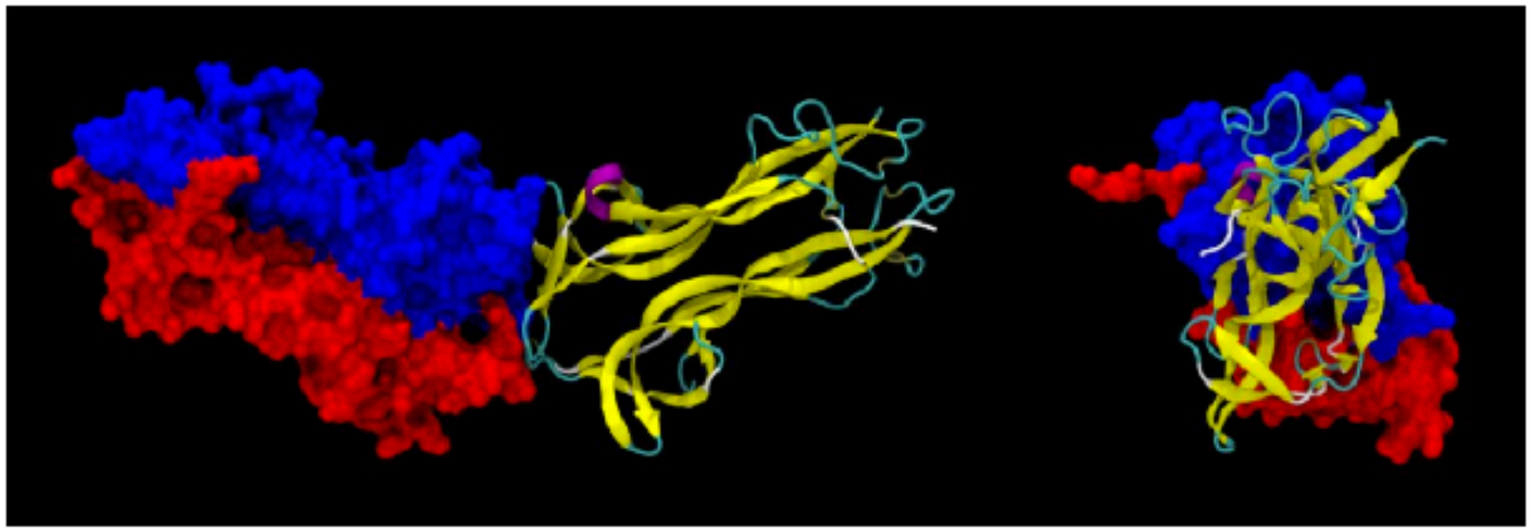
For example:

- **Getting out in the sun**
- **Doing yoga**
- **Doing mental tasks like puzzles**
- **Doing physically demanding tasks**
- **Doing anything new and/or challenging for you.**
- **Spending time with loved ones**
- **Curcumin (from turmeric)**
- **Resveratrol (from red grapes or Japanese knotweed)**
- **Intermittent fasting (even with as little as 12 hours of fasting)**

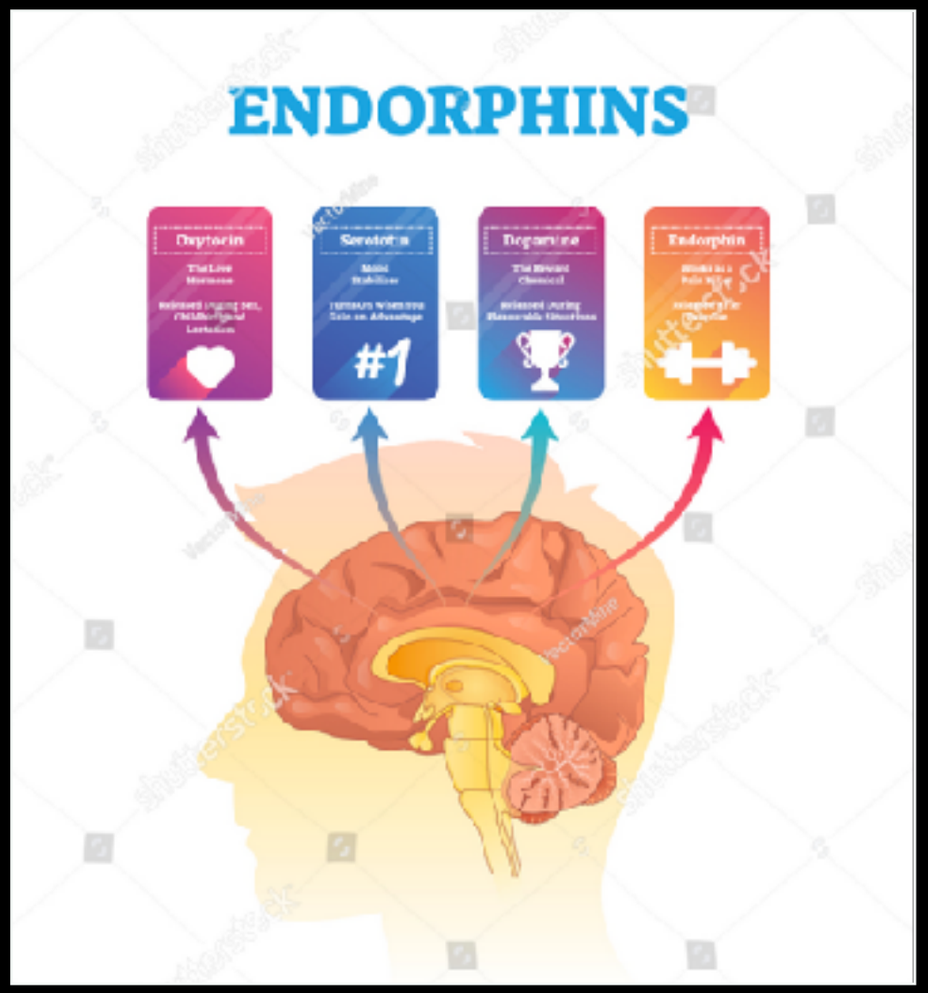
How Do I Make All of This Work?

In an attempt to keep this as simple and practical as possible, **there are certain nutrients that serve as the pieces that new neurons will built from, and then there are signaling molecules called neurotrophins that tell all of those pieces to come together in a specific way.**
It's like you have all of the materials to build a house, but then you need the construction contractor who tells all of the workers to put the pieces together in a certain way.
The neurotrophins are the contractors, the nutrients are the workers and the materials, and the neuron is the finished house.

Natural Ways to Raise BDNF aka "Fertilizer for Your Brain"!



3D Model of BDNF



all cardiovascular exercise increases perfusion of oxygen to the cerebral cortex and production of feel good neurochemistry:
oxytocin
serotonin
dopamine (reward from skill pursuit and accomplishment)
endorphins


THE CHEMICALS
THAT MAKE YOU HAPPY
SEROTONIN
MOOD STABILIZER
MORE SENSITIVE
TO DIET
THAN ANY OTHER
NEUROTRANSMITTER
DOPAMINE
THE "REWARD"
CHEMICAL
RELEASED DURING
PLEASURABLE
SITUATIONS
OXYTOCIN
THE "LOVE" HORMONE
RELEASED
DURING SEX,
CHILDBIRTH
AND LACTATION
ENDORPHIN
WORKS AS
A PAIN-KILLER
RELEASED
AFTER EXERCISE

The brain continually reorganizes itself by forming **new neural connections throughout life.**

This phenomenon is known as **neuroplasticity.**

How does neuroplasticity work? A large amount of research focuses on this question. Scientists are certain that the brain continually adjusts and reorganizes. In fact, while studying monkeys, they found that the neuronal connections in many brain regions appear to be organized differently each time they are examined! Existing neural pathways that are inactive or used for other purposes show the ability to take over and carry out functions lost to degeneration, and there is evidence that reorganization in the adult brain can even involve the formation of new neural connections. Understanding the brain's ability to dynamically reorganize itself helps scientists understand how patients sometimes recover brain functions damaged by injury or disease.

CRITICAL COMPONENTS FOR ADULT NEUROPLASTICITY:

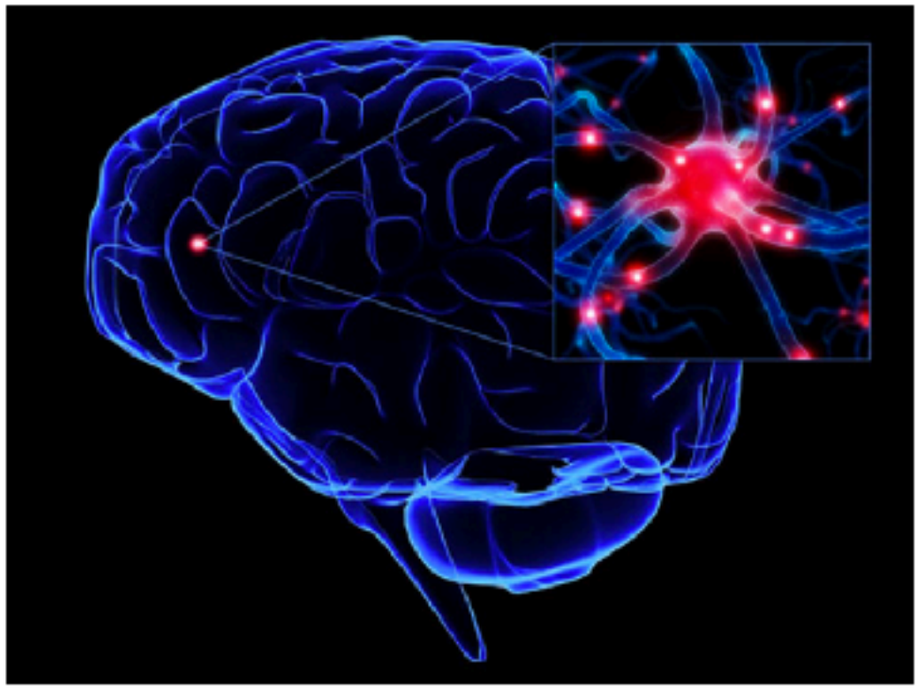
ATTENTION
FOCUS
URGENCY
(ENGAGEMENT)
DEEP REST/QUALITY SLEEP

Increasing connectivity in brain could influence:

memory
cognition
executive function (higher recruitment of frontal lobe)
emotional regulation
spatial learning
attention
psychomotor functions

COMPLEX MOVEMENT & NEUROPLASTICITY

Adult neuroplasticity (from complex, skill based) movement: synaptogenesis, increased connectivity between neurons, dendritic spines



Synaptogenesis

Synaptogenesis simply means "to create new synapses". What is a synapse? At the end of a neuron, there is a portion called the synapse where one neuron can communicate to another neuron by sending chemical messages that we call neurotransmitters.

Chemicals like dopamine, which is known to many as the "reward" chemical, is an example of one of these neurotransmitters. **In the womb and in the first few years of life is when the most rapid growth of neurons, and synapses occurs.**

What is a Dendrite

A dendrite is a short-branched extension, which carries nerve impulses to the cell body from the synapses. Many dendrites are extended from a single cell body of a nerve cell. Dendrites are highly branched structures. This highly-branched nature increases the surface area that can receive signals from the synapses. Dendrites and axons of nerve cells are shown in *figure 2*.

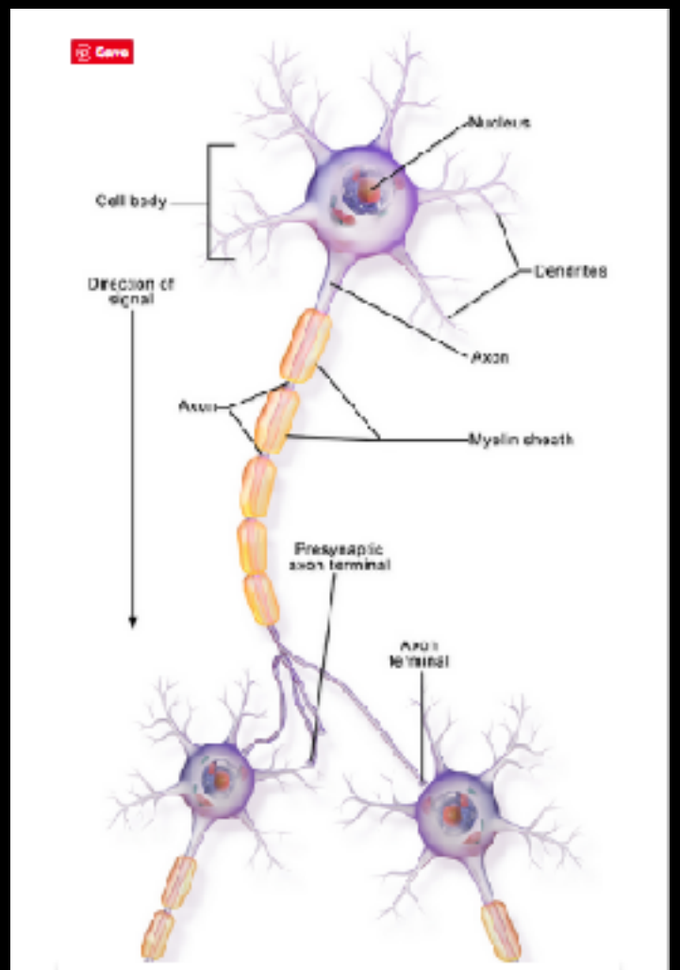


Figure 2. Dendrites and Axons

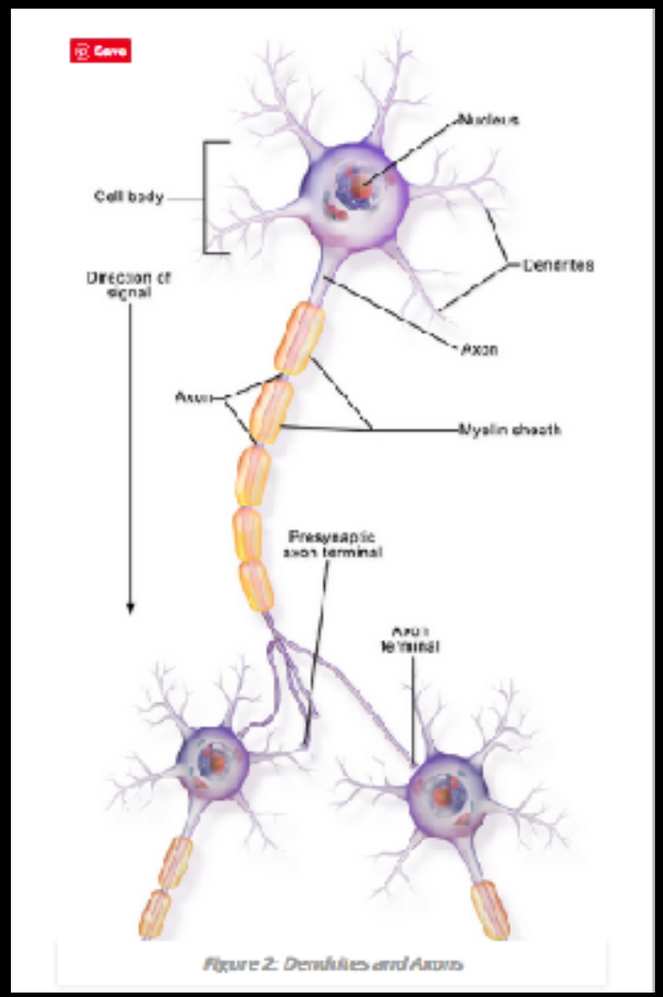


Figure 2: Dendrites and Axons

Most Complex Game of Building Blocks in The Universe

Scientists estimate that the number of neurons in a human nervous system is approximately 10 trillion!
Imagine you have a few different types of building blocks, and this allows you to create a variety of ways that you can put those building blocks together.
For example, you could make vertical stacks, horizontal lines, or even more complex figures that are only limited by your imagination, or the number of blocks that you have at your disposal.

Infinite Blocks that Can Link Up in Infinite Ways

Well the human nervous system has roughly 10 trillion building blocks to work with, and the designs are constantly responding, and changing to every little stimuli in your environment whether or not you are aware of the stimulus!
Below is an image with more detailed anatomy of a neuron. Synapses can send neurotransmitters directly into your bloodstream, into the middle of an axon or dendrite, into the fluid surrounding normal cells, or even into another synapse!

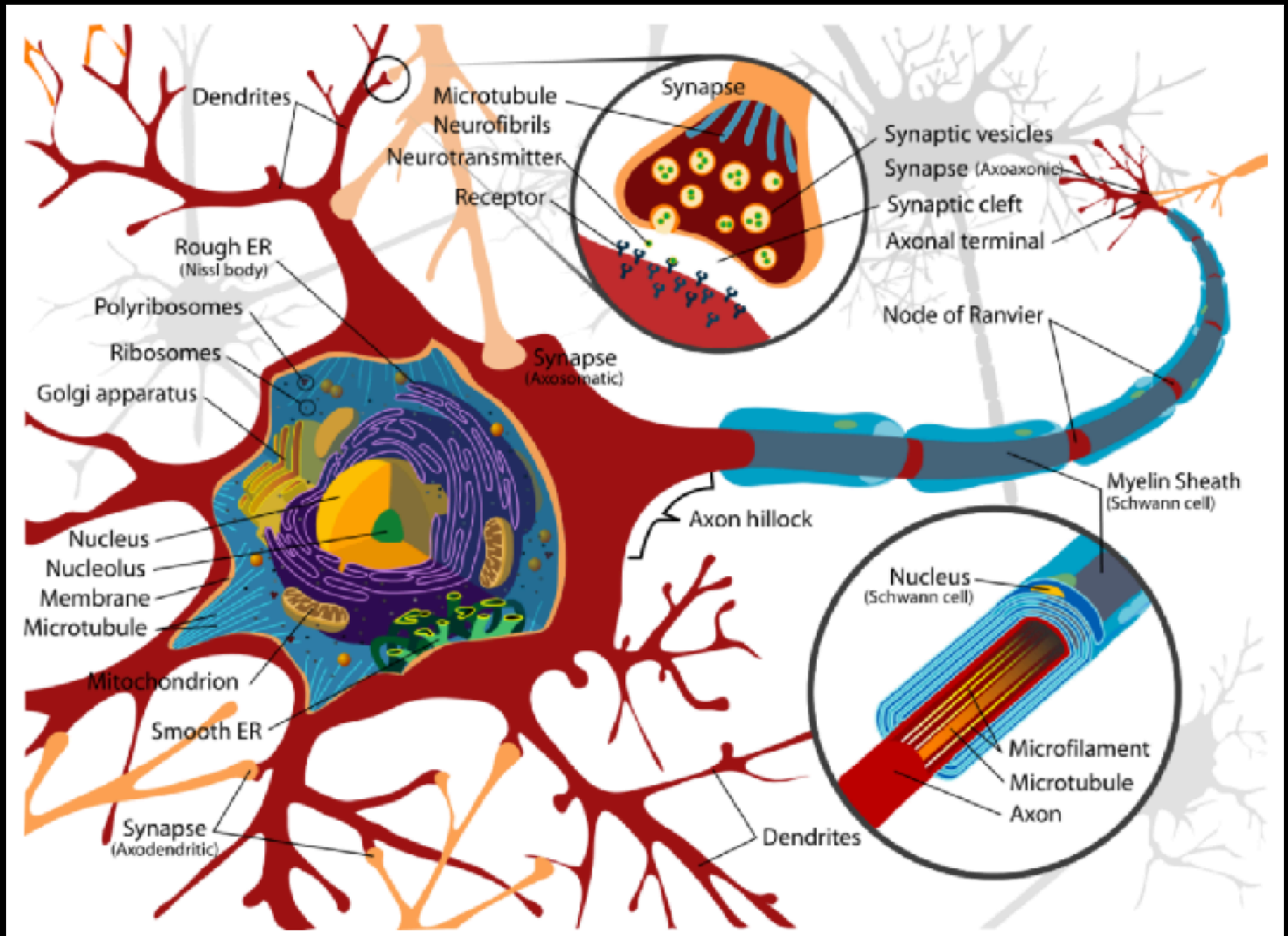
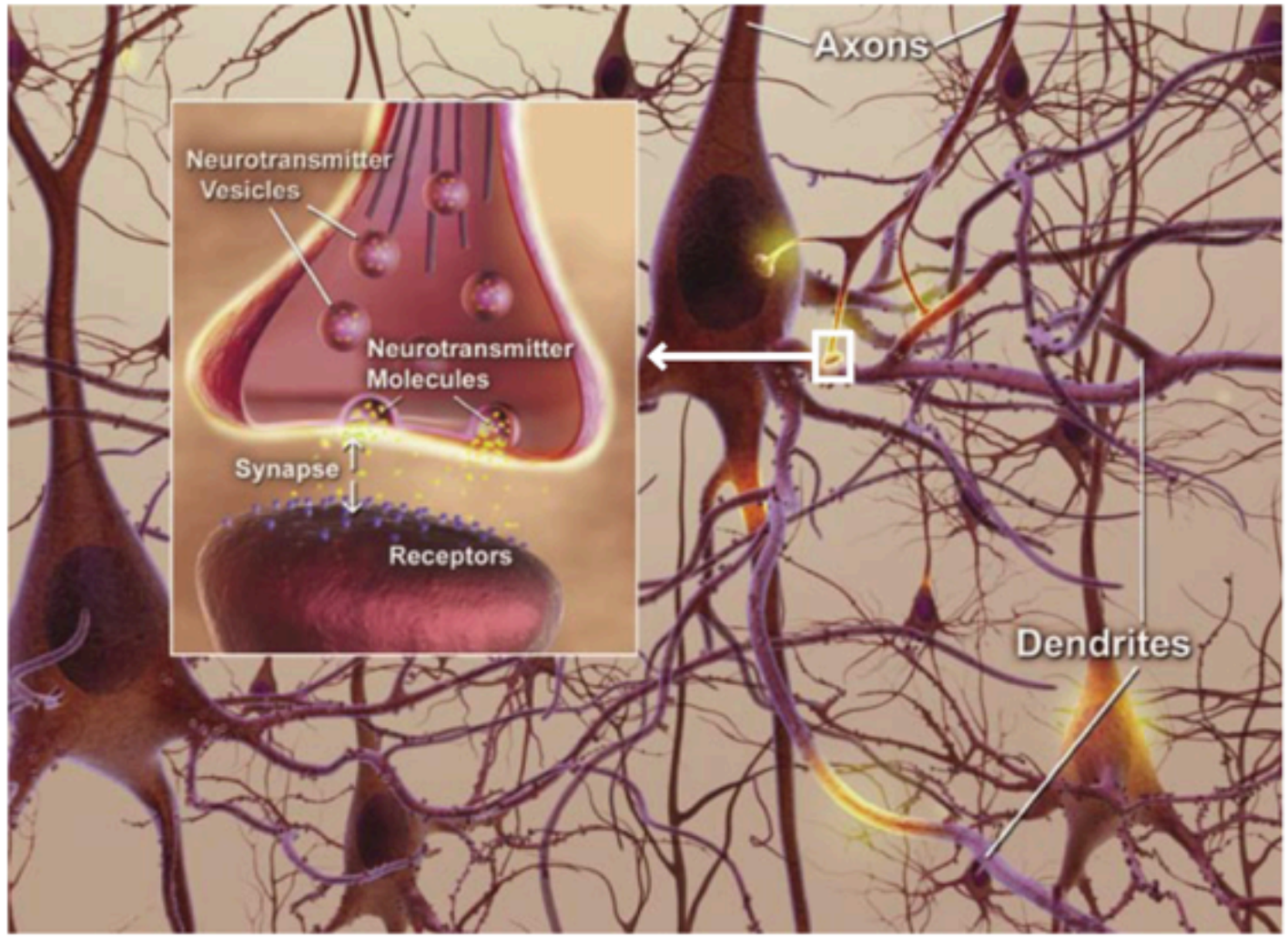


Diagram of a Neuron: This also shows some of the different ways that neurons can connect.

The Structure of Neurons and Synapses



Axons and dendrites are the part of the nerves that do that send electrical signals back and forth through the neuron, and they function very much like the wires we use in our homes that channel electricity.

The synapse is the part that does the communication between neurons as this is where the neurotransmitters are sent across the synaptic cleft to the next neuron.

This is how neurons communicate with one another. This seems very simple at first glance, and the basic mechanisms are very simple.

However, like a bunch of building blocks, the blocks themselves are fairly simple, but when we put a lot of them together in interrelationship the systems can get very complex.

What is an Axon

An axon is single, long projection of a nerve cell. Axons carry nerve impulses away from the cell body. The membrane that covers the axon is called the axolemma. Axoplasm is the cytoplasm of the axon. Axons are branched at their terminal ends. The tips of the branched ends are formed by telodendria. The axon terminals are the swollen ends of the telodendria. The axon terminals form the synaptic connection with a dendron of another neuron or with an effector organ. The membrane of the axon terminal is linked to the membrane of the target cell. Vesicles that contain neurotransmitters are present in the axon terminals to transmit the nerve impulses by means of chemical signals through the synaptic gap. The axon hillock is the initial segment of an axon. It initiates the action potential. A cross section of an axon is shown in *figure 1*.

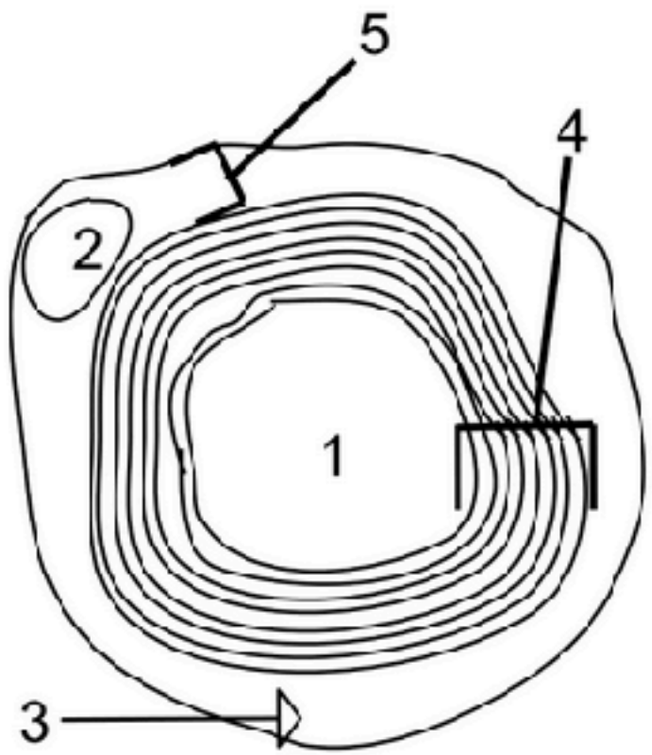


Figure 1: Axon cross section

1 – Axon, 2 – Nucleus of the Schwann cell, 3 – Schwann cell, 4 – Myelin sheath

AXON
VERSUS
DENDRITE

AXON	DENDRITE
Axon is the long thread-like part of a nerve cell which conducts nerve impulses away from the cell body	Dendrite is the short branched extension of a nerve cell, which transmits nerve impulses to the cell body from synapses
A nerve cell has only one axon	A nerve cell has many dendrites
Arises from a conical projection called axon hillock	Arises directly from the nerve cell
Very long	Very short
Have a uniform diameter	Diameter continuously decreases due to tapering ends
Branched at their ends	Branched all along
Tips of the terminal branches are enlarged to form synaptic knobs	No synaptic knobs occur at the tips of the branches
Synaptic knobs of the axons contain vesicles with neurotransmitters	Do not have vesicles that contain neurotransmitters
Do not contain Nissl's granules	Contain Nissl's granules
Either myelinated or non-myelinated	Non-myelinated
Carry nerve impulses away from the cell body	Carry nerve impulses towards the cell body
Form the efferent component of the nerve impulse	Form the afferent component of the nerve impulse

How to Make Your Dendrites Grow and Grow

by Daniel Golden, Adapted from Life Magazine

What can the average person do to strengthen his or her mind? "The important thing is to be actively involved in areas unfamiliar to you," says Arnold Scheibel, head of UCLA's Brain Research Institute. "Anything that's intellectually challenging can probably serve as a kind of stimulus for dendritic growth, which means it adds to the computational reserves in your brain." So pick something that's diverting and, most important, unfamiliar. A computer programmer might try sculpture; a ballerina might try marine navigation. Here are some other stimulating suggestions from brain researchers:

Do puzzles. "I can't stand crosswords," says neuroscientist Antonio Damasio of the University of Iowa, "but they're a good idea." Psychologist Sherry Willis of Pennsylvania State University says, "People who do jigsaw puzzles show greater spatial ability, which you use when you look at a map."

Try a musical instrument. "As soon as you decide to take up the violin, your brain has a whole new group of muscle-control problems to solve. But that's nothing compared with what the brain has to do before the violinist can begin to read notes on a page and correlate them with his or her fingers to create tones. This is remarkable, high-level type of activity," says Scheibel.

Fix something. Learn to repair your car or repair a shaver, suggests Zaven Khachaturian, a brain expert at the National Institute of Aging. "My basement is full of electronic gadgets, waiting to be repaired. The solution is not the important thing. It's the challenge."

Try the arts. If your verbal skills are good, buy a set of watercolors and take a course. If your drawing skills are good, start a journal or write poetry.

Dance. "We keep seeing a relationship between physical activity and cognitive maintenance," says Harvard brain researcher Marilyn Albert. "We suspect that moderately strenuous exercise leads to the development of small blood vessels. Blood carries oxygen, and oxygen nourishes the brain." But be sure the activity is new and requires thinking. Square dancing, ballet or tap is preferable to twisting the night away.

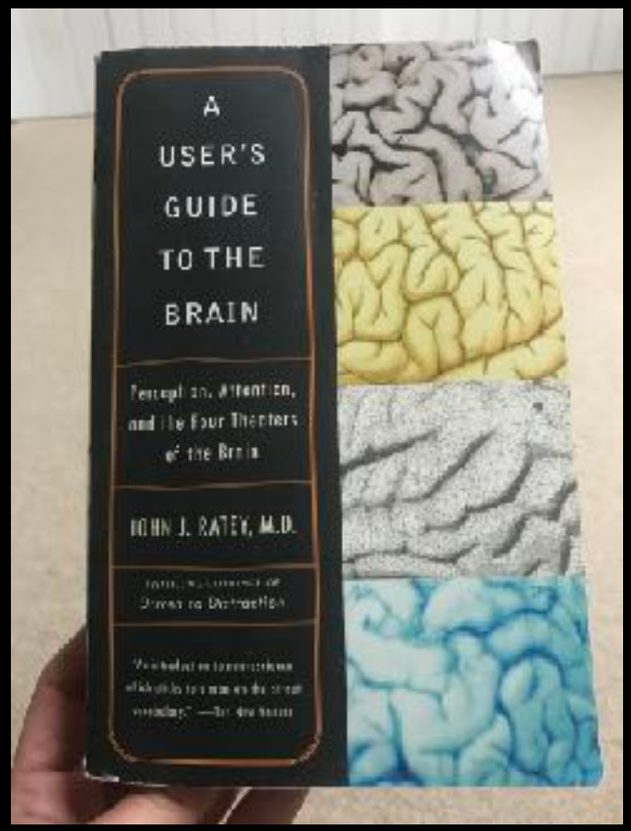
Date provocative people. Better yet, marry one of them. Willis suggests that the most pleasant and rewarding way to increase your dendrites is to "meet and interact with intelligent, interesting people." Try tournament bridge, chess, even sailboat racing.

And remember, researchers agree that it's never to late. Says Scheilbel, "All of life should be a learning experience, not just for the trivial reasons but because by continuing the learning process, we are challenging our brain and therefore building brain circuitry. Literally. This is the way the brain operates."

5. Non-Dominant Hand Exercises

Using your non-dominant hand to do simple tasks such as brushing your teeth, texting, or stirring your coffee/tea can help you form new neural pathways. These cognitive exercises, also known as "neurobics," strengthen connectivity between your brain cells. "It's like having more cell towers in your brain to send messages along. The more cell towers you have, the fewer missed calls," explains Dr. P. Murali Doraiswamy, chief of biological psychiatry at Duke University Medical Center.

Studies have also shown that non-dominant hand activities improves your emotional health and impulse control. Switch hands with simple tasks to give you brain a workout.



Neurologists are finding evidence that the cerebellum, which coordinates physical movement, also coordinates the movement of thoughts. Just as it orders the physical movements needed to catch a ball, it plays a role in the sequence of thoughts needed to visualize the kitchen, make an argument, or think up a tune. As we are finding again and again in this book, the old view that each brain function is isolated in a particular region of the brain is just not true. Spatial guidance, language, emotion, and many other functions share parts of the same brain systems, bringing different regions into play, in different ways.

Motor function is as crucial to some forms of cognition as it is to physical movement. It is equally crucial to behavior, because behavior is the acting out of movements prescribed by cognition. If we can better understand movement, we can better understand thoughts, words, and deeds.