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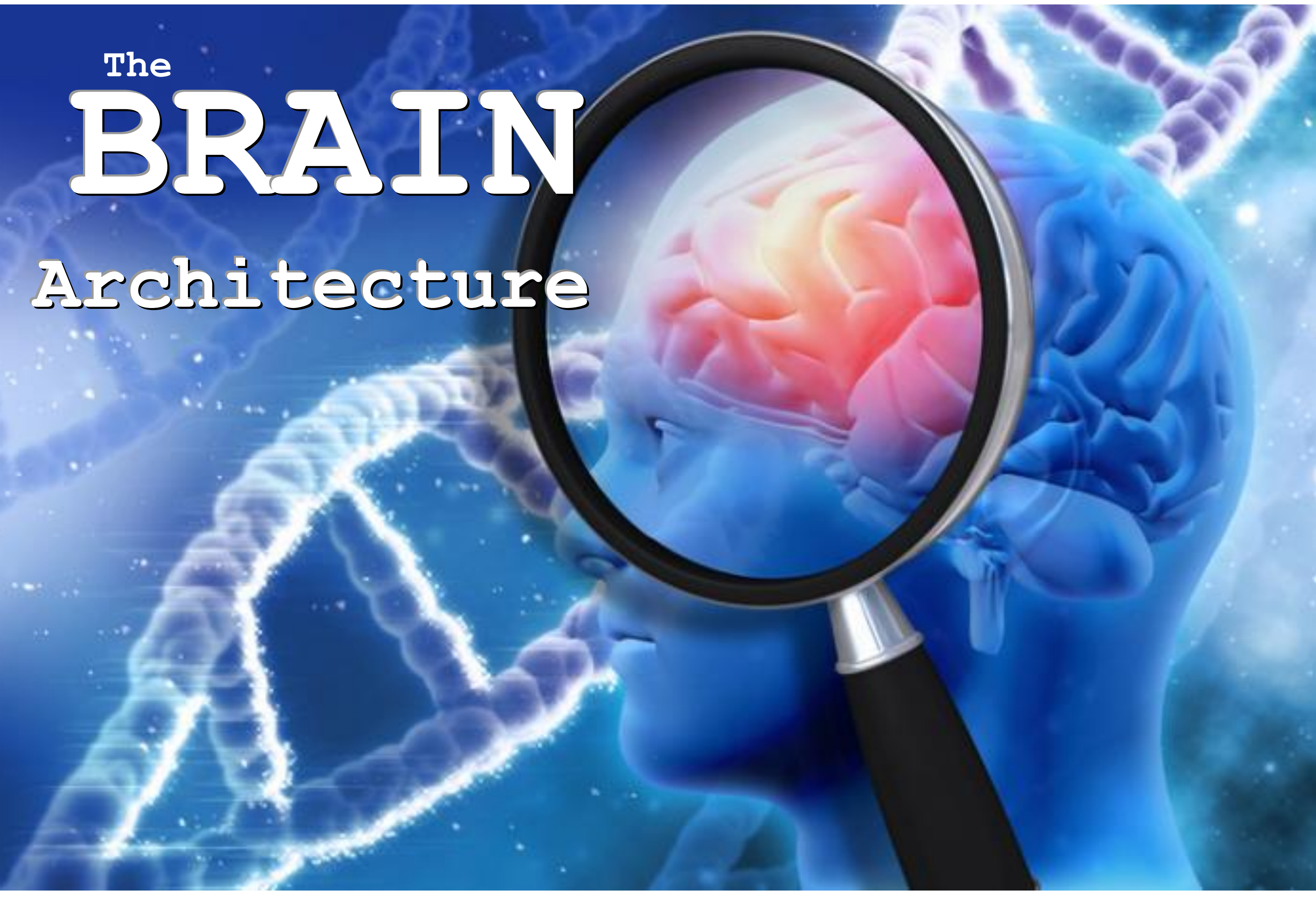


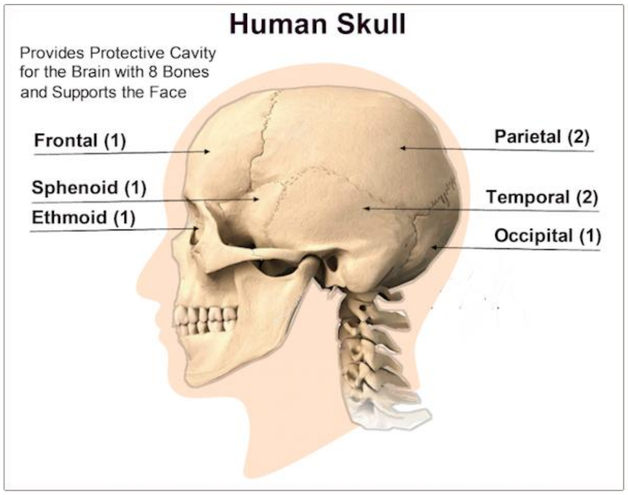
The Basics – Brain Architecture

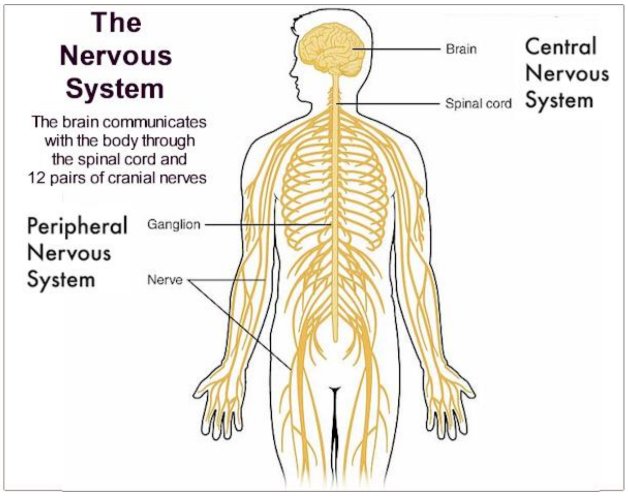
Your brain is unique, the most complex part of your body and the most valuable.   It is the command centre, the seat of your intelligence and the source of all the qualities that define your humanity.   Lying in its bony shell and washed by protective fluid, it uses about 20% of your body's energy to coordinate all of your body's internal and external actions, manage complex thoughts, feelings and behaviours, and make sense of the world around you.

Your brain is a configuration of many intricately designed parts that work together. While it is worthy of a thick textbook full of elaborate illustrations and difficult to pronounce and remember names, we offer you a brief and superficial sketch of your brain and the central nervous system to help you understand how a healthy brain works and why it is important to keep yours in tip top shape.

Skull

Your skull is a bone structure that supports the structures of your face and provides a protective cavity for your brain where your brain is suspended in cerebrospinal fluid, and isolated from the bloodstream by the blood–brain barrier. The skull is composed of two parts: the cranium and the mandible. It consists of eight bones that fuse together along suture lines. These bones include the frontal, parietal (2), temporal (2), sphenoid, occipital and ethmoid. The face is formed from 14 paired bones





The Nervous System

The nervous system is a complex network of nerves and cells that carry messages to and from the brain to the rest of your body. The nervous system has two main parts: the central nervous system (CNS), made up of the spinal cord and the brain; and the peripheral nervous system (PNS), the nerves and other types of supporting cells that branch throughout the rest of your body and communicate back to the CNS. When you are healthy, the parts of the CNS work together seamlessly, allowing your brain to govern functions and behaviors ranging from breathing to reading.   The brain communicates with the body through the spinal cord and twelve pairs of cranial nerves.

Regions of the Brain

Your brain is one part of your nervous system. According to the average, your brain weighs about three pounds or 1300 grams which is about 2% of the total average body weight. The brain can be divided into three basic units and each has its own special properties:

1. Hindbrain – the lower part includes the upper part of the spinal cord, the brain stem, and a wrinkled ball of tissue called the cerebellum . The brain stem connects the base of the brain to the spinal cord and PNS to help coordinate your brain's communication with the rest of the body. It is responsible for autonomic processes, or processes that occur reflexively, like breathing and heart rate. Near the brain stem is a major structure of the hindbrain called the cerebellum which plays a vital role in all your physical movement. It handles balance, posture, and coordination in fine-tuning muscle movement.

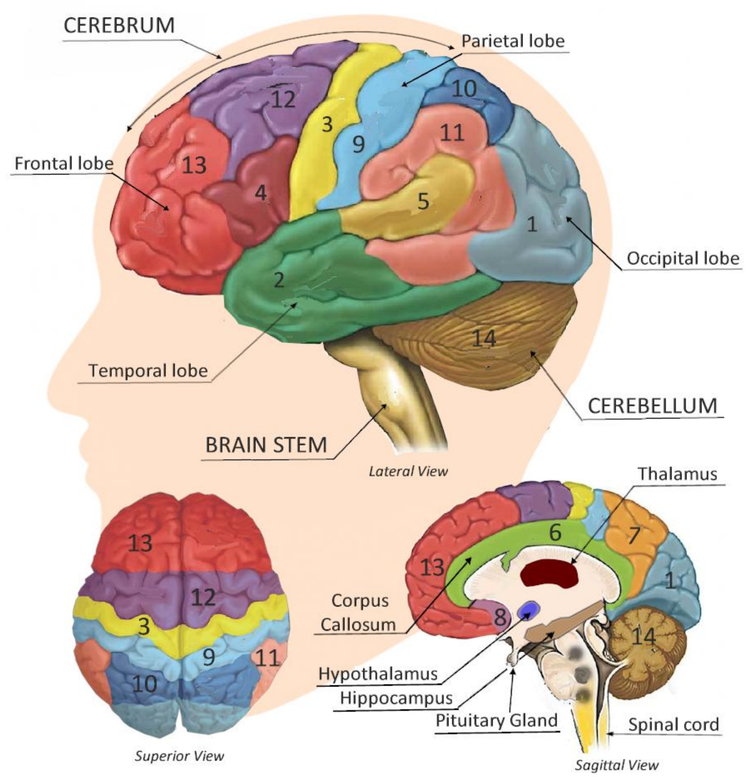
2. Midbrain - the uppermost part of the brainstem is the midbrain, which controls some of your reflex actions and is part of the circuit involved in the control of eye movements and other voluntary movements.

3. Forebrain - the largest and most highly developed part of your brain sits above the brainstem and cerebellum. It consists primarily of the cerebrum and the structures hidden beneath (see sagittal view.

The Cerebral Hemisphere

The cerebrum sits at the topmost part. When people see pictures of the brain it is usually the walnut shaped wrinkled cerebrum that they notice. It spans both the left and right hemispheres (see superior view). The cerebrum is the source of your higher functions and intellectual activities.

- Determining intelligence
- Determining personality
- Thinking
- Reasoning
- Producing/understanding language
- Interpretation of sensory impulses
- Controlling fine motor function
- Planning and organization
- Processing sensory information



You cerebrum holds your memories, allows you to plan, enables you to imagine and think, recognize friends, read books, and play games. You also need your cerebrum to interpret emotions, solve problems and learn.

Right and Left Hemispheres

The cerebrum is divided into right and left hemispheres. Despite the split, the two cerebral hemispheres can communicate and send signals to each other through a thickly arched bridge of nerve fibres that connect the two hemispheres. This bridge, called the corpus callosum (visible in sagittal view) which lies at the base of this fissure, allows you to coordinate activity.

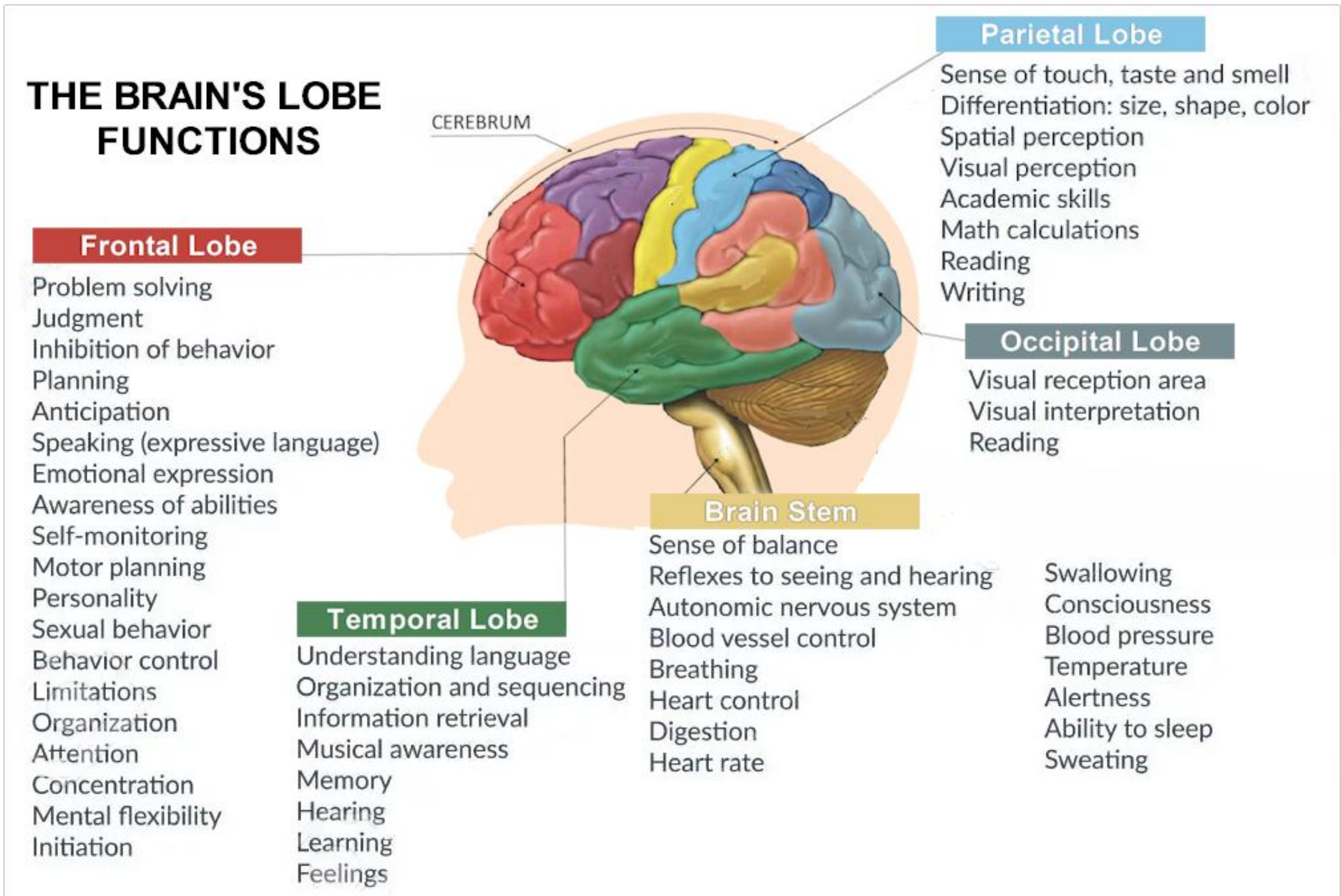
Although the two hemispheres seem to be mirror images of each other and do not function independently of one another, they are different; there are certain functions for which one hemisphere excels over the other. For instance, the ability to form words seems to lie primarily in the left hemisphere, while the right hemisphere seems to control many abstract reasoning skills.

Left Hemisphere	Right Hemisphere
Analytical skills/Problem solving	Creativity
Logic	Imagination
Reasoning	Spatiotemporal awareness
Language	Reflective, conscious thought
Calculations; Mathematics	Music interpretation
	Visual imagery
Muscles of the right side of the body	Muscles of the left side of the body

For some as-yet-unknown reason, the cerebrum is contralaterally organized which means that nearly all of the signals from the brain to the body and vice-versa cross over on their way to and from the brain. In other words, the right cerebral hemisphere controls and processes signals from the left side of the body, while the left hemisphere controls and processes signals from the right side of the body. When one side of the brain is damaged, the opposite side of the body is affected. For example, a stroke in the right hemisphere of the brain can leave the left arm and leg paralyzed.

Behavioral Geography of Your Brain and Thought

The structures of the brain are well visualized with current technology and minute details of cell structure which can be seen with electron microscopy. Even structural changes in the neuron associated with learning have been photographed. One thing that continues to be puzzling is the exceedingly intricate relationship between brain and thought and behavior. The ability to feel and express emotion is a unique feature of our mind. Yet, as much as we know, our understanding of this fundamental relationship is still very limited. Here is what we do know and what we have learned through brain mapping technology.



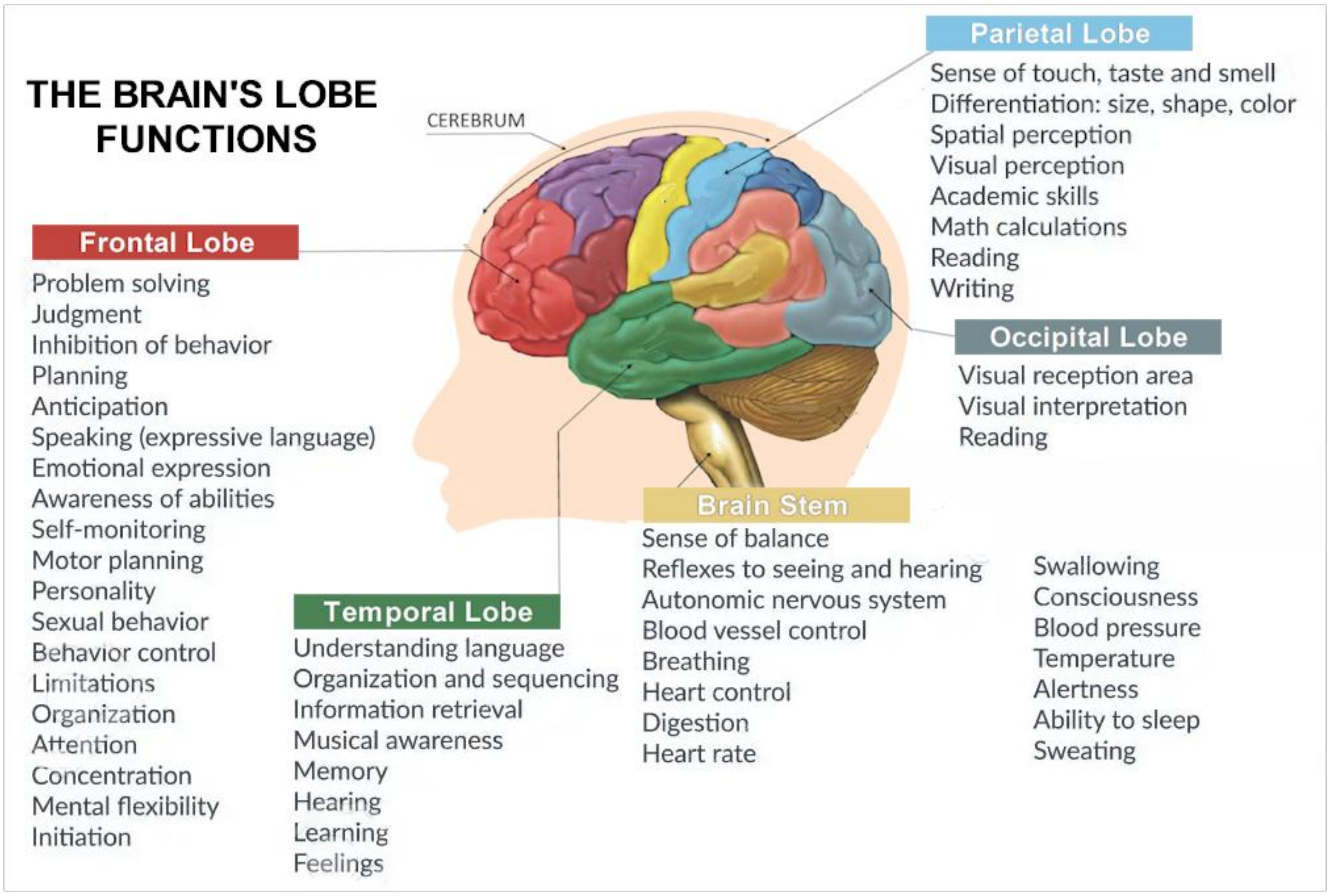
The cerebral cortex is subdivided into identifiable zones called lobes, four of which are visible, comprising the lateral surface of each hemisphere's of the cerebrum. These four lobes have the same name as the bone over them: the frontal lobe, the parietal lobe, the occipital lobe, and the temporal lobe. In the medial part of the brain you will find the limbic system and insular lobe which are sometimes controversially not considered lobes, but part of another. These zones of the brain have specific functions directly related to thought, emotion and behaviours.

Frontal lobes: These are the two frontal lobes located at the front of the brain which lies directly behind your forehead. They are responsible for things like critical thinking, planning, motivation, feelings of reward and self-awareness. When you plan a schedule, imagine the future, or use reasoned arguments, these two lobes do much of the work. One of the ways the frontal lobes seem to do these things is by acting as short-term storage sites, allowing one idea to be kept in your mind while you consider other ideas. In the rearmost portion of each frontal lobe is a motor area, which helps you to control voluntary body movement. A nearby place on the left frontal lobe called Broca's area contains the speech centre where your thoughts are transformed into words.

Parietal lobes: Two sections behind the frontal lobes are called the parietal lobes. When you enjoy a good meal—the taste, aroma, and texture of the food— the forward parts of these lobes, just behind the motor areas of the frontal lobes, are the primary sensory areas that receive information about temperature, taste, and touch. The parietal lobe is also responsible for sensing proprioception which helps you understand the space around your body and movement from the rest of your body. It also contains the sensory strip which is the region in your brain that helps you sense things like pain and temperature. Reading and arithmetic are also functions in the repertoire of each parietal lobe.

Occiptital lobes: These lobes found at the back of the brain contains the visual cortex, which allows you to interpret colour, light and movement. They process images from the eyes and link that information with images stored in memory. What you see through your right eye is processed on the left side of your brain and what you see through your left eye is processed on the right side of your brain. Damage to the occipital lobes can cause blindness.

Temporal lobes: Nested in front of the visual cortex and under the parietal lobes lie the temporal lobes. Whether you appreciate symphonies or rock music, your brain responds through the activity of these temporal lobes. At the top of each temporal lobe is an area responsible for receiving information from the ears. The underside of each temporal lobe plays a crucial role in forming and retrieving memories, including those associated with music. Other parts of this lobe seem to integrate memories and sensations of taste, sound, sight, and touch. The temporal lobe runs the full width of your brain, behind your temples. It's responsible for learning, memory, understanding language (Wernicke's area) and organization.



Limbic System

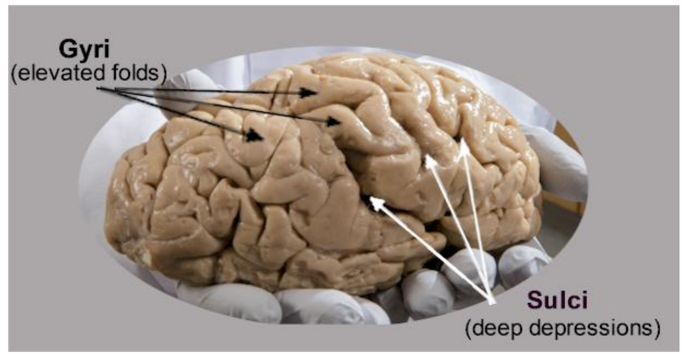
Buried under the cerebral cortex and forming a physical border or rim around the corpus callosum is the limbic system which is considered the epicenter of your emotional and behavioral expression. It is a collection of structures involved in controlling the experience and expression of your emotions and your response to stress particularly related to survival. Your limbic system is an important element in the formation and storage of your memories, sexual arousal, the pleasures of eating, motivations and learning as well as some automatic functions of your body.

Insular Cortex

This portion of your brain is a portion of the cerebral cortex folded deep within the fissure separating the temporal lobe from the parietal and frontal lobes. The insula is often thought to be a part of the temperol lobe. The insulae are believed to be linked to consciousness functions such as empathy, taste, perception, motor control, self-awareness, cognitive function, interpersonal experience and your awareness of your hunger, pain, fatigue, body temperature and fluid balance.

The Cerebral Cortex – Where most of the Processing Stuff Happens

When you see an image of the brain one striking feature stands out: the cerebral cortex with its stereotyped pattern of deep wrinkles. The cerebral cortex (cortex is the Latin word for bark) is an outer layer of very vital neural tissue that completely covers the surface of the two cerebral hemispheres. This grayish pink cerebral mantle is about 2 to 4 mm thick, about the thickness of two to three dimes. The squashed wrinkled appearance comes from the mass of distinct convolutions and elevated folds called gyri and the fissures and depressions called sulci.



The convolutions where the cortex is folding in on itself allow a large surface area of brain to fit inside your skull. You normally would only see about a third of a brain's surface – the other two-thirds are hidden in its folds. You can hold a human brain in your two hands, but if you could unpack its folds and spread it flat it would cover about 2500 square centimeters. It could stretch over a 20"x 18" table top.

The more wrinkled a brain gets, the bigger the surface of the cortex becomes. That is a good thing because most of the actual information processing in your brain takes place in the cerebral cortex. A larger surface area allows for more neurons to be present which translates into a greater quantity of information that can be processed. Think of it as a giant computer network spread out over a thin surface. And yes, this is the grey matter that people talk about. (More on that to come.)

The cerebral cortex is organized into distinct functional areas including perception and awareness of sensory information, planning, and initiation of motor activity and higher cognitive functions.

Functional Areas of the Cerebral Cortex

1. Visual
Sight
Image recognition
Image perception

2. Association
Short-term memory
Equilibrium
Emotion

3. Motor Function
Initiation of
voluntary muscles

4. Brocha's
Muscles of speech

5. Auditory
Hearing

6. Emotional
Pain
Hunger
"Fight or flight" response

7. Sensory Association

8. Olfactory
Smelling

9. Sensory
Sensation from muscles and skin

10. Somatosensory
Evaluation of weight,
texture, temperature, etc.
for object recognition

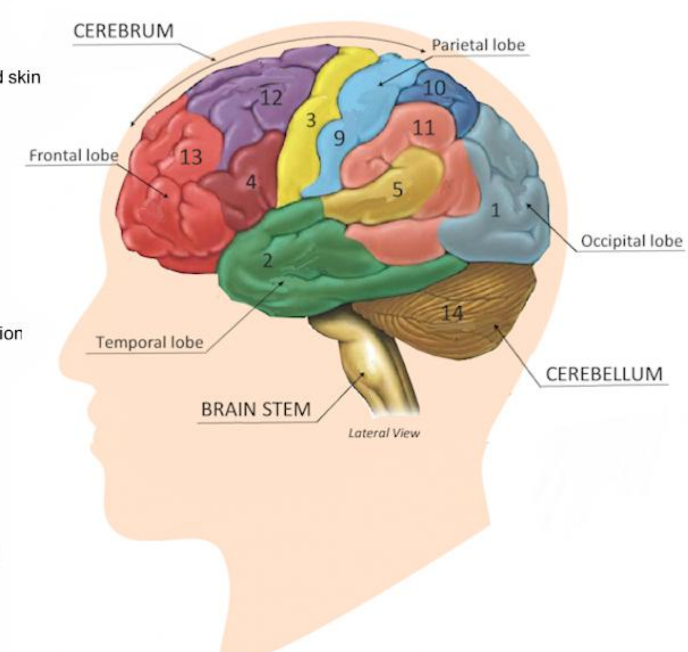
11. Wernicke's
Written and spoken
language comprehension

12. Motor Function
Eye movement and orientation

13. Higher Mental Functions
Concentration
Planning
Judgement
Emotional Expression
Creativity
Inhibition

Functional Areas of the Cerebellum

14. Motor Function
Coordination of movement
Balance and equilibrium
Posture



Inside the Brain

Deep within the brain, hidden from view, lie structures that are the gatekeepers between the spinal cord and the cerebral hemispheres. These structures not only determine your emotional state, they also modify your perceptions and responses depending on that state, and allow you to initiate movements that you make without thinking about them. Like the lobes in the cerebral hemispheres, the structures described below come in pairs: each is duplicated in the opposite half of the brain.

Hypothalamus: this region of the brain is about the size of a pearl. It directs a multitude of important functions. It wakes you up in the morning, and gets your adrenaline flowing. The hypothalamus is also an important emotional center, controlling the molecules that make you feel exhilarated, angry, or unhappy.

Thalamus: This area is a major clearinghouse for information going to and from the spinal cord and the cerebrum. The thalamus is surrounded by clusters of nerve cells called basal ganglia which are responsible for initiating and integrating movements. Parkinson's disease, which results in tremors, rigidity, and a stiff, shuffling walk, is a disease of nerve cells that lead into the basal ganglia.

Hippocampus: An arching tract of nerve cells leads from the hypothalamus and the thalamus to the hippocampus which is a tiny nub that acts as a memory indexer – sending memories out to the appropriate part of the cerebral hemisphere for long-term storage and retrieving them when necessary.

Brain Cell Communication

Brain cells make up the functional tissue of your brain. The rest of brain tissue is structural or connective and includes blood vessels. Each brain cell has a specific function. The two main types of cells in your brain are neurons, also known as nerve cells and glial cells.

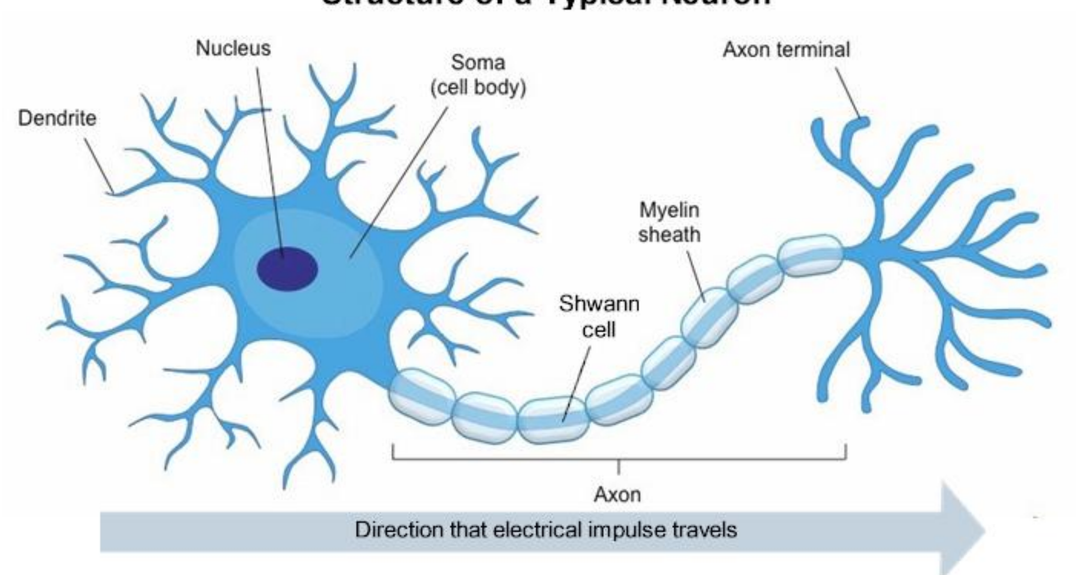
Neurons are excitable cells, which mean they produce electrical impulses for the purpose of communicating with other neurons in your brain network. Glial cells do not produce electrical impulses. Their purpose is to form myelin in the peripheral nervous system, and provide nutrients, support and protection for neurons.

The Neuron

The neuron is the most common and the brain's most basic working cell unit. All sensations, movements, thoughts, memories, and feelings are the result of signals that pass through neurons.

Neurons consist of three parts: cell body, dendrites and axons. At one end each neuron has a cell body which contains the nucleus, where most of the molecules that the neuron needs to survive and function are manufactured. The cell body is surrounded by dendrite branches, which receive messages from other nerve cells. Dendrites receive chemical signals from other neurons, which are then converted into electrical impulses that are transmitted toward the cell body.

Structure of a Typical Neuron



Axons are nerve fibers that extend out from the soma to connect the cell body to the axon terminal at the other end of the neuron. Schwann cells surround the axon. They provide a fatty coating called the myelin sheath. The axon carries nerve impulses (a cell's signal) to other cells, neurons, muscles, glands or cell in some other organ.

Where dendrites are short, tapered and spread out to provide an enlarged surface area to receive electrochemical signals, the axon may be very short carrying a signal to another cell less than a hair's width away, or axons may be very long, such as those that carry messages from the cerebral hemispheres all the way down the spinal cord.

When the neurons transmits an electrical signals the impulse flows from the dendrite and soma through the axon toward the axon terminal. A ceaseless flow of impulses jump from the axon end of one neuron to the dendrite end of the next neuron. To do this, the signal has to cross a tiny gap called a synapse where the cell messages are exchanged.

The Synapse Connection

There is a flow of billions of neuron impulses circuiting through the nervous system. Synapses are an essential part of the circuit that connects neurons in the brain to neurons in the rest of the body.

The synapse is essential for life. At the majority of synapses, signals cross from the axon of one neuron to a dendrite of another. However, synapses can connect an axon to another axon or a dendrite to another dendrite. The synapses allow electrical and chemical messages to be transmitted from the neuron to the other cells in the body.

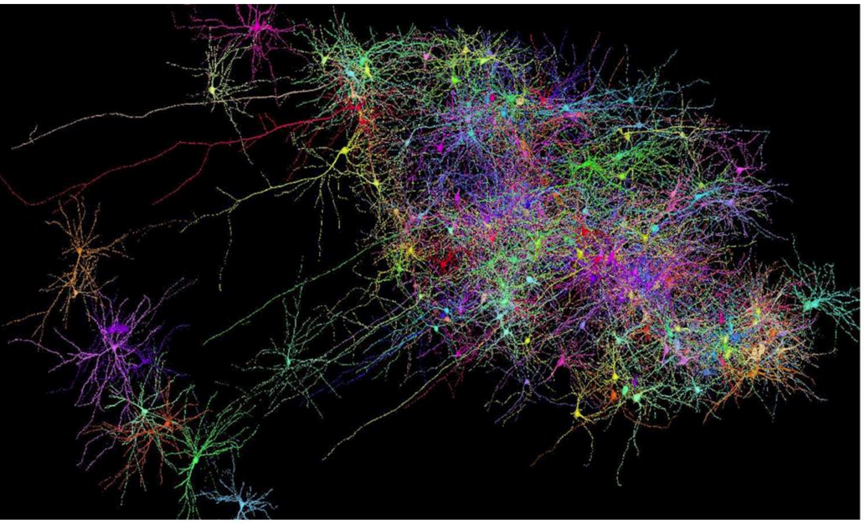
When your brain is well nourished and adequately stimulated the tiny transmission organs at the neuronal tips proliferate abundantly providing your nervous system with an astronomical multiplicity of points of interaction between nerve cells. A single neuron can have direct synaptic contact with several thousand other neurons.

Scientists have learned a great deal about neurons by studying the synapse. The synapse can convert electrical impulses into chemical signals before it is received by other nerve cells. When the signal reaches the end of the axon it stimulates the release of tiny sacs. These sacs release chemicals known as neurotransmitters into the synapse. The neurotransmitters cross the synapse and attach to receptors on the neighboring cell. These receptors can change the properties of the receiving cell. If the receiving cell is also a neuron, the signal can continue the transmission to the next cell.

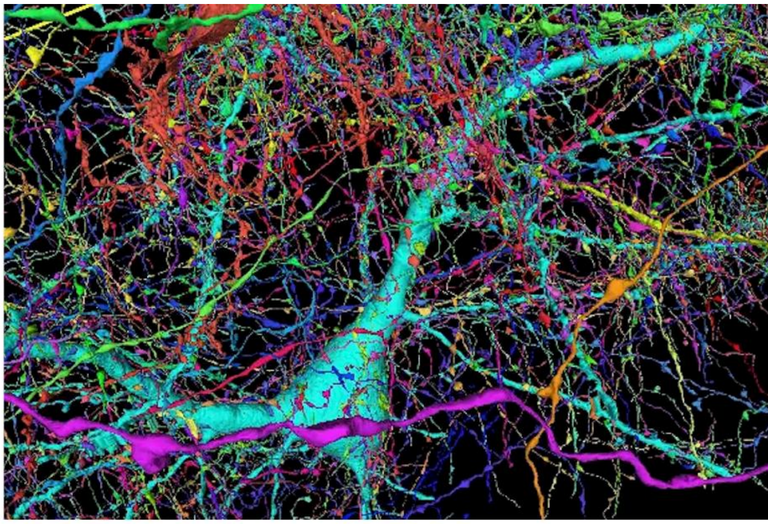
The Connectome

Neurons only function in collaboration with other neurons. They are often grouped into a cluster to form a nucleus where they have similar connections and functions, but this cluster cannot work in isolation. Nuclei are connected to other nuclei by bundles of axons tracts. Dendrites and axons allow neurons to communicate with one another.

Your brain contains about 86 billion neurons. Each neuron is connected to at least one other neuron forming close to 100 trillion connections to physically and functionally wire different sets of brain regions together. Strongly connected to one another through these tracts of networked neurons important regions of your brain communicate with one another with ease. This intricate pattern of this structural connectivity is called your brain's *connectome.*



White matter fiber pathways in a human brain imaged with MR tractography.



Around 4000 nerve fibres connect to this single neuron

Harvard University neuroscientists and Google engineers released the first wiring diagram of a piece of the human brain. The tissue, about the size of a pinhead shown here is mind-boggling.

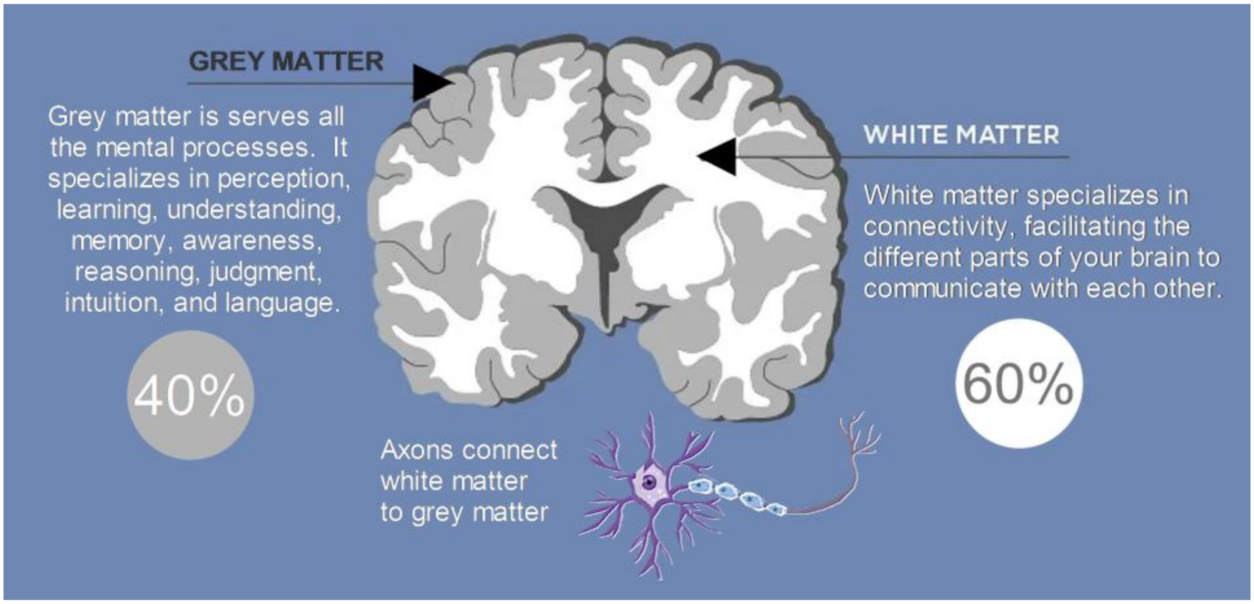
This image illustrates just how astonishing your connectome is. Joined in collaboration your complex brain network becomes a self-organized coalition that produces the different cognitive functions you perform.

Grey Matter and White Matter

It is the different sections of neurons that make up the brain's two types of matter: grey and white matter. Both are vital to the brain. Remember, nuclei are connected to other nuclei by bundles of axons tracts. The bundles are in fact tracts of white matter. About 60% of the human brain's volume is not gray, but white matter. How are they different from each other? Basically grey matter contains the nerve cells, while white matter is composed of nerve fibres. But, there are other significant differences.

Grey Matter

Grey matter is peculiar for containing a high concentration of neuron cell bodies called *soma* which is the brain's most basic working cell unit. These bulbous cells have a grey tone because they lack the insulation that makes most of the other parts of the brain appear white. Grey matter found in your brain stem and spinal column is called the *grey column.*

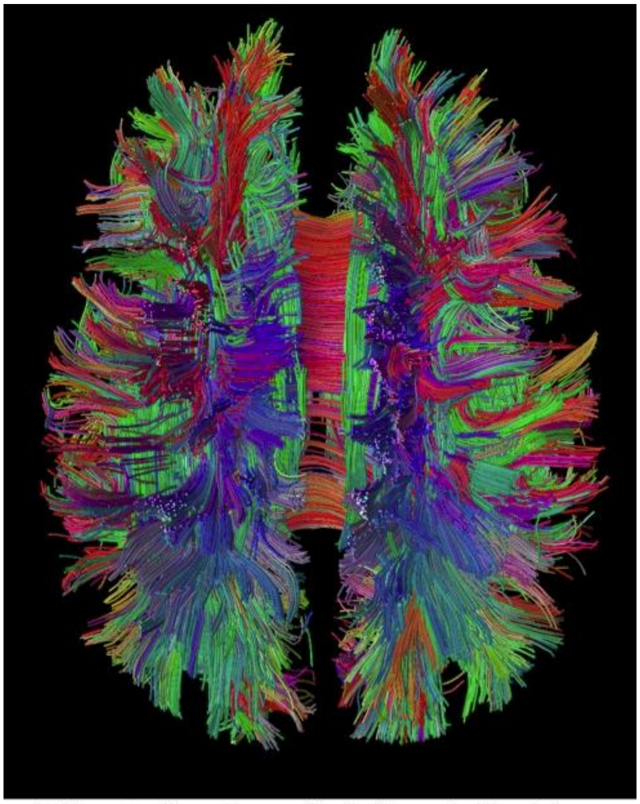


White Matter

White matter consists of a preponderance of axons tracts which transmit global electrical signals to other neurons, even neurons in the furthest regions of the body. Axons are sheathed in myelin. This fatty insulation also serves a purpose. It helps brain cells communicate more efficiently. Myelin acts as an insulator, which allows electrical signals to jump, rather than coursing through the axon, which increases the speed of transmission of all nerve signals. It's the myelin that gives white matter its signature color.

In simplified terms, the axons connect white matter to grey matter. Grey matter processes information. Then it hands the results over to white matter. The white matter transmits the information to different parts of your body. Without functioning white matter, the various regions of your brain could be like having a committee of people in proximity to each other but unable to communicate with each other.

Efficiency Matters


White matter fibre pathways of the brain's cerebral hemispheres, as depicted with MR tractography. (Provided by Patric Hagmann, CHUV-UNIL, Lausanne, Switzerland)

Only quite recently have neuroscientists begun to understand the importance of this long-neglected part of the brain.

Where grey matter makes up most of the surface of your cerebral cortex and cerebellum white matter tracts are typically distributed under the grey matter closer to the centre of your brain.

IWhite and grey matter trade places when they extend all the way from the brain down into the spinal cord. In the spinal cord white matter takes up most of the outer layer. Why? The answer can be explained as efficiency.

In the cortex white matter forms a vast intertwining system of neural connections that join all the regions of the brain. It is an efficient system due to the inward folding wrinkles in the cortex which reduces the distance and therefore the amount of interconnecting white matter.

Since the spinal cord is responsible for bringing motor information from your brain to your body, the short connections of grey matter in the spine would have to reach further to send signals to the body to move. However, since long axon tracts are on the outside layer, it's much faster for signals to get to your motor neurons. These longer pathways on the outside layer help create fast signal transmission so you can react and move quickly

Oxygen Matters

White matter may dominate volume wise, but grey matter gets the edge is in oxygen – 95% of the oxygen that goes to your brain is used by grey matter. This may be because the grey matter handles things like higher processing and other cognitive functions, whereas white matter is greatly responsible for carrying electrical signals. Sort of like a computer compared to a power supply.

Significance of Grey Matter Communication through White Matter

White matter works in concert with gray matter to enable the extraordinary repertoire of your cognitive capacities. Because of this communication this is how you used an abundance of grey matter:

- In the external mantle that covers your cerebral hemispheres, your brain uses grey matter for higher learning, attention, memory, computation, thinking, etc.
- In the depths of the cerebrum, grey matter in your hypothalamus and thalamus is used to control your emotional centre and the initiation of movement .
- In the outer layer of your cerebellum, grey matter is essential for motor control, coordination, and precision.
- In your brainstem the grey column is essential for control of reflex actions, eye movements and other voluntary movements.
- In your spinal cord three grey columns travels down the spinal cord taking responsibility for the movement of muscles, receiving sensory information from the skin, bones, and joints pertaining to fine touch, proprioception, and vibration, and the sympathetic nervous system or emergency functioning.

Some Key Neurotransmitters at Work

Neurotransmitters are chemicals that brain cells use to talk to each other. Some neurotransmitters make cells more active (called *excitatory*) while others block or dampen a cell's activity (called *inhibitory*).

Acetylcholine is an excitatory neurotransmitter because it generally makes cells more excitable. It governs muscle contractions and causes glands to secrete hormones. Alzheimer’s disease, which initially affects memory formation, is associated with a shortage of acetylcholine.

Glutamate is a major excitatory neurotransmitter. Too much glutamate can kill or damage neurons and has been linked to disorders including Parkinson's disease, stroke, seizures, and increased sensitivity to pain.

GABA (gamma-aminobutyric acid) is an inhibitory neurotransmitter that helps control muscle activity and is an important part of the visual system. Drugs that increase GABA levels in the brain are used to treat epileptic seizures and tremors in patients with Huntington’s disease.

Serotonin is a neurotransmitter that constricts blood vessels and brings on sleep. It is also involved in temperature regulation. Low levels of serotonin may cause sleep problems and depression, while too much serotonin can lead to seizures.

Dopamine is an inhibitory neurotransmitter involved in mood and the control of complex movements. The loss of dopamine activity in some portions of the brain leads to the muscular rigidity of Parkinson’s disease. Many medications used to treat behavioral disorders work by modifying the action of dopamine in the brain.

Neurological Disorders

When the brain is healthy it functions quickly and automatically. Even though your brain is protected by the skull, suspended in cerebrospinal fluid, and isolated from the bloodstream by the blood–brain barrier it is still susceptible to damage, disease, and infection.   When problems occur, the results can be devastating. Millions of people suffer from devastating brain disorders. Damage can be caused by trauma to the spinal cord and head injury, or a loss of blood supply known as a stroke. There are metabolic and infections diseases, degenerative disorders, such as dementias, multiple sclerosis, or Parkinson's disease, psychiatric conditions including schizophrenia and clinical depression, and convulsive disorders such epilepsy. The brain is susceptible to tumours which can originate from other sites of the body.

Knowing more about the brain can lead scientists to the development of new treatments for diseases and disorders of the nervous system and improve many areas of human health.

Keep your Brain Young

Your brain is one of the hardest working organs in your body. Keeping it healthy should be a priority. Changes to your body and brain are normal as you age. Yet many people fear mental decline which is one of the consequences of aging. However, there are things you can do to help slow any decline in memory and lower your risk of developing diseases or dementias:

- Maintain strong social ties because friends and social activities are associated with lower risk of dementia.
- Take care of your emotions because people who are anxious, depressed, sleep-deprived, or exhausted tend to score poorly on cognitive function tests.
- Maintain a regimen of adequate sleep and a healthy diet because sleep and nutrition are both absolutely necessary to keep your brain healthy.
- Perform mental gymnastics. Sounds difficult, but all it means is that you do a variety of things that are mentally stimulating to help build new connections, generate new cells, develop neurological plasticity and build up a functional reserve to hedge against future cell loss. Read, learn something news, do word puzzles or math problems, perform specific activities that stimulate your individual senses, experiment with things that require manual dexterity as well as mental effort.
- Exercise regularly – research shows that using your muscles also helps your mind
- Protect your head; moderate to severe head injuries, even without diagnosed concussions, increase the risk of cognitive impairment.

You can take better care of your brain, starting today!

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Inspired and Committed, We Celebrate Your Journey

At Corro, we believe in the power of people. We are inspired to expand humanity's capacity for wisdom, compassion, and courage.

In our commitment to helping you achieve long-term personal development and use your organizational platform for positive impact, we celebrate the journey of lifelong learning while fostering an all-inclusive community driven environment of meaning, personal connection, and fun.

Corro is not just a Work Space – Our Aim is Helping the Community Thrive through People Success