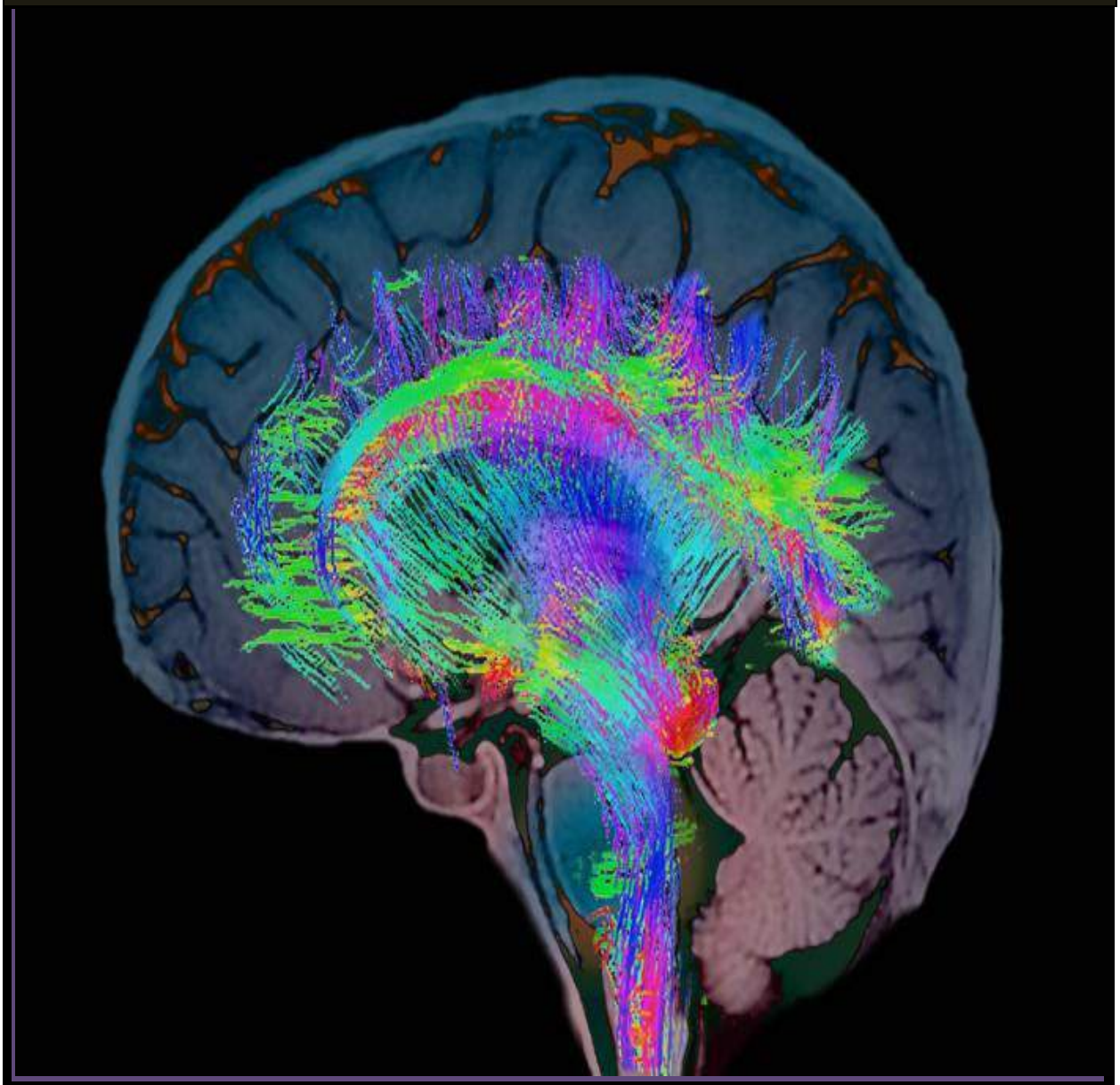
LIFE STREAM

ANNUAL ISSUE 2021 - OUR MYSTERIOUS BRAIN



*As humans we can identify galaxies light years away, and we can study particles smaller than an atom, but we still haven't unlocked the mystery of the 3lb of matter that sits between our ears-**Barak Obama***

THEME: OUR MYSTERIOUS BRAIN

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Cover page: Diffusion Weighted Imaging (DWI) of the brain- Credit: Sovereign, ISM/Science Photo Library

LIFE STREAM – ANNUAL ISSUE 2021 is a publication of the Life Science Foundation

*We are shaped by our thoughts. We become what we think-**Buddha***

WE PRESENT

*The twenty-first century is witnessing rapid advancements in the field of neuroscience. The new discoveries enable us to de-mystify the human brain, the most complex part of the human body. These exciting discoveries have inspired us to dedicate this issue of Life Stream to the '**Mysterious Human Brain'.***

*Included in this issue are articles on the **anatomy and functions of the brain and its parts, brain research and human consciousness.***

*A concise account of the **disorders of the brain** is provided by **Dr. Madhuri Behari**, a noted neurologist. We also introduce you to the emerging field of Neuroeconomics.*

*In the section on **Personalities**, the contributions made by the great men and women in this field, in the past and present, find a mention.*

*In the **Art & Architecture section** we feature some of the astonishing drawings of the brain by **Santiago Ramon Cajal,** the father of neuroscience.*

*We are happy to include the widely quoted poem '**The Brain is Wider than the Sky**' by **Emily Dickinson,** American poet. Sudha has contributed a short and meaningful poem on **The Mind Mystery**.*

*A trip to **Mansarovar**, the mind lake, can be a divine experience.*

The kind of foods which could enhance or adversely affect the functioning of the brain may be of interest to the readers.

*As **space travel** is increasingly becoming common these days, we thought it fit to include an article on its impact on the brain functions and human behavior.*

We have compiled information on the subjects from the electronic and print media, reports, books, speeches and other sources so as to make it available all at one place. We invite suggestions and criticisms from our readers.

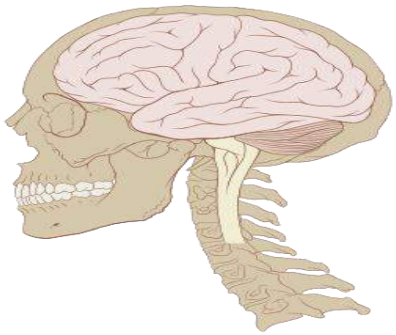
*We have great pleasure in presenting the **Annual Issue of Life Stream, 2021**.*

Life Science Team

*The human brain is the last and greatest frontier. It is truly the internal cosmos that lies contained within our skulls---the most elaborate structure in the known universe-**Joel Davis***

NATURE: THE HUMAN BRAIN-ANTOMY AND FUNCTIONS

'The brain is the seat of intelligence, interpreter of the senses, initiator of body movement, and controller of behavior, and is the source of all the qualities that define our humanity'.



en.wikipedia.org

The brain is the most complex part of the human body. It functions as the command center for the human nervous system by receiving signals from the body's sensory organs and sending information to the muscles. It also controls our thoughts and feelings. We are able to sense the outside world, interpret and respond to it, due to its presence. Here we discuss the basic anatomy and functioning of the different parts of the human brain.

Facts about the human brain

- The human brain is the largest brain of all vertebrates relative to body size.
- It weighs about 3.3 lbs. (1.5 kilograms).
- The average male has a brain volume of 1,274 cm3.
- The average female brain has a volume of 1,131 cm3.
- The brain makes up about 2 percent of a human's body weight and uses 20%of its energy and oxygen intake
- The brain is roughly 73% water (2% dehydration affects our attention, memory, cognitive skills)
- 60% of its dry weight is fat-the fattiest organ

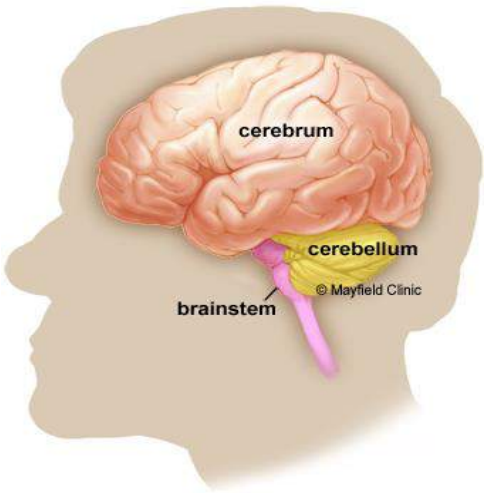
Every human brain is different---- the brain makes each human unique and defines who he or she is--- ***Stanley B Prisiner***

- The cerebrum makes up 85 percent of the brain's weight.
- All brain cells are not alike; It contains about 86 billion nerve cells (neurons) — the "gray matter."
- It contains billions of nerve fibers (axons and dendrites) — the "white matter."
- the brain is the last organ to mature." (Ref. www.lifescience/ book- Keep Sharp)

Evolution: From fossil brain tissue present in sites of exceptional preservation, scientists infer that the first brain structure appeared at least 521 million years ago; modern human brain evolved about 1.7 million years ago, when the stone tools developed in Africa became increasingly complex.

Anatomy of the human brain

All of us learn in our school science classes that the brain comprises essentially of three parts-the cerebrum, brain stem and the cerebellum. Today we know much more about even the tiniest part of the brain.



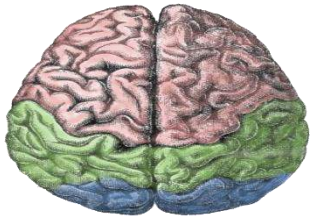
The cerebrum is the largest and most developed part of the brain. With the assistance of the cerebellum, the cerebrum controls all voluntary actions in the body. Underneath the cerebrum lies the brainstem, and behind that sits the cerebellum.

Like in other vertebrates, they develop from three areas known as the forebrain, midbrain and hindbrain. The forebrain develops into the cerebrum and underlying structures- the midbrain becomes

*In a structure as complex as the human brain a multitude of things can go wrong. The wonder is that for most people the brain functions effectively and unceasingly for more than 60 years---**Seymour S. Kety***

part of the brainstem; and the hindbrain gives rise to regions of the brainstem and the cerebellum.

The Cerebrum The outermost layer of the cerebrum is the cerebral cortex. It is divided into two anatomically symmetrical hemispheres by the **longitudinal fissure** (see below). Dura mater fills this fissure.



Upper lobes of the cerebral hemi spheres:
frontal lobes **(pink),** parietal lobes **(green),**
occipital lobes **(blue) Ref: Wikipedia**

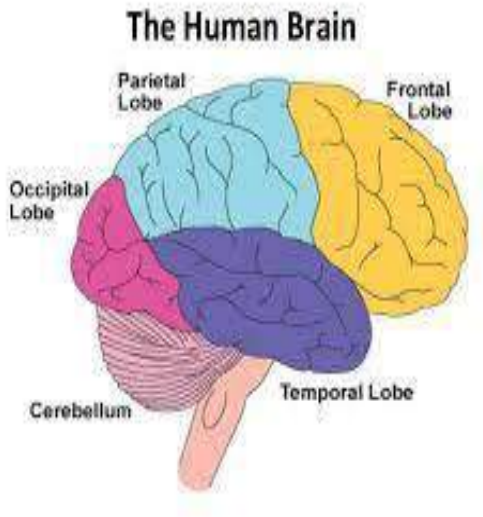
Externally, the cerebrum has a highly wrinkled or convoluted appearance, due to ***sulci*** (grooves or depressions) and ***gyri*** (ridges or elevations). 'If the cerebral cortex were unfolded, making the *gyri* its protrusions and the *sulci*, its clefts disappear, it would have the size and thickness of a large table napkin. It would contain at least 30 billion neurons."

The central nervous system is made up of **grey matter** and **white matter**. Grey matter makes up the outer most layer of the brain. It plays the most significant part in our daily functions. The grey matter is mainly composed of neuronal cell bodies and un-myelinated axons. The underlying layer is composed of white matter**.** Grey matter is distinguished from white matter in that it contains numerous cell bodies and relatively few myelinated axons, while white matter contains relatively few cell bodies and is composed chiefly of myelinated axons. The color difference arises mainly from the whiteness of myelin. The grey matter gets its grey tone from a high concentration of neuronal cell bodies.

The cerebral cortex is greatly enlarged in human brains and is considered the seat of complex thoughts. It consists of four lobes: **the frontal, parietal, temporal and occipital**. Visual processing takes place in the occipital lobe, near the back of the skull. The temporal lobe processes sound and language, and includes the ***hippocampus*** and ***amygdala,*** which play roles in memory and emotion, respectively. The parietal lobe integrates input

The evolution of the brain was a feat of fantastic difficulty—the most spectacular enterprise since the origin of life itself--- **Peter Medawar**

from different senses and is important for spatial orientation and navigation (see below).



Credit: seevividly.com

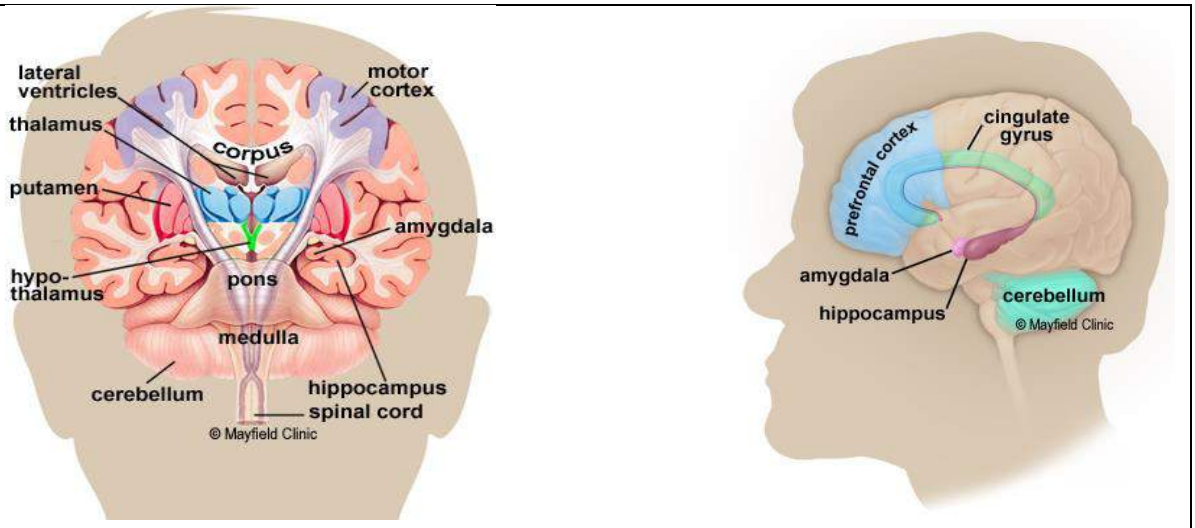
The **sub-cortical structures** of the cerebrum include the **hippocampus,** the **basal ganglia** and **olfactory bulb.** Located in the core of the brain is the **diencephalon**. Between the cerebrum and brainstem lie the **thalamus** and **hypothalamus.** The thalamus relays sensory and motor signals to the cortex and is involved in regulating consciousness, sleep and alertness.

The **hypothalamus** is important for keeping bodily processes like temperature, hunger, and thirst balanced. The hypothalamus connects the nervous system to the endocrine system — where hormones are produced via the pituitary gland (see illustration below).

The brain stem The brain stem connects the brain to the spinal cord and consists of the medulla oblongata, pons and the midbrain. The primary functions of the brainstem include relaying information between the brain and the body. It is connected through the cranial nerves to the face and head. It performs critical functions like controlling the heart, breathing and consciousness. The brain stem also controls automatic functions like heartbeat, breathing, pleasure, pain, hunger, thirst, and body temperature in the body.

*The chief function of the body is to carry the brain around-**Thomas A. Edison***

Cerebellum lies at the back of the head, between the brain stem and the cerebrum. It plays a role in coordination and balance and may also have some cognitive functions.



Parts of the brain (Credit: Mayfield Clinic)

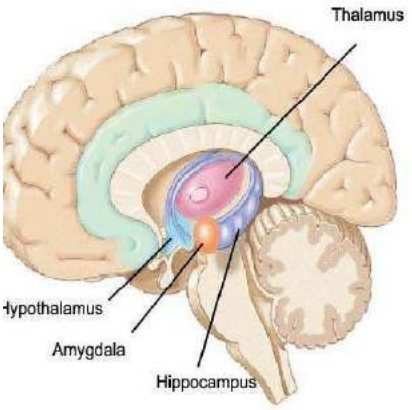
The **limbic system** is a set of brain structures located on both sides of the thalamus, immediately beneath the medial temporal lobe of the cerebrum, primarily in the forebrain. The system is buried deep within the brain, underneath the cerebral cortex and above the brainstem. It is the major **primordial brain** network involved in our behavioral and emotional responses, especially those we need for survival. It regulates autonomic or endocrine function, in response to emotional stimuli.

The limbic system first appeared in small mammals, about 150 million years ago. It is thought to have been among the first to develop in the human species. The limbic structures were first identified by J.W. Papez in 1937, when he proposed that the hypothalamus and several other sub-cortical structures were connected together forming a "circuit" responsible for the control of emotions.

There is debate within the scientific community about which structures are part of the limbic system; nevertheless, there is unanimous agreement about three of them: the amygdala, hippocampus, and cingulate gyrus. The thalamus, hypothalamus (controls production of important hormones and regulation of thirst, hunger, mood etc.) and basal ganglia (reward processing, habit formation, movement and learning) are also involved in the actions of the limbic system.

*The most important thing in life is to keep the brain young-**Henry Ford***

Hippocampus The hippocampus, is shaped like a sea horse and hence the name. It is present as a pair, located in each hemisphere of the brain. It is essentially the memory center of our brains. Our episodic memories are formed and catalogued here to be filed away as long-term memories in the cerebral cortex. Hippocampus also helps us associate memories with various senses, and also spatial orientation and our ability to navigate the world. The hippocampus is one of the sites in the brain where new neurons are generated from stem cells, and is, therefore, a key brain structure for learning new things.



Credit: research gate

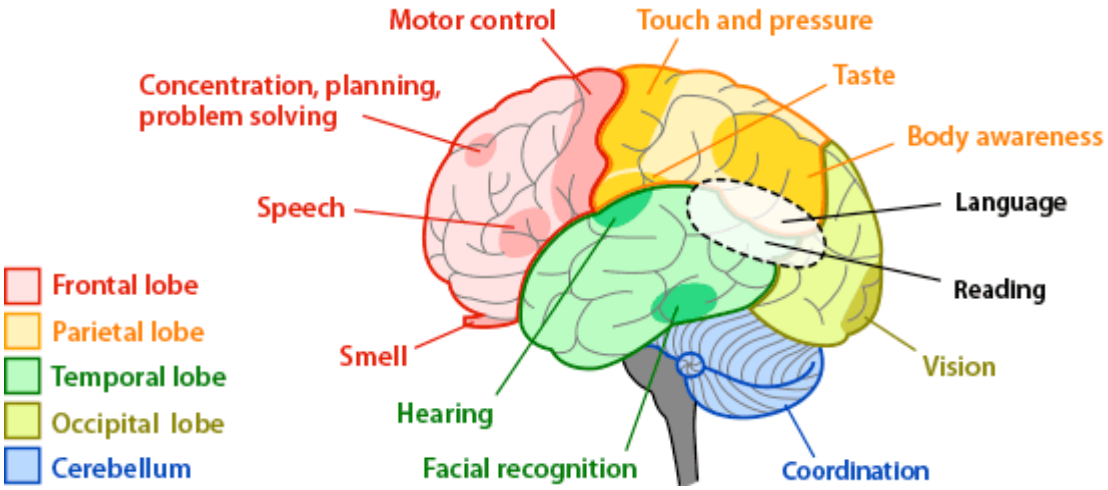
The **amygdala** is named so, due to its almond-like shape. Located right next to the hippocampus, the left and right amygdalae play a central role in our emotional responses, including feelings like pleasure, fear, anxiety and anger. The amygdala also attaches emotional content to our memories, and so plays an important role in determining how robustly those memories are stored. Patients with anxiety disorders often show heightened amygdala response to anxiety cues. The amygdala does not just modify the strength and emotional content of memories; it also plays a key role in forming new memories specifically related to fear.

The amygdala and other limbic structures are connected to prefrontal cortex regions. Damage to the limbic system can cause the hormonal system to become unbalanced. The ability to perceive hunger or a feeling of satiety is reduced and emotional reactions can change.

*Biology gives you a brain. Life turns it into a mind----**Jeffrey Eugenides***

The Skull

The bony skull protects the brain from injury. The skull is formed from 8 bones - the frontal, parietal (2), temporal (2), sphenoid, occipital and ethmoid that fuse together along suture lines. 14 paired bones including the maxilla, zygoma, nasal, palatine, lacrimal, inferior nasal conchae, mandible, and vomer form the face.



Cranial nerves

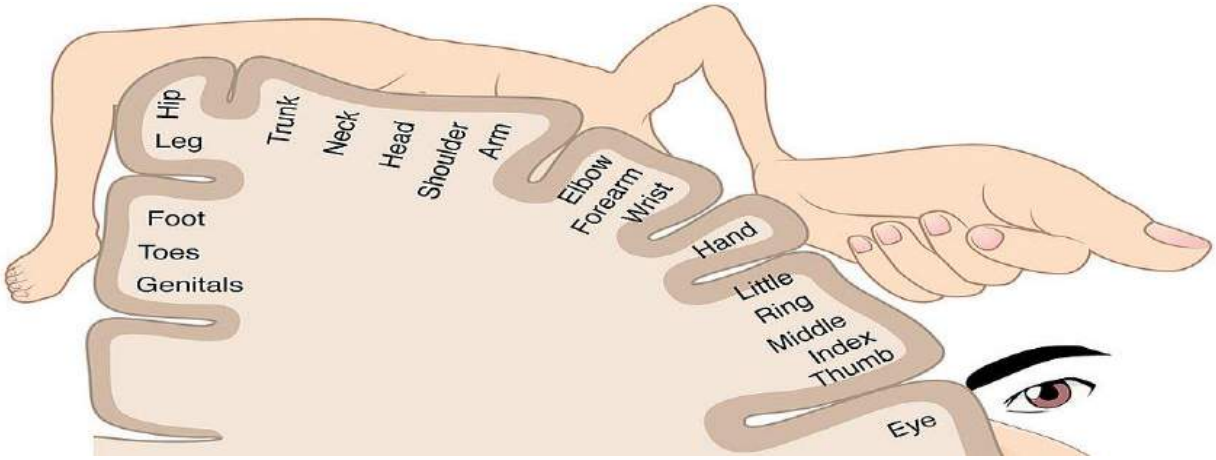
The brain communicates with the body through the spinal cord and twelve pairs of cranial nerves, out of which ten pairs of cranial nerves that control hearing, eye movement, facial sensations, taste, swallowing and movement of the face, neck, shoulder and tongue muscles originate in the brainstem. The cranial nerves for smell and vision originate in the cerebrum.

Meninges The brain and spinal cord are covered and protected by three layers of tissue called meninges- (outer most layer), the dura mater, arachnoid mater (middle layer), and pia mater (innermost layer).

Homunculus (Map of body parts in the brain**)** In 1951 Wilder Penrose, a neuroscientist, while fixing tips of electrodes into the brain of a man undergoing brain surgery, was astonished to note that *neighboring parts of the body were represented by neighboring spots on the brain.* If a small shock is given to a specific area in the brain, there was a corresponding response in the related area of the body. The mapping was laid out in an orderly fashion. He named these maps of the body on the brain **homunculus or "little man".** Further studies ruled out the possibility that the brain map of the body is genetically pre-programmed,

*Computers are incredibly fast, accurate and stupid: humans are incredibly slow, accurate and brilliant: together they are powerful beyond imagination-**Albert Einstein***

but was flexibly defined by active inputs from the body-- if any change happens to the body (like losing a body part), the homunculus also changes.



Credit: en.wikipedia.org

Left brain vs. right brain The two hemispheres, the left and right, of the brain are connected by a bundle of nerve fibers called the *corpus callosum*. The left brain controls all the muscles on the right-hand side of the body and the right brain controls the left side.

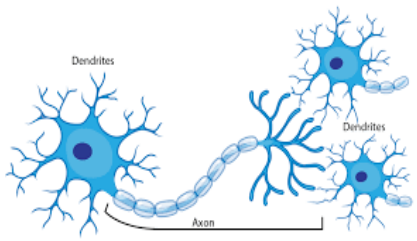
According to Eric Holland, a neurosurgeon and cancer biologist at the Fred Hutchinson Cancer Research Center and the University of Washington" --the popular notions about "left brain" and "right brain" qualities are generalizations that are not well supported by evidence--'. Still, there are some important differences between these areas. 'The left brain contains regions involved in speech and language (called the Broca's area and Wernicke's area, respectively) and is also associated with mathematical calculation and fact retrieval. The right brain plays a role in visual and auditory processing, spatial skills and artistic ability — more instinctive or creative things. Everyone uses both halves all the time'.

Neurons or nerve cells are the fundamental units of the brain and nervous system. The human brain consists of 86 billion neurons. Neurons are densely connected to one another in intricate, forest-like networks, and the total number of connections between the neurons in your head is in hundreds of trillions (around 0.2quadrillion). Each neuron is connected to more than 1,000 other neurons.

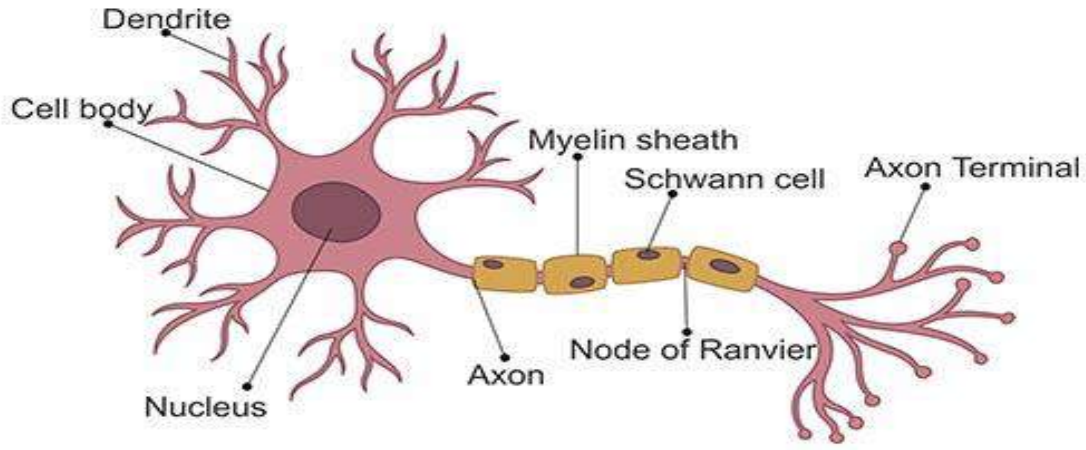
Neurons are organized into patterns and networks within the brain and communicate with each other at incredible speeds.

*The brain is the organ of destiny. It holds within its humming mechanism secrets that will determine the future of the human race----****Wilder Penfield***

"The elaborate patterns of connections in the brain circuitry is full of life - connections between neurons ceaselessly blossom, die, and reconfigure". They receive sensory inputs from the external world, and send motor commands to our muscles, by transforming and relaying the electrical signals.



Credit: mhwcenter.org All sensations, movements, thoughts, memories, and feelings are the result of signals that pass-through neurons.



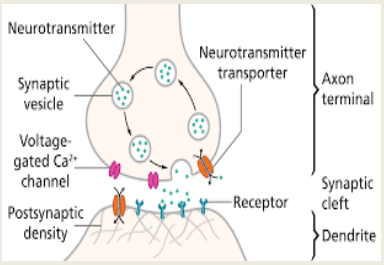
An enlarged view of a neuron (Credit; cusabio.com)

A neuron has three main parts: a **cell body or soma**, **dendrites** and **axons** (see image above), which can be represented as the trunk, branches, and roots of a tree.

The **cell body** contains the nucleus. **Dendrites** extend out from the cell body like the branches of a tree and receive messages from other nerve cells. Signals then pass from the dendrites through the cell body and travel down an **axon** to another neuron, a muscle cell, or cells in some other organ.

*Neurons don't perceive change beyond their life-span---**Albert Einstein***

How do the neurons communicate with each other? A **synapse** is a structure that permits a neuron (or nerve cell) to pass an electrical or chemical signal to another neuron. **T**ransmission of nerve impulses from one neuron to another take place from the pre-synaptic neuron to post-synaptic neuron. The pre-synaptic portion of the synapse contains a special set of minute vesicles within which are chemicals known as neurotransmitters (see diagrams below)



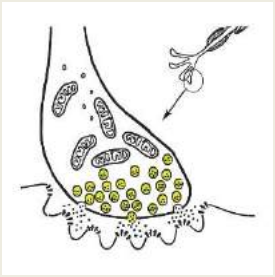


Diagram-1 Action potentials and synapses 2. An enlarged view of a synapse (commons.wikipedia.org)

Neurons posses an electrical charge as a result of the properties of their membranes. When a neuron is excited, current flows through channels that open across the membrane. As a result, a wave of electrical potential known as an action potential moves from the cell body down the pre-synaptic axon, and causes the release of neurotransmitter molecules from vesicles to the synaptic cleft. These molecules bind to the molecular receptors or channels in the post-synaptic cell. That cumulatively can cause it to fire an action potential of its own. *Thus, neural communication occurs by a combination of controlled electrical and chemical events* (Ref; en.wikipedia.org/book by Gerald Edelman- Wider than the Sky)

The neuron is usually surrounded by many support cells. Some types of cells form an insulating **sheath** made of a fatty molecule called **myelin,** around the axon. Axons may be very short, such as those that carry signals from one cell in the cerebral cortex to another cell, or may be very long, such as those that carry messages from the brain all the way down the spinal cord.

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

*You're nothing but a pack of neurons-**Francis Crick***

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.

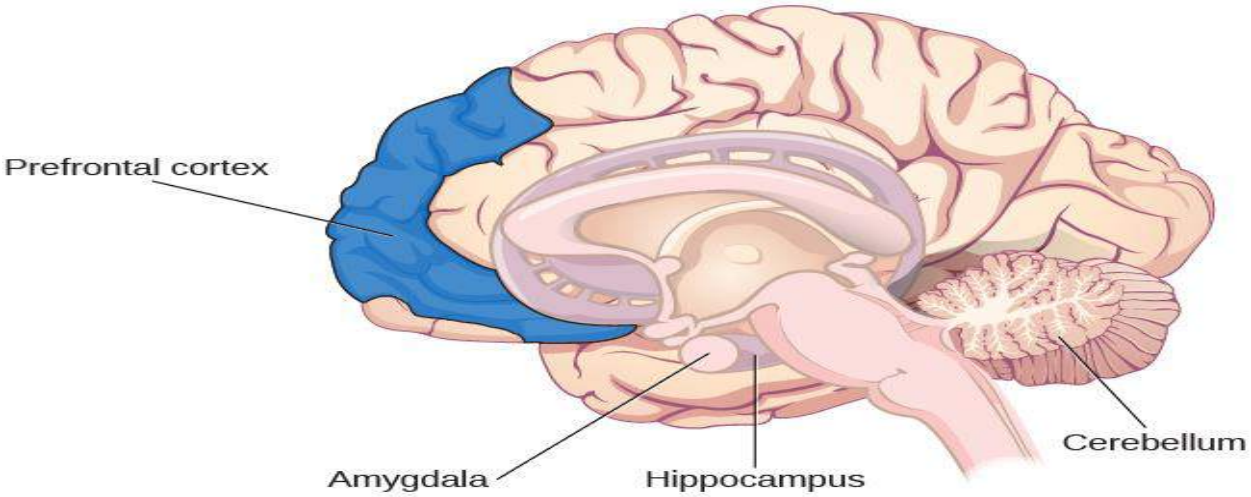
GABA (gamma-aminobutyric acid) is an inhibitory neurotransmitter that helps control muscle activity, and is an important part of the visual system. Drugs that increase GABA levels in the brain are used to treat epileptic seizures and tremors in patients with Huntington's disease.

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. www.ninds.nih.gov

Memory refers to 'the processes that are used to acquire, store, retain, and later retrieve information'. The three major processes involved in memory are: **encoding, storage, and retrieval**. Different areas of the brain are involved in different types of memory. Structures of the limbic system are involved in memory formation. The prefrontal cortex holds recent events briefly in short-term memory. The hippocampus is responsible for encoding long-term memory.

Intelligence cannot be present without understanding. No computer has any awareness of what it does-----
Roger Penrose



Computerized illustration of different regions of the brain involved with memory (Credit: bodyparts3D)

Short-term memory The prefrontal cortex is concerned with short-term memory or working memory. It retains information for about one minute and its capacity is limited to about 7 items. For example, we are able to dial a phone number which we have just heard. While reading, we memorize the sentence we have just read, to makes sense of the next (Ref: courses.lumenlearning.com)

Long-term memory Structures of the limbic system involved in memory formation are the **hippocampus** and **amygdala.** Long term memory is processed in the hippocampus of the temporal lobe and is activated when you want to memorize information like personal memories as well as facts and figures for a longer time. *This memory has unlimited content and duration capacity*. Studies show that the hippocampus is involved specifically in normal recognition memory as well as spatial memory. Hippocampus also project information to cortical regions that give memories meaning and connect them with other connected memories. It also plays a part in memory consolidation: the process of transferring new learning into long-term memory. Injury to this area leaves us unable to process new declarative memories.

Because of its role in processing emotional information, the amygdala is also involved in memory consolidation. Amygdala helps determine what memories to store, based on whether we have a strong or weak emotional response to the event.

Skill memory is processed in the cerebellum, which relays information to the basal ganglia. It stores automatic learned memories like riding a bike.

"Everything that is past is either a learning experience to grow on, a beautiful memory to reflect on, or a motivating factor to act upon." ***Denis Waitley***

Certain neurotransmitters are involved with the process of memory, such as epinephrine, dopamine, serotonin, glutamate, and acetylcholine. Strong emotional experiences can trigger the release of neurotransmitters, as well as hormones, which strengthen memory, so that memory for an emotional event is usually stronger than memory for a non-emotional event.

The brains of other animals The human brain has the same basic structure as other mammal brains, but is larger in relation to body size than any other brains. The brains of vertebrates other than humans are divided into three main sections: hindbrain, midbrain, and forebrain. In fish and amphibians, the midbrain is the center of the brain, whereas, the midbrain is less important in mammals, birds, and reptiles. These animals have larger forebrains. The cerebrum is the largest part of the forebrain in mammals, birds, and reptiles and is the center of learning.

Groups of nerve cells function as brains in insects, lobsters, squid, and other invertebrates. These groups are located at the ends of nerve cords that run through the animal's body. This type of brain allows the animal to control its body and to sense its environment. Very simple animals, such as jellyfish and corals, have no brains, but only networks of nerves, instead. **(Ref: britanica.com)**

Brain size and intelligence Does the brain size correlate with level of intelligence? In nature no such correlation is noted. The brain of a sperm whale is more than five times heavier than the human brain, but humans are considered to be of higher intelligence than sperm whales. The intelligence of an animal could be measured as the ratio between the size of the brain and the body size. Compared to other mammals our brain size relative to the rest of the body is surprisingly large (elephant 1/550; humans 1/40). We can more successfully use language, acquire complex skills, create tools and live in social groups.

Among humans, also there is no correlation between brain size and the level of intelligence. According to Christof Koch, a neuroscientist and president of the Allen Institute for Brain Science in Seattle "Some geniuses in their field have smaller-than-average brains, while others larger than average. For example, two highly compare the brains of The Russian acclaimed writers. novelist Ivan

*Science and technology revolutionize our lives, but memories, tradition and myth frame our response –**Arthur m Schlesinger***

Turgenev's brain was found to be 2,021 grams, while writer Anatole France's brain weighed only 1,017 grams".

Human intelligence Humans have a very high brain-weight-to-body-weight ratio, but so do other animals. Greater number of neurons and folds in the brain partly explains human intelligence. Humans have more neurons per unit volume than other animals, due to folds in the outer layer, or cortex.

Eric Holland, a neurosurgeon and cancer biologist at the Fred Hutchinson Cancer Research Center and the University of Washington is of view that "The more complicated a brain gets, the more gyri and sulci, or wiggly hills and valleys, it has". Other intelligent animals, such as monkeys and dolphins, also have these folds in their cortex, whereas mice have smooth brains, he said. Humans also have the largest frontal lobes of any animal which are associated with higher-level functions such as self-control, planning, logic and abstract thought — basically, 'the things that make us particularly human'. **(ref; livescience.com)**

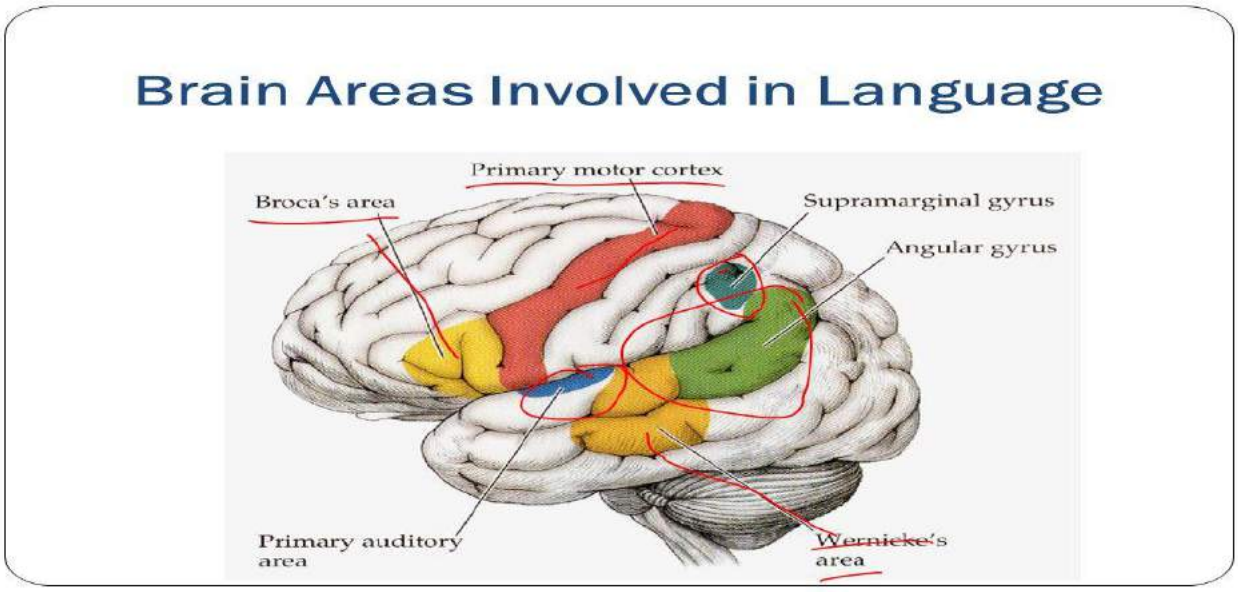
The blood–brain barrier The larger arteries throughout the brain supply blood to smaller capillaries. These smallest of blood_vessels in the brain, are lined with cells joined by tight junctions to prevent fluids from seeping in or leak out to the same degree as they do in other capillaries; this creates the blood-brain barrier. The barrier although is less permeable to larger molecules, is permeable to water, carbon dioxide, oxygen, and most fat-soluble substances (including anesthetics and alcohol).

Speech & Language

According to **www.news- medical.net** the earliest studies on speech and language centers of the brain dates back to the early nineteenth century. In general, the left hemisphere of the brain is considered responsible for language and speech, and the right hemisphere plays a large part in interpreting visual information and spatial processing. Physicians noted that brain-injured patients with damage to the left hemisphere would lose power of speech and language abilities, while those with injuries to the right hemisphere did not lose this ability. Recent studies have shown that in around 97% of people, language is represented in the left hemisphere, whereas, in about 19% of left-handed people, the areas responsible for language are in the right hemisphere. 68% of them have some language abilities in both the left and the

*Language is the means of getting an idea from mine into yours without surgery-**Mark Amidon***

right hemispheres.



credit: quora.com

In humans, language and speech skills are acquired after birth. Neural networks are developed over a long period of time, as individuals learn and experience by interacting with their environment.

Regions related to speech and languages are studied with the aid of a technique called cortical stimulation mapping. We have already seen that the two main areas of the human brain concerned with speech and language are the **Wernicke's area** and the **Broca's area**. Other two areas identified are **the primary auditory cortex** and the **angular gyrus.**

Other areas: **The primary auditory cortex** identifies pitch and loudness of sounds. It is located in the temporal lobe and is connected to the auditory system. The **angular gyrus** is responsible for several language processes, including (but not limited to) attention and number processing. It is responsible

*"The structure of language determines not only thought, but reality itself."— **Noam Chomsky***

Pioneers in Language Research

1. Paul Broca

Pierre Paul Broca (1824 – 1880) was a French physician, anatomist, anthropologist, Neuroscientist, Scientist and Politician. He is best known for his research on Broca's area, a region of the frontal lobe involved with language that is named after him.

Broca noticed an impaired ability to produce speech in two patients who had sustained injury to the region. His work revealed that if this area is damaged, one may have difficulty moving the tongue or facial muscles to produce the sounds of speech. The person can still read and understand spoken language, but has difficulty in speaking and writing called Broca's aphasia. This was the first anatomical proof of localization of brain function.

2. Carl Wernicke, (1848 -1905), was a German neurologist, Anatomist, Physician, Neuroscientist, Psychiatrist, University teacher & Neurologist. His research, along with that of Paul Broca, led to groundbreaking realizations of the localization of brain function, specifically in speech. As such, speech area in the brain, called Wernicke's area has been named after the scientist.

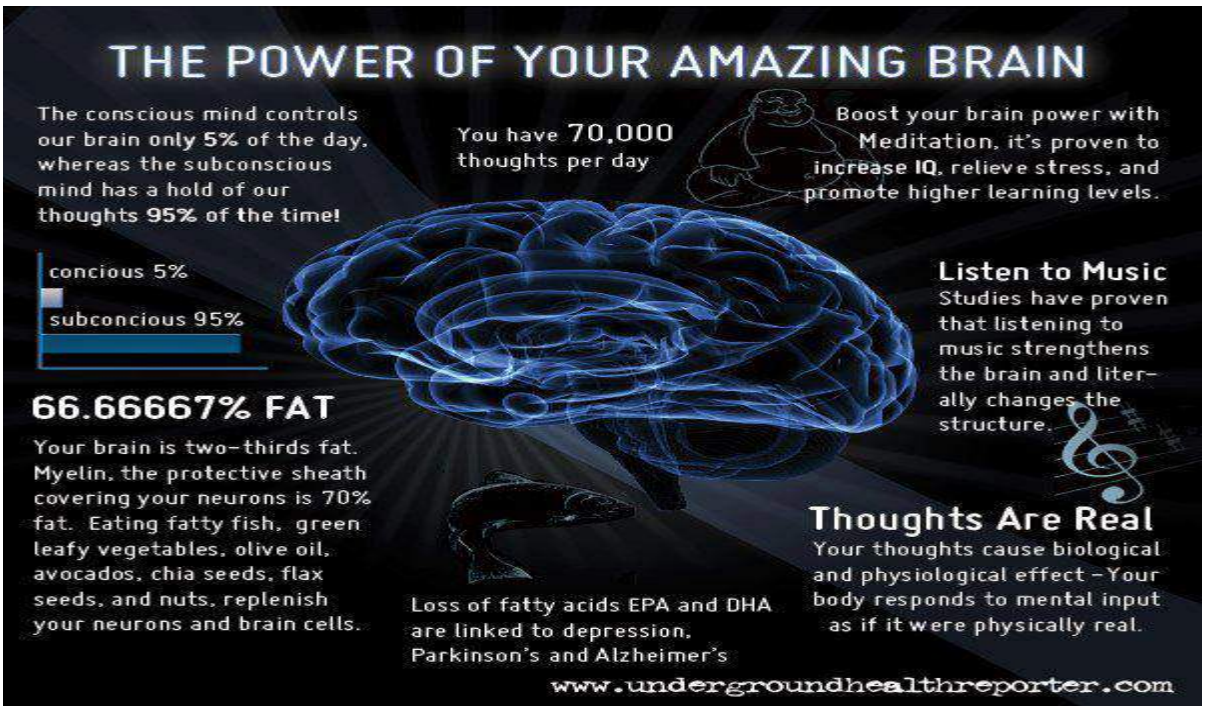
Wernicke's area lies in the cerebral cortex (left frontal lobe) related to speech and is involved in both spoken and written language. *Wernicke's area is primarily responsible for language comprehension;* Damage to this area causes Wernicke's aphasia. The individual may speak in long sentences that have no meaning. They can make speech sounds; however, they have difficulty understanding speech, and are, therefore, unaware of their mistakes. Wernicke related nerve diseases to specific areas of the brain. He is best known for his descriptions of the aphasias, and disorders interfering with the ability to communicate in speech or writing.

Wernicke studied at the University of Breslau and did graduate work at Breslau, Berlin, and Vienna before entering practice in Berlin. In 1885 he joined the faculty at Breslau, where he remained until 1904. His *Lehrbuch der Gehirnkrankheiten* (1881; "Textbook of Brain Disorders") is an attempt to comprehensively account for the cerebral localization of all neurologic disease. Wernicke also demonstrated the dominance of one hemisphere in brain functions in these studies.

for several language processes, including number processing, spatial recognition and attention.

Brain Studies With a basic understanding of the anatomy and functions of the different parts of the brain we are able to appreciate the impact of brain studies on **multiple** disciplines. We discuss new developments in these areas in remaining articles in this issue.

Ref: en.wikipedia.org; www.ninds.nih.gov;www.lifescience;www.ninds.nih.gov;askabiologist.asu.edu;mhwcenter.org;qbi.uq.edu.au> brain-anatomy



*Remember that politics, colonialism, imperialism and war also originate in the human brain-**Vilayanur S Ramachandran***

SCIENCE: EXPLORING THE HUMAN BRAIN

(Credit: the week .in)

In this article we discuss the exciting field of brain research, and how it has brought to light hither to unknown facts about the human brain.

"The human brain is the most complicated material object in the known universe" wrote late Gerald Edelman, Nobel Laureate.

Understanding how the human brain works is one of the most complex challenges that scientists face. Considered as an evolutionary marvel'-- it remains the last and grandest biological frontier---.'

Rapid advances are being made in research in the fields of neurological and behavioral sciences, with the aid of newer technologies and collaboration across fields such as physics and genetics. Scientists are unraveling the mysteries of the brain, through detailed imaging and mapping of networks and deciphering chemical pathways.

It is said that we have learned more about the brain in the last 10 years than in all previous centuries put together.

Before we consider the progress made in neuroscience in recent times it would be fascinating to see when and how human beings learnt about the existence of the brain and what it does, over centuries.

As long as our brain is a mystery, the universe, the reflection of the structure of the brain, will also remain a mystery--- ***SantiagoRamón y Cajal.***

The Brain in History

Sections of a Man's head, showing the anatomy of the eye, drawn by Leonardo Da Vinci, circa 15 (credit: Alamy Stock Photos)

- The early civilizations lacked adequate means to obtain knowledge about the human brain.
- In ancient Egypt, the brain was regularly removed in preparation for mummification, for the heart was assumed to be the seat of intelligence
- Pythagorean Alcmaeon of Croton (5th century BC) was **first** to consider the **brain** to be the place where the mind was located.
- In the 4th century BC, Hippocrates believed the brain to be the seat of intelligence.
- Aristotle thought that, while the heart was the seat of intelligence, the brain was a cooling mechanism for the blood.
- Around 170 BC Roman physician Galen suggested that the four ventricles (fluid-filled cavities) of the brain were the seat of complex thought, and determined personality and bodily functions.
- Until the 1660s the concepts on the anatomy of the **brain** did not change significantly.
- In the 16th century, Belgian anatomist Andreas Vesalius created a highly detailed map of the nervous system and argued against the ventricles as the site of brain functions.
- Thomas Willis, English physician, published his book Anatomy of the Brain in1664. Nicolaus Steno, Danish anatomist, published his Lecture on the Anatomy of the Brain in 1669
- In 1791, in the first suggestion was made that electrical impulses were important in the nervous system. Italian Luigi Galvani showed that electricity applied to nerves could make muscles contract.

Credit lumenlearning.com

There is no scientific study more vital to man than the study of his own brain. Our entire view of the universe depends on it- ***Francis Crick***

- In 1848, American railroad worker Phineas Gage had an iron rod strike his head, passing through his left frontal lobe. He survived, but aspects of his personality changed, suggesting that specific brain regions were important for certain functions.
- In the 1860-70s physicians Paul Broca and Carl Wernicke showed that specific parts of the brain were dedicated to different components of speech.
- In the early 1900s, anatomists with the aid of microscopes, started exploring even the smallest parts of the brain.
- Neuro-anatomists Santiago RamÓn y Cajal and Camillo Golgi were awarded the 1906 Nobel Prize for identifying that nerve cells (neurons) are the building blocks of the brain, and showed that there are many different types of nerve cells.
- In 1932 Sir Charles Sherrington and Edgar Adrian won the Nobel Prize for proposing the concept of synapses, junctions between neurons, which advanced the understanding of the central nervous system.
- Alan Hodgkin, Andrew Huxley and Australian Sir John Eccles won a Nobel Prize in 1963 for showing how neurons communicate via electrical and chemical signaling.
- From the 1960s there was an explosion in neuroscience research (ref: **(ref: en.wikipedia.org/qbi.uq.edu.au)**

The Importance of Brain Research According to CDC, US, brain research tends to capture the attention and imagination of the modern audience. Studying the nervous system helps us in understanding our basic biology and body function besides, learning about diseases, disorders, and injuries that affect different parts of the nervous system. In the US Brain research received a new impetus when President Obama decided to support it in a big way (see box)

The BRAIN Initiative

In April 2013, President Barack Obama announced the BRAIN Initiative (Brain Research through Advancing Innovative Neuro-technologies). The $100-million-plus effort is aimed to develop new technologies to aid brain research.

In September 2014, the NIH announced $46 million in BRAIN Initiative grants, industry pledged another $30 million, and, major foundations and universities agreed to provide more than $240 million of their own research toward BRAIN Initiative goals.

The commission to evaluate the ethical issues involved in research on the brain released the first half of its report in May 2014, calling for ethics to be integrated

early and explicitly in neuroscience research. In March 2015, the second half of the report was released. It focused on issues of cognitive enhancement, informed consent, and, using neuroscience in the legal system.

The research funding facilitated the development of new brain-imaging and brain-mapping tools, and helped create the BRAIN Initiative Cell Census Network — an effort to catalog the brain's "parts' list." Together, these efforts contribute to major advancements in understanding the brain **(Ref: www.ninds.nih.gov)**

Tools used in brain studies The study of neuroscience will be incomplete without acknowledging the role of cutting -edge technology in mapping our brains. Studies on the brains of cadavers helps researchers understand brain structure, but are limited because the brain is no longer alive or active. Lesion studies are informative about the effects of lesions on different brain regions.

Many brain imaging tools are available to cognitive neuroscientists at present, including, positron emission tomography (PET). By combining functional brain imaging with sophisticated experimental designs and data analysis methods, functions of brain regions and their interactions are now examined. Advanced non-invasive neuro-imaging techniques such as EEG and fMRI, the most widely used tools, allow researchers to directly observe brain activities, while subjects perform various perceptual, motor, and/or cognitive tasks. "Brain Imaging has now become a window into the mind".

Some of the techniques employed for studying the human brain are detailed below:

1. Electroencephalogram (EEG)
2. Magneto-encephalography (MEG)
3. Functional Magnetic Resonance Imaging (fMRI)
4. Photon migration tomography
5. Trans-cranial magnetic stimulation
6. Positron Emission Tomography (PET)

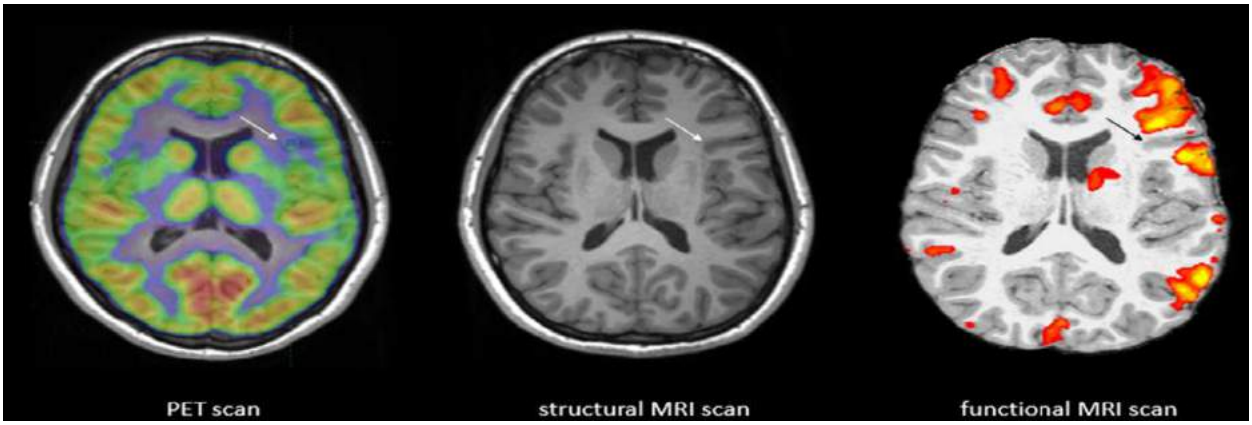
EEG is used in measuring electrical activity in the brain, and, therefore is often used as a tool in scientific studies. It helps identify sleep disorders and other medical conditions relating to the brain.

The human brain must continue to frame the problems for the electronic machine to solve-
*--**David Sarnoff***

A participant in an EEG study with a number of electrodes placed around his head (credit: lumenlearning.com) Electrical activity in the brain is usually measured with the help of electrodes that are attached to the surface of the skin in specific places around the head. The brain activity is recorded as a series of waves called electroencephalograms (EEG). The first human electroencephalogram was recorded by Hans Berger in 1924.

2. Magneto-encephalography (MEG) can map brain activity by recording the electromagnetic fields that are produced by the naturally occurring electrical currents in the brain. This technique offers a better spatial resolution than EEG.

3. Functional Magnetic Resonance Imaging (fMRI) EEG and MEG have their disadvantages and have been replaced by more recent methods such as functional magnetic resonance imaging (fMRI).

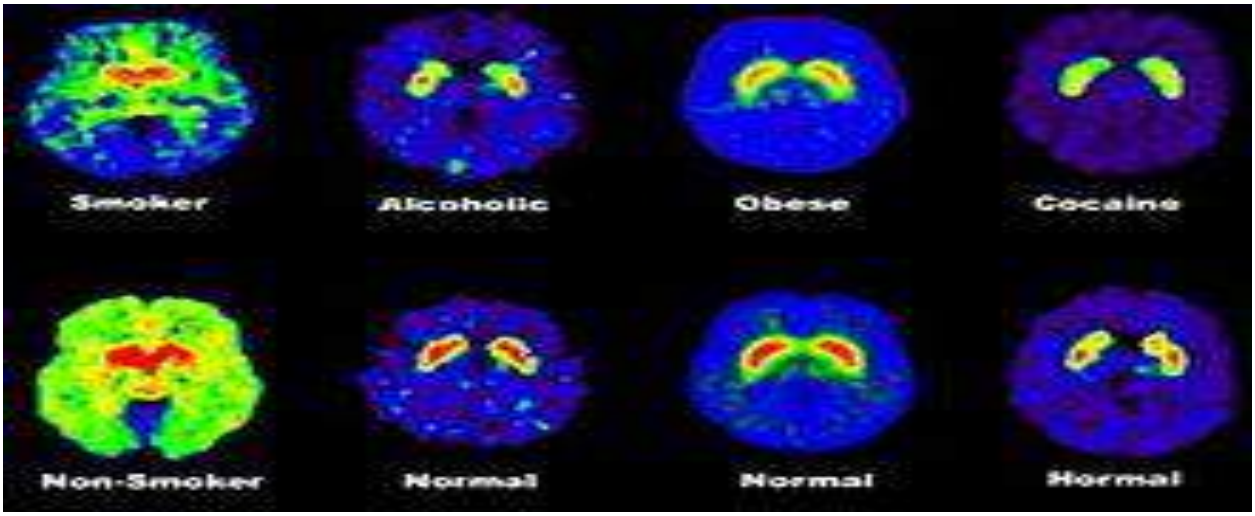


Difference between PET scan, MRI and FMRI (Credit: kryptonite. global)

For more specific brain images scientists rely on Functional **MRI** (fMRI). *It is* a type of brain scan that uses a magnetic field to create images of brain activity in each brain area.

The human brain doesn't come with an instruction manual -----***Bill Engvall***

This technique can detect the smallest of changes using very powerful magnets and can localize brain activity changes to regions as small as one cubic millimeter. In addition, it is not an invasive procedure, and therefore, can be used widely. It is useful in both diagnosis of disease and the development of treatments. However, fMRI, does fail to provide real-time dynamics of blood flow within the brain.



Images obtained with PET (axial sections) showing the effects of chronic drug exposure on dopamine (DA) neurotransmission and on brain function (en.wikipedia.org)

4. Photon Migration Tomography (PMT- also called near-infrared spectroscopy or optical imaging) measures cortical activity on the basis of scattering of near-infrared light from the brain tissue.

5. Trans-cranial Magnetic Stimulation is a technique used to excite neurons using strong and time-varying magnetic fields. The procedure is non-invasive and painless.

6. Positron Emission Tomography (PET) is a technique used to investigate activity in areas of the brain. It is a powerful imaging technique which enables in vivo examination of brain functions. It allows non-invasive quantification of cerebral blood flow, metabolism, and receptor binding.

New revelations

1. The brain and the genome

We often wonder why the human baby is so helpless, having a brain that is largely incomplete, unlike the infants of most other animals. When the draft of the Human

*Your brain has the capacity for learning that is virtually limitless, which makes every human a potential genius---**Michael J Gelb***

Genome Project was completed at the turn of this century, scientists were surprised to learn that humans have only 20,000 genes, much against their expectation of hundreds of thousands of genes. In fact, 'the number of neurons and their connections vastly outstrip the number of genetic combinations'. They, therefore, wondered "--how does the massively complicated brain, with 86 billion neurons, get built from such a small recipe book?

Our DNA is not a fixed blueprint for building an organism, rather 'it is a dynamic system that continuously rewrites its circuitry to adjust to the changes in the environment--- "Genetic instructions play only a minor role in the detailed assembly of cortical connections----neural networks require interaction with the world for their proper development"---"The flexibility of the brain allows the events in your life to stitch themselves directly into the neural fabric"-wrote David Eagleman, neuroscientist. Humans at birth, therefore, have unfinished brains, leaving nature to modify and complete it.

Studies showed that rats raised in different environments (enriched or deprived) had altered their brain structure significantly. Rats raised in enriched environment performed better at tasks and had well grown tendrils. In contrast, rats from deprived environments were poor learners and had abnormally shrunken neurons. Proper development of the brain requires proper input received on time. If the opportunity is missed, it is difficult or impossible to reopen as shown by experiments conducted on monkeys. By totally isolating them at an early stage, their brain becomes malformed.

2. **Neuroplasticity /Brain plasticity** For a long time, it was believed that as we aged, the connections in the brain became fixed, and then gradually disappear. Research has shown that in fact the brain never stops changing through learning. It reorganizes itself by forming new connections between neurons to match the demands of the environment and the body. In addition to genetic factors, the environment, as well as the actions of each person, play a significant role in plasticity.

A plastic object can be shaped by us and it can hold on to that shape. The concept that a system can be changed due to external pressure and change its shape led William James, American psychologist coin the term 'plasticity' of the brain. We have seen that unlike the plastic objects which are set, the brain is a dynamic

Any man could, if he were so inclined, be the sculptor of his own brain----***Santiago Ramon Y Cajal***

system, alive, growing, learning and changing, all throughout our lives. Neuroplasticity – or brain plasticity – is the ability of the brain to modify its connections or re-wire itself.

According to the website sharpbrains.com, neuro-plasticity occurs in the brain 1) At the beginning of life: when the immature brain organizes itself 2) in case of brain injury: to compensate for lost functions or maximize remaining functions 3) through adulthood: whenever something new is learned and memorized. Without this ability, any brain, not just the human brain, would be unable to develop from infancy through to adulthood or recover from brain injury.

Changes associated with learning occur mostly at the level of connections between neurons. Thereafter, the internal structure of the existing synapses changes. For example, London taxi drivers have a larger hippocampus than the London bus drivers because this region of the hippocampus is specialized in acquiring and using complex spatial information in order to navigate efficiently. Taxi drivers have to navigate around London, whereas, bus drivers follow only a fixed route.

'The brain has many neural pathways that can replicate another's function. Therefore, small errors in development or temporary loss of function through damage can be easily corrected by re-routing signals along a different pathway'. In a classic case reported from USA, after removal of the entire hemisphere of brain, the brain of the patient rewired to take over the functions of the missing hemisphere.

Plasticity can also be observed in the brains of bilinguals. Learning a second language is possible through functional changes in the brain: the left inferior parietal cortex is larger in bilingual brains than in monolingual brains. Changes are also noted in the brains of musicians, compared to non-musicians.

Plasticity emerges from a struggle for survival of the parts of the system-- compete or die. The brain builds an internal model of the world and adjusts whenever changes are needed.

Cortical re-organization /Cortical re-deployment We have seen that the brain maps are not genetically pre-fixed, but instead are modified by the inputs they receive. *'Brains leverage whatever information that streams in'*. The cortex is not pre-determined as visual, auditory areas etc. Different areas are assigned different functions because of different inputs received, as supported by studies on transplanting tissues or rewiring inputs.

The magic of our brain lies not in its constituent elements, but in the way those elements unceasingly reweave themselves to form a dynamic, electric, living fabric-- ***David Eagleman***

The brain contains a map of the body because individual brain cells make connections with one another**.** Neurons keep sending electrical impulses, but they do not bond with all neurons. The timing is critical, as neurons reach out to other neurons, based on timings. Neurons that are active at the same time tend to make connections between themselves. *Neurons that fire together wire together.*

Brain-mapping studies done on monkeys in 1981 by Institute of Behavioral Research in silver Spring, Maryland showed that after severing nerves in their limbs, their somato-sensory cortex had dramatically re-arranged; the areas formerly representing nerve severed limbs were taken over by neighboring areas in the cortex. Similarly, when an arm is amputed, its representation in the cortex is taken over by neighboring areas as seen by imaging techniques. When inputs cease, sensory cortical areas do not remain bare, they are invaded by neighbors. Cortical territory can be reassigned to different tasks.

Let us see what happens when areas devoted to vision are taken over by other senses. Brain studies have shown that

- When part of the body no longer sends information, it loses its territory.
- In those born blind, their occipital cortex is completely taken over by other senses.
- If a person is blind at an early age, the takeover is less comprehensive
- For those who are blind late, the cortical takeovers are even smaller.
- The older the brain, the less flexible it is for redeployment.
- Blind people are up to ten times better determining a musical pitch, as they simply have more territory devoted to the task of listening.
- Many blind people develop, in the course of time, a considerable hearing ability to avoid obstacles by means of auditory signals received from the sounds of their own foot- steps, cane tapping, etc.
- The sighted have less cortex devoted to sound.

Researchers at McGill university demonstrated through brain scanning that in the recently gone blind, sounds caused activity in their occipital cortex area devoted to vision. Experiments showed that even in temporarily blindfolded this takeover happens. But once blind folding is removed the position is reverted. Such takeover changes in the brain are remarkably swift. Interestingly, such takeovers offer a possible explanation as to why we have dreams (See box below).

We see with our eyes, but we see with our brain as well. And seeing with the brain is often called imagination--- ***Oliver Sacks***

Why do we dream?

ECG brain activity during sleep (Wikipedia) Scientists so far have not been able to give a satisfactory answer to this question. Now David Eagleman, Nobel laureate has proposed an answer.

During night time our visual cortex remains idle. Since sensory deprivation causes neighboring areas to take over, the visual system is in danger of being takeover by other senses, whereas, other senses like touch, sound taste or smell are not affected by darkness. Dreams are the means by which the visual cortex keeps itself active, to prevent its takeover by other senses.

During sleep the brain is fully electrically active, due to the flow of electrical waves into the occipital cortex, triggered by a set of neurons called the Pons in the brain stem, resulting in muscular shut down 'which allows the brain to simulate world experiences without moving the body around'. "These activities are very precise-they begin in the brain stem, and are directed only to the visual cortex". The neural activity is experienced as visual, causing the dreams to be pictorial and filmic, instead of being abstract.

Do blind people dream? *People who have been blind from birth or are blinded at a very young age experience no visual imagery in their dreams as o*ccipital cortex of a blind person becomes overtaken by other senses.

Occipital activity occurs in congenitally blind, but is experienced as non-visual. People who become blind after the age of seven have more visual content in their dreams than those who become blind earlier.

Why do we not remember dreams? Hippocampus and pre-frontal cortex are less active during dream sleep, than during waking stage. Therefore, we do not remember our dreams.

Do animals dream? During REM sleep dreams occur. Animals born immature have more REM sleep up to 08 times. In others the brain is fully formed at birth; there is no need to keep activity going on in the visual area.

Do dreams decrease with age? REM sleep decreases with age, as animals mature cortical takeovers are less possible. **(Ref: Live wired- book)**

It may be noted that such takeovers/ encroachment of areas is not limited to areas for vision alone, but also in respect of areas devoted other senses like hearing, touch etc. Cortical reorganization has great evolutionary significance in that '--it allows natural selection to test out varieties of body types from claws to fins, wings to prehensible tails. Nature does not need to genetically re-write the brain each time it wants to try out a new body plan; it simply lets the brain adjust itself '.

Autistic Savants are children or adults who have an Autism Spectrum Disorder (ASD). They display remarkable abilities or skills in one or several domains. Not all autistic persons are **savants**, and not all savants are autistic. Only 10% individuals within Autistic Disorder have savant syndrome; but savant syndrome can also occur in conditions other than Autistic Disorder.

Savant abilities are usually in certain skill areas - hyperlexia (the exceptional ability to read, spell and write); art; music; mechanical or spatial skill; calendar calculation; mathematical calculation; sensory sensitivity; athletic performance; and computer.

The pairing of cognitive disabilities with outstanding talents in some people has attracted many theories in the past. The latest explanation is that since brain has to distribute all its tasks across a finite volume of cortex. When there is unusual distribution of cortical area some disorders could arise. Therefore, these human super powers come at the expense of other tasks.
The savants may have a very low IQ or other mental challenges — and yet show almost super-human strengths in one very specific area, while **prodigies** are persons also with special skills or abilities, *but without such mental disabilities.*
The best-known autistic savant is a fictional one, Raymond Babbitt, as portrayed by Dustin Hoffman in the highest-grossing 1988 movie *Rain man*. He had damage to his cerebellum, and the bundle of nerves that usually connects the two hemispheres of the brain was missing. He memorized over 6000 books and has encyclopedic knowledge of geography, music, literature, history, sports and nine other areas of expertise, according to Wikipedia. In 2009 at age 58, he had a heart attack and passed away.

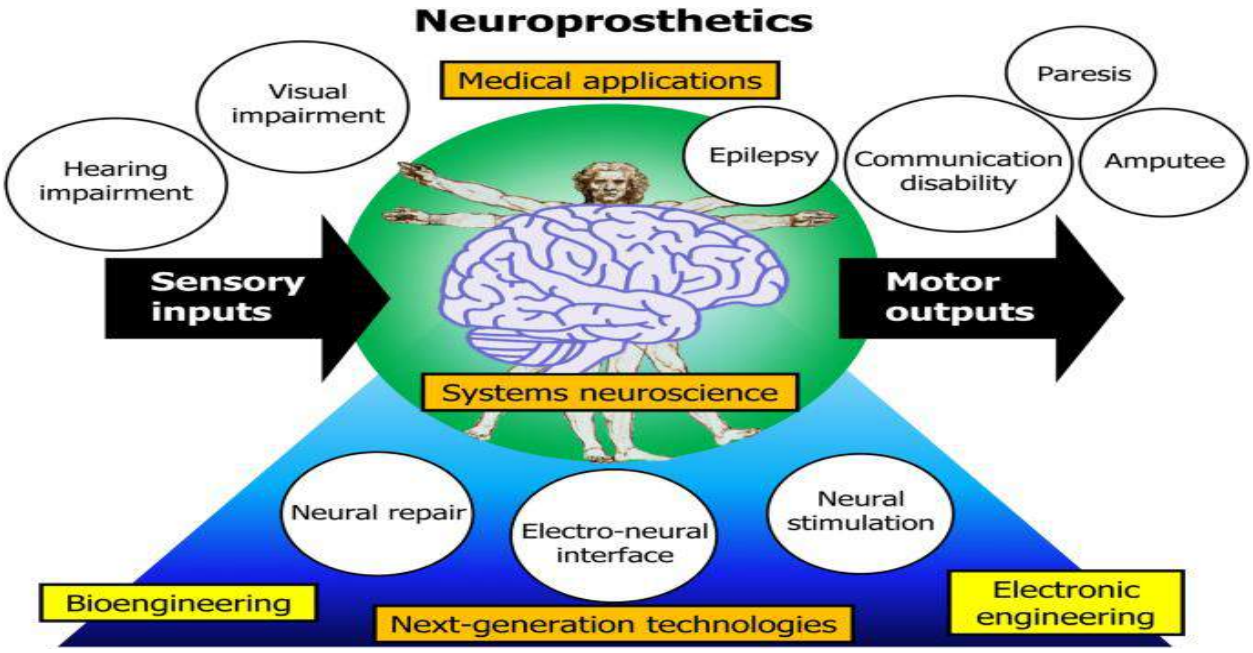
Implants

Technology can be used to improve the quality of life. Cochlear implants have been used since 1982 and today half a million people are dependent on them for hearing.

*Eventually, brain implants will become as common as heart implants. I have no doubt about that---**Miguel Nicolelis***

The brain is not directly seeing or hearing; it only receives electrical signals and interprets patterns. This principle is used in having implants to aid those whose hearing or vision are impaired.
The implant is a mini computer lodged directly into the inner ear. It passes information from outside to the auditory nerves by means of tiny electrodes, bypassing the damaged part of the inner ear. However, for those with implants, the change is not immediately felt. It takes time to get adjusted to the device. The software can be updated and improved, making the device more efficient each time.
In 2004 a research team at the University of Southern California implanted a mini chip in a patient named Terry Byland, with degenerative disorder of the retina. Bionic retinal chip is a tiny device with a grid of electrodes plugged into the retina. A camera beams signals to the chip generating signals directly to retinal cells activating the optic nerve.

Neuroprosthetic The concept of sensory substitution opens new opportunities to compensate for sensory loss.
Neuroprosthetic devices can substitute for motor, sensory, or cognitive functions that have been impaired as a result of disorders in the nervous system. Therapeutic devices (neutoprosthetics)



Credit: nature.com

help the system to get back to normal, especially, in cases of brain injury. These implantable

Man has, as it were, become a kind of prosthetic God. When he puts on all his auxiliary organs, he is truly magnificent; but those organs have not grown on him and they still give him much trouble at times ***Sigmund Freud***

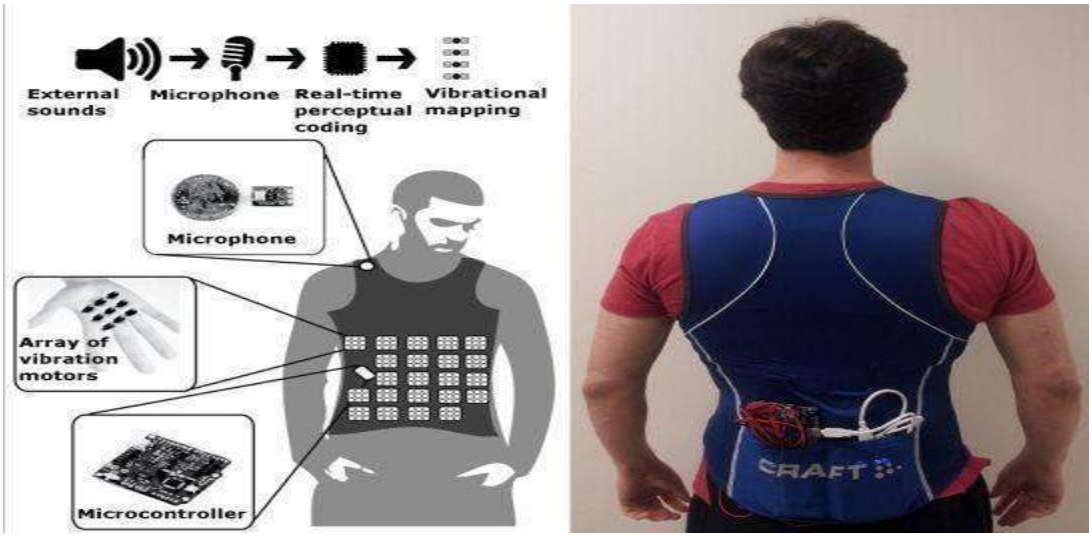
devices are also commonly used in animal experimentation.

How it happens The brain has the remarkable ability to accept any sensory input. All our sensory inputs are converted into common electrical signals. The cortex is only 'an all-purpose data processing engine'.
The brain analyzes the input and puts into context, regardless of where it comes from. For example, inputs from visual area to the auditory cortex showed that the latter adjusted its circuitry to resemble the connections of primary visual cortex. The brain adjusts itself according to what relevance tasks are aligned to goals or reward. For example, in blind people the sense of hearing becomes sharper, since the change is relevant in getting a better feel of the environment.

Neuro prosthetics: Credit: speakingofresearch.com

In another experiment, a small device called brain-port, with a camera is attached to the forehead of a blind person and a small grid of electrodes are placed on his tongue. The electrodes deliver small shocks. *The tongue is an organ of taste but when loaded with touch receptors it aids in vision.* This shows that our vision arises not in the eyes but in the brain. The brain can make out visual inputs regardless of the path by which they reach it. Similarly, experiments were conducted to see whether a blind person could pick up visual information through the ears.
Scientists have developed a neo-sensory vest which captures the sound around and maps it onto vibratory motors on the skin. People can feel the sonic world around them**.** "All we're doing is transferring the inner ear, which captures sounds and sends frequencies to the brain, to your torso." (see picture below).
Unlike a cochlear implant, it is non-invasive and it is hoped that the wearable product will be ready in a year's time, costing around £1,000 a vest — considerably less than an implant. Sensory technology can be deployed worldwide at even lower costs than phones and are not confined to the rich alone. In the near future people may increasingly choose their own plug and-play peripheral devices.

Human beings are essentially prosthetic creatures, due to our propensity to create tools, such as glasses and smart phones---- ***Bernard Stigler***



Neo-sensory vest that could improve your hearing, smell. It works by receiving a stream of data which is transmitted to 32 vibratory motors on the vest (Credit: standard.co.uk)

Apart from using electrical grids to feed visual information via the tongue and vibratory motors to feed hearing via the skin, cell phones now can feed video-streams via the ears. Neuroprosthetics are also used in pain relief, bladder control and control of movements.

Today neuroprosthetic devices are available which are sleek, minimally invasive and convenient to wear.

Brain-computer interface Until recently, ideas on our ability to control our environment through thoughts were confined to science fiction. However, with the advance of technology '----Today, humans can use the electrical signals from brain activity to interact with, influence, or change their environments'. The emerging field of brain-computer interface (BCI) technology is helping individuals unable to speak and/or use their limbs to once again communicate or operate assistive devices.

A **brain-computer interface** (**BCI**) is a **computer**-based system that acquires **brain** signals, analyzes them, and translates them into commands that are relayed to an output device to carry out a desired action.

According to www.ncbi.nlm.nih.gov, in principle, any type of **brain** signal could be used to control a **BCI** system. The main goal of BCI is to replace or restore useful function to people disabled by neuromuscular disorders such as amyotrophic lateral sclerosis, cerebral palsy, stroke, or spinal cord injury. Brain-computer interfaces may also prove useful for rehabilitation after stroke and for other disorders.

The differences between BCIs and

We will continue to live in a form in which we become cyborg. Either we download our information to a machine or we incorporate so many machine parts that we don't know where we end and the machine begins.

neuroprosthetics are mostly in the ways the terms are used: neuroprosthetics typically connect the nervous system, to a device, whereas the term "BCIs" usually connect the brain (or nervous system) with a computer system.

Neuro-prosthetics and BCI are today showing exciting possibilities, and, no doubt, will be widely utilized to improve the quality of life of persons who need these aids. As pointed out in www.nature.com the complexity of the nervous system made of billions of neurons is a barrier to our deep understanding of the brain and for creating high-end neuroprosthetic devices. Focusing on neural circuits has provided a better understanding of the brain functions. The effects of BCIs can be

What are Cyborgs**?** A **Cyborg**, (short for cybernetic and organism) is a being with both organic and bio-mechatronic body parts. The term was coined in 1960 by Manfred Clynes and Nathan S. Kline.

Cyborg" is not the same thing as bionic, bio-robot, or android; **Bionics** is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology. An **android** is a robot or other artificial being designed to resemble a human, and often made from a flesh-like material. A **robot** is an automated machine while a **cyborg** is a combination of an organism with a machine. **Robots** are not alive while **cyborgs** are. **Bionic man or woman** is a human being whose body has been taken over in whole or in part by electromechanical devices.

Advantages Cyborg technology is considered as the next step in human evolution. With the aid of wearable devices we are already moving towards becoming cyborgs. They are being used to monitor our health and our fitness, as well as provide other valuable information. These removable accessories, would be replaced by implants, which would be mass-adopted. Cyborg technology would help people avoid dangers in the workplace and elsewhere.

Concerns are expressed about Cyborg technology. Some fear that it would turn human bodies into hackable pieces of technical units. Some have warned against the growth of artificial intelligence, a necessary part of creating cyborg technology. The biggest threat to a human-cyborg future is the areas of privacy and security. Despite having a number of potential negatives, cyborg- technology is likely to stay. We need to take care of privacy, security and the ethical issues involved with concern and care. **Wikipedia; interestingengineering.com**

both positive and negative. The associated ethical issues that include manufacturing, animal experimentation, human trials,

*The cyborg is now the ideal to which all our most advanced technology is tending—**Bryan Applevard***

scope of use, and individual and societal concerns need to be addressed.
Use of robots Robots are increasingly being utilized to aid people with infirmities. High density electrodes are surgically implanted into different areas of a volunteer's brain, which allows 'patients to channel their own brain activity to take command of the robots'. A user can control a robot at a distance, 'seeing what it sees and feeling what it feels' as robots will be perceived as a part of our body.

Scientists perceive that in the not so distant future, we will mind control robots in factories, under water, or on the surface of the moon. In future, 'we do not have to limit themselves to the boundaries of our bodies; we will be able to extend the boundaries'.

Future With the fast-paced research in Neuroscience the mysteries of the brain are getting unraveled day by day. The new developments in neuroscience could be described only as explosive.

In this write-up we have included only the more important developments in this field. In the near future we will know more and more about the structural and functional aspects of the human brain. More light will be thrown into neuronal behavior. No doubt, there will be matching advances in the development of technology by way of brain imaging, computer applications, artificial intelligence and robotics. Advances in technology will take our lives to a level, never seen before. At the same time, we need to ensure that we remain essentially human.

----------**Ref: en.wikipedia.org; www.ncbi.nlm.nih .gov; www.news-medical.net; www.nature.com; interestingengineering.com; Live Wired-book by David Eagleman**

The human brain is the only object in the known universe that can predict its own future and tell its own fortune. The fact that we can make disastrous decisions even as we foresee their consequences is the great, unsolved mystery of human behaviour. When you hold your fate in your hands, why would you ever make a fist? **Daniel Gilbert**

No brain injury is too mild to ignore or too severe to lose hope-Unknown

HEALTH: BRAIN DISORDERS

----Dr Madhuri Behari

(Credit: quotav.com)

Dr Madhuri Behari is the former Head of the Department of Neurology, Neuroscience Center, All India Institute of Science (AIIMS), New Delhi. Presently, she is working as a consultant. In this article she briefly discusses various brain disorders.

Protected in a bony box, the skull, brain occupies the highest position in our body. It is the center of control of all body functions and receives the highest amount of blood supply to meet its high rate of metabolism.

Brain is part of nervous system which also consists of spinal cord and a large network of nerves and neurons (Ref: page 10 of this issue). Together they control sensations of all types (vision, sound, smell, taste, balance touch, heat, cold, pressure, movement), movements (limbs, face, eyes, tongue, heart, urinary bladder, intestines and stomach), hormones and growth and higher cognitive functions like memory, calculation, speech, judgement and personality etc.

Also, there is precise localization of each body part and function in the brain (Ref: Page 11 of this issue). The brain consists of neurons (the nerve cells) supporting cells (oligodendrocytes and astrocytes). The brain cells connect to each other through large network of nerve fibers.

*My belief is that we are not going to get human-level abilities until we have systems that have the same number of parameters in them as the brain----- You have about 1000 trillion synapses (in your brain)-**Geoffrey Hinton***

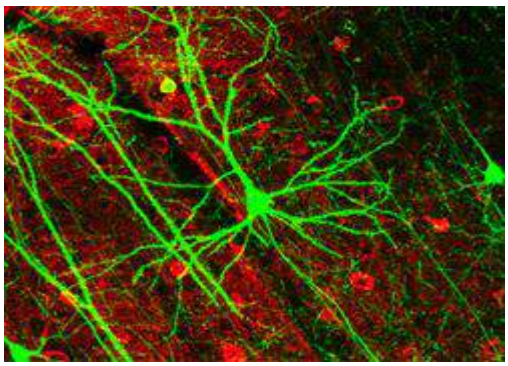
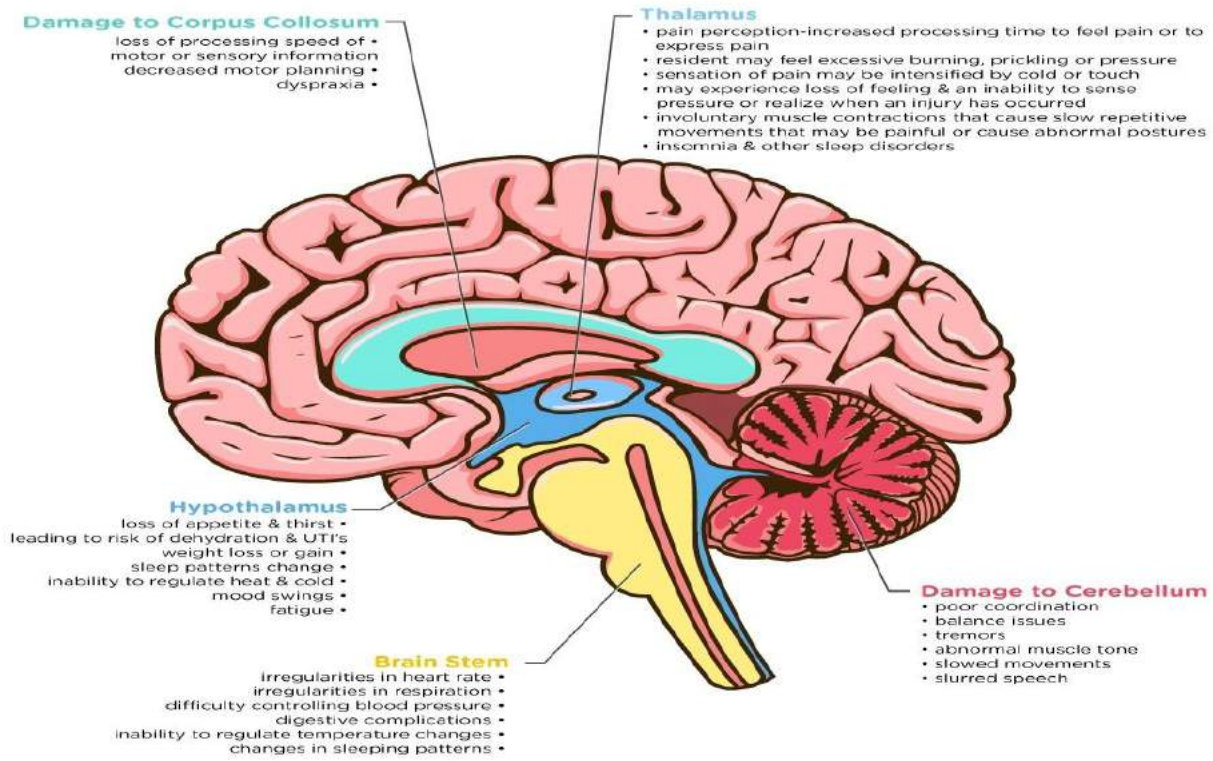


Image of pyramidal neurons in mouse cerebral cortex (en.wikipedia.org)

It is estimated that there are 100 billion neurons in brain. These nerve fibers carry messages from one nerve to another as electric current and either stimulate (excitatory) of inhibit (inhibitory) the cells to whom they synapse. These fibers run in bundles to form tracts. To prevent getting (electric) shocks and cross-talks, these fibers are individually enveloped in an insulator material called the myelin. In addition, there are large numbers of blood vessels.



Credit: permobil. blog

*Consciousness is simply the brain's neural response to its surrounding environmental stimuli. Hence when the neural circuits malfunction, consciousness tends to malfunction as well---**Abhijit Naskar***

Hence, when the brain gets damaged due to any cause, there is usually loss of function of that part of body (weakness, memory loss, numbness etc.)

Types of disorders

Certain conditions that can affect brain can be broadly divided as:

1. Genetics

2. Traumatic injury

3. Infection.

4. Vascular (related to blood supply)

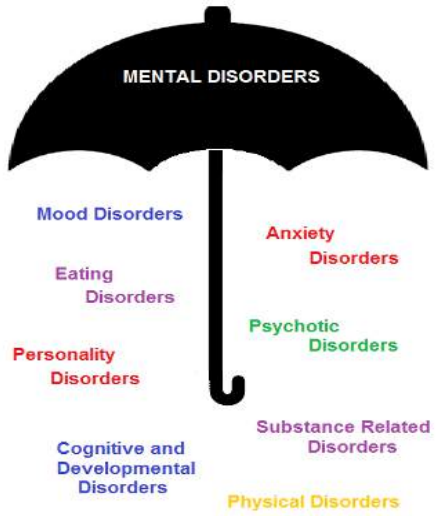
5. Loss or defective myelin formation

6. Tumor

7. Degeneration

8. Metabolic

This is a broad category of disorders, which vary greatly in symptoms and severity. What are the different types of brain disorders?



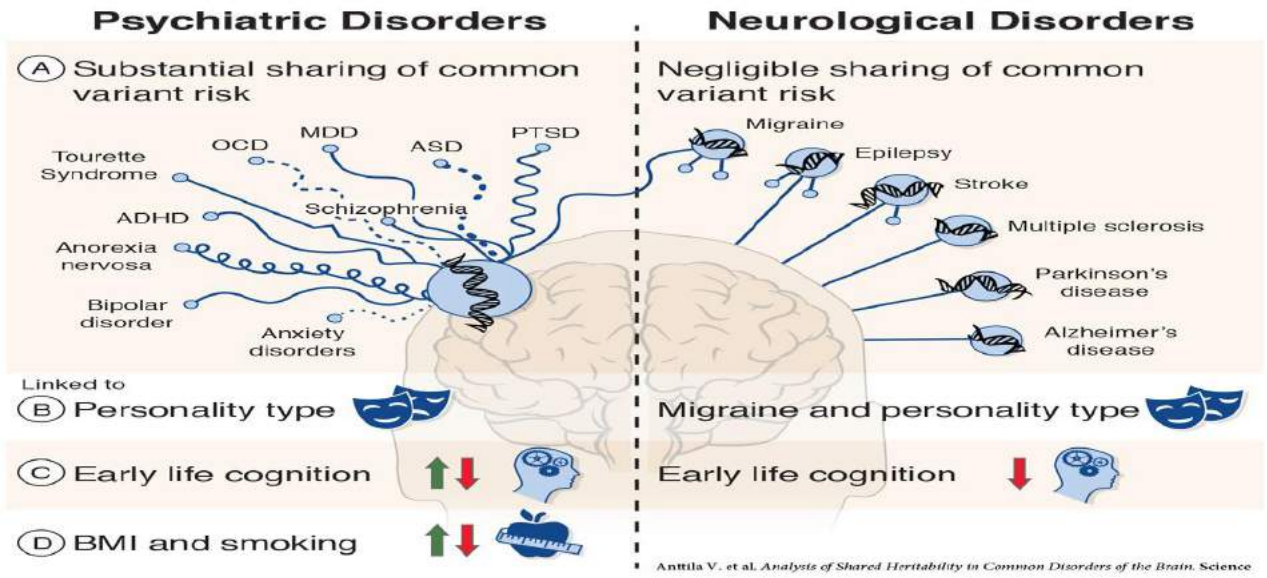
(Credit: papermasters.com)

1.Genetic disorders

Savant syndrome and autism, I think are not disorders of the brain structure, but they are the disorders of the brain function- ***Darold Treffert***

Genetics plays in important role in development, especially the brain. These disorders are usually present in childhood. Among brain disorders of genetic causation, the common ones are Tay-Sech's disease, Wilson's disease, leukodystrophies, Down's syndrome etc. Many Children with delayed development suffer from some form of genetic disorder or other.

2. Trauma There can be blunt injury to brain or spinal cord or both in road traffic accidents (RTA) or falls from height, gun shots or by any blunt object or there may be sharp injuries by any sharp object like lancet, *Khukhri* or any such object.



(Image courtesy: University of Florida)

These may result in bleeding inside brain or spinal cord or direct injury to neurons or tracts in spinal cord or brain. Other means are contusion or bruising of brain tissues, cerebral edema (swelling in brain), concussion or damage to an artery causing stroke.

When any of the above condition occurs, patients experience headache, vomiting, bleeding from ear or nose, unconsciousness, paralysis, convulsions and memory loss. Brain edema can be life threatening if it reaches threshold level. As brain is enclosed in a bony structure, swelling of brain results in compression of brain, resulting in herniation of brain through the small hole from where it comes out and forms the spinal cord. This causes pressure on the structures located at the lower surface of brain i.e. the brain stem which houses functions of respiration, heart beating that maintains blood pressure and other vital functions. Due to compression of brain

Often looking at the brain, it is important to go beyond its structure to function. This is because often in cognitive disorders, the structure of the brain is intact, but its function is compromised---Aditi Shankardass

stem, initially blood pressure rises and then falls, followed by cessation of breathing and ultimately death, unless intervention is done.

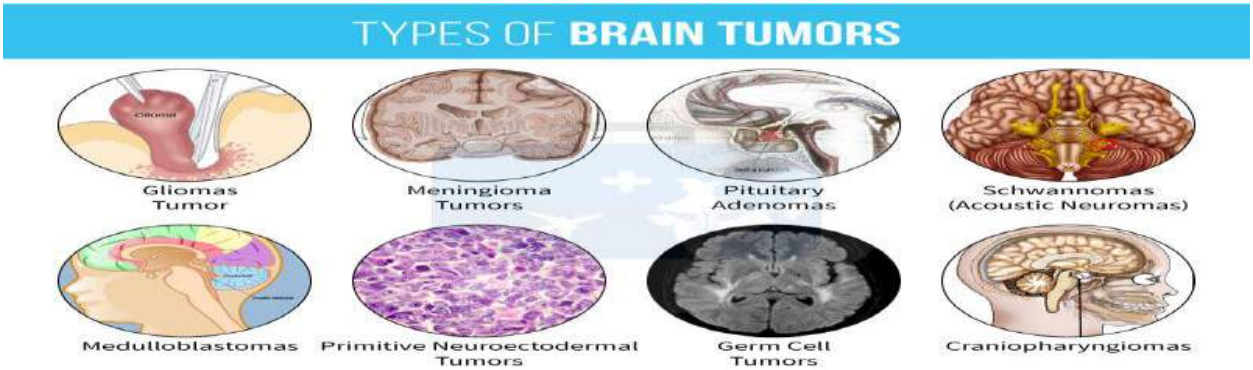
Brain injuries usually cause weakness of one side of body with or without speech problem, whereas, spinal cord injury usually leads to weakness of both lower limbs or all four limbs, depending if the injury is on lower cord below neck or upper cord

in the neck area respectively. In spinal cord injury there is also numbness i.e. loss or impaired sensation or spontaneous pain along with impaired bladder control and even erectile dysfunction.

Skull MRI (T2 flair) of a brain metastasis with accompanying edema (Wikipedia)

If the injury is minor, there may be minor intellectual decline, behavior and personality disturbance and / or epileptic attacks. When injury is major there may be requirement for brain or spinal cord surgery to remove the blood clot and relieve pressure on brain. Most patients require long term rehabilitation and medications for symptoms they have.

4. Tumor There are many types of tumors that can occur in brain and spinal cord. These may be cancerous or non-cancerous. Brain tumors are known as primary



(Ref: blogspot.com)

Don't deny the diagnosis. Try to defy the verdict- unknown

tumors. In addition, cancers of other parts of body may spread and secondaries can lodge anywhere in the brain, but rarely in spinal cord. Common symptoms of brain tumors are headache, vomiting, seizures, weakness or numbness of any part of body, change in personality, loss of balance etc.

Different tumors have predilection for different age groups. Depending on size and other consideration they may require, surgery, chemotherapy or radio-therapy.

5. Infections may also occur in brain or in spinal cord or in both. Infection to brain can be caused by any infective agent right from viruses to large parasites, including, bacteria and fungus.

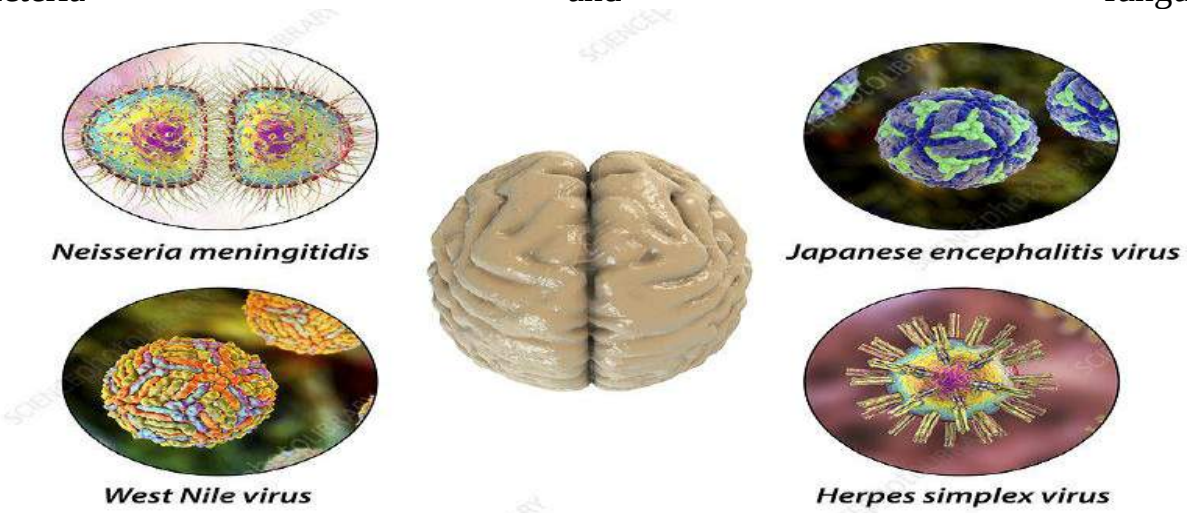


Illustration of brain- viral infections (Stock Photos)

There is thin film which surrounds brain and spinal cord. Outside this there is another layer which is thicker and a third layer that is stiff and thick. These are together known as meninges. When infection occurs in meninges it is known as *meningitis* and then it involves the meninges of both brain and spinal cord.

Common causes of meningitis are tuberculosis (TB) and bacterial infections. Infections are more common in people who are immune-compromised like diabetics, those receiving immune-suppressant drugs like steroids, transplant recipients, those with autoimmune disorders and those having acquired autoimmune deficiency syndrome (AIDS). Meningitis causes fever, headache, altered conscious state and sometimes seizures. Some patients have stroke like symptoms also.

Our dreams and nightmares are kept apart by this thin line of sanity. Some of us are just fortunate that we only cross that line in our sleep- ***Wiss Auguste***

Infection in the brain with fungus bacteria and tuberculosis can cause space occupation just like a tumor, and can cause headache and weakness of a limb, or even seizures. Some parasites like tape worm and dog tapeworm can cause a number of symptoms. The larval form of tape worm can gain access to brain and other body parts when we eat unhygienic food or food not properly cooked. These can also result in formation of lumps which can cause headache, vomiting and weakness of any body part; when single they can cause seizures.

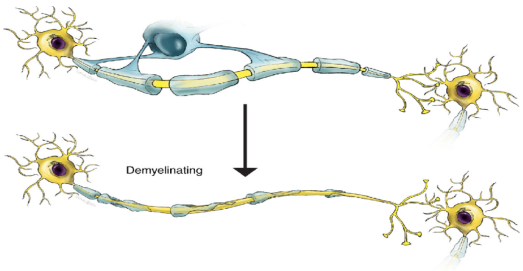
We have seen fungus infection of brain in the wake of Corona infection, especially in people who are diabetic and those who have received steroids and other situations where immune system is weak. There are several types of fungi which cause brain infection. Some of these are Cryptococcus, aspergillus, mucormycotic and many others. The spores of fungi are freely present in the air and some are even present in nostrils and sinuses. When the situation is suitable, they grow and cause disease, in the form of meningitis and lumps near eyes, sinuses and anywhere in the brain. These lumps cause headache, vomiting and weakness or numbness of any body part.

Syphilis is another infection which can involve brain and can cause vision loss, cognitive impairment, weakness of limbs and meningitis.

6. Diseases of the Myelin Sheath

As alluded to earlier, myelin sheath is the insulating layer around the nerve fibers. The disease may be acquired later in life when it is known as demyelinating disorder. When a child is born with defective myelin formation due to genetic or metabolic cause, it is said to suffer from de-myelinating disorder.

1. **Demyelinating disorders in children:** Disorders in this group are those in which there is defective formation of myelin called leukodystrophies. It usually affects children and is genetically determined. These is mental slowness, difficulty in walking poor vision and rarely seizures.



Demyelination results in a loss of functional conduction and may result in axonal damage and synapse loss (ref: ResearchGate)

"Anxiety is the monster that resides within"— ***Karon Waddell***

2. **Demyelinating disorders acquired later in life** occur when suddenly antibodies are formed against one's own myelin, which then destroys it. Usually the persons who acquire it are in their twenties or thirties. Women are more commonly affected. The common problems are double vision, visual loss, unsteadiness of gait (the way we walk) and hand tremors.

The major and common disorder in this group is multiple sclerosis (MS). There is lot of research going in the field of treatment of MS and a new drug is produced almost every two years. Most of these drugs act against the antibodies which are produced against myelin or suppress antibody formation. There are other causes of demyelinating disorders e.g. after viral infections, vaccinations etc.

7. Stroke

By definition stroke is a disorder of brain which occurs due to sudden cessation of blood supply to brain.

There are three types of stroke. They are:

1. Brain Infarction

2. Brain Hemorrhage

3. Venous infarction

Brain Infarction: In this type of stroke the blood supply to a part brain is stopped due to a blood clot arising from heart or a larger artery or the artery gets stenosed (narrowed) due to a clot or deposition of fats (Cholesterol, lipid). The onset is rather rapid, within minutes the patient is unable to move limbs, speak or stand. Sometimes a convulsion may be the first symptom.

There are several risk factors, some of which can be controlled such as high blood pressure, diabetes mellitus, smoking, sedentary life style, obesity, high cholesterol and abnormal lipid profile, heart disease etc. Other non-controllable risk factors are age, gender (more in men), genetic factors etc.

Most strokes can be avoided by improving lifestyle, controlling high blood pressure and diabetes, use of small dose of aspirin after a certain age, controlling lipids in diet and hence in blood. These days this type of stroke is imminently treatable within 4.5

"Unexpressed emotions will never die. They are buried alive and will come forth later in uglier ways." – ***Sigmund Freud***

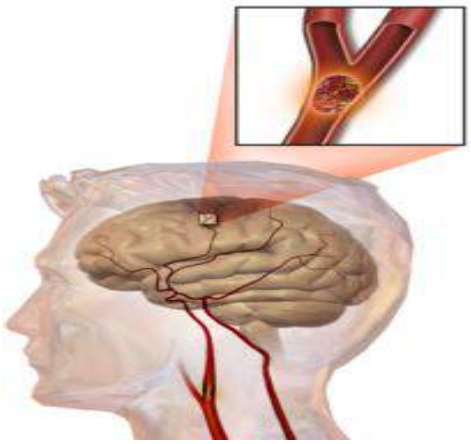


Illustration of an embolic stroke, showing a blockage lodged in a blood vessel. (en.wikipedia.org)

hours, if one is able to detect and reach hospital within the time frame. Medicines are available which can dissolve the clot within the artery and salvage the brain tissue. Later, the person reaches hospital, more damage to neurons will occur.

Hemorrhagic stokes: are those in which there is tear in a blood vessel resulting in bleeding inside the brain. This also occurs suddenly and within minutes there is headache, vomiting and weakness of one side of body. The common risk factors are high blood pressure, diabetes mellitus, presence of aneurysm in brain (aneurysms are small balloon like swellings of the arteries, which have very thin walls). These aneurysms can burst any time when the person is excited, especially when angry, watching an exciting match etc. Depending on where the bleeding occurs, symptoms will be weakness of one side of body, speech problem, balance problem, double vision, unconsciousness.

Venous stroke: These are due to blockage in the venous system of brain. There are small venous system and large veins and venous sinuses. A stroke usually occurs when there is hemo-concentration (high concentration of blood). Which usually occurs when lots of fluid is lost such as in hot weathers, lot of sweating, vomiting and diahorrea. People who live at high altitude having high hemoglobin are also likely to get it. Additionally, smokers also have high hemoglobin. Women during and flowing child birth and during pregnancy have high viscosity of blood and hence are liable to this type of stroke.

Trauma creates change you don't choose. Healing creates change you do choose--- ***Michaele Rosenthal***

There are some genetic causes which cause high viscosity of blood and can cause venous stroke. Due to blockage of a vein there is back pressure in that area which causes sluggish blood supply and hence over a period of days the person gets headache, vomiting and dizziness, weakness of one side of body, seizures etc. Treatment consists of treating the cause, if known, treatment of seizures and use of blood thinners. The treatment goes for several months.

7. Neurodegenerative diseases Neurodegenerative diseases are those in which there is slow and progressive degeneration of nerve cells with accumulation of abnormal protein in nerve cells which slowly cause strangulation of these cells and ultimate cell death. There is slow deterioration of functions of brain, which results in personality changes, confusion, impaired memory, inability to make judgement, dress up and bathe or look after their hygiene. Later, there may be hallucinations or false belief that someone might loot them or harm them or their family members. There may also be difficulty in understanding spoken or written commands and inability to find the right words or speak. These diseases are progressive without respite and currently no cure is available. Any treatment for these disorders only gives symptomatic relief. Common diseases in this group are:

· Alzheimer's disease, (and other dementias)

· Parkinson's disease

· Amyotrophic Lateral Sclerosis (ALS, MND) or Lou Gehrig's Disease.

Alzheimer's disease

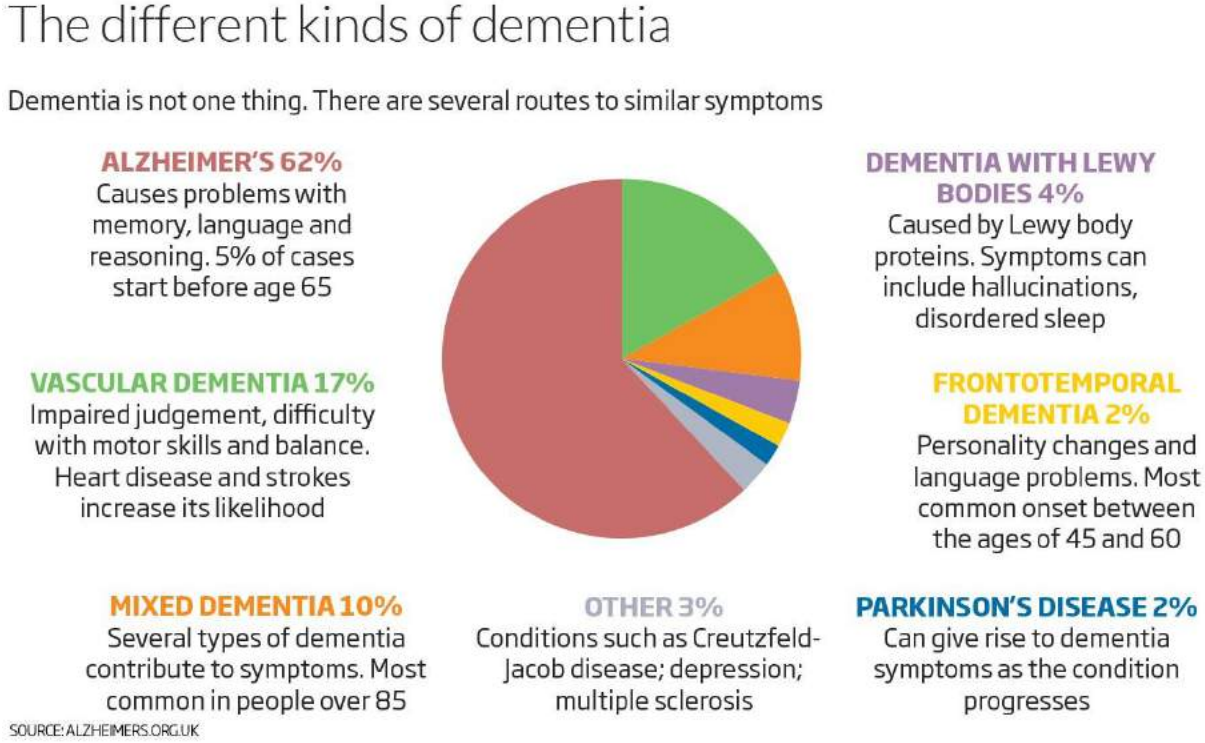
Alzheimer's disease is the most common cause of dementia among older adults. It is named after Dr. Alois Alzheimer who first described the disease in 1906. Out of the approximately 50 million people worldwide with dementia, between 60% and 70% are estimated to have Alzheimer's disease.

Alzheimer's disease is a progressive brain disorder that gradually destroys a person's memory and ability to learn, reason and make judgements, communicate and carry out daily activities. It causes the brain to shrink (atrophy) and brain cells to die.

The cause of Alzheimer's disease is poorly understood. There are many environmental and genetic risk factors associated with its development. The disease

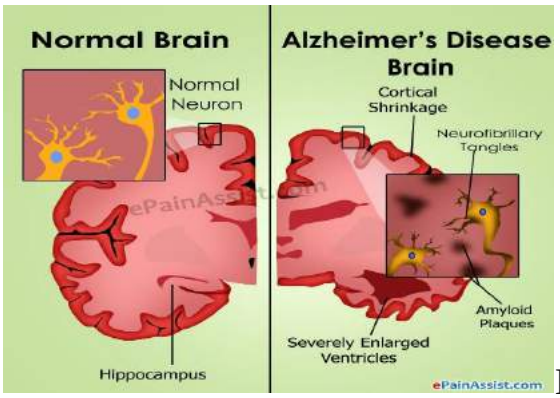
No one would ever say that someone with a broken armor broken leg is less than a whole person, but people say that or imply that all the time about people with mental illnesses---- ***Elyn R. Saks***

process is largely associated with amyloid plaques, neurofibrillary tangles, and loss of neuronal connections in the brain. Alzheimer's disease is characterized by loss



(Credit: New Scientist)

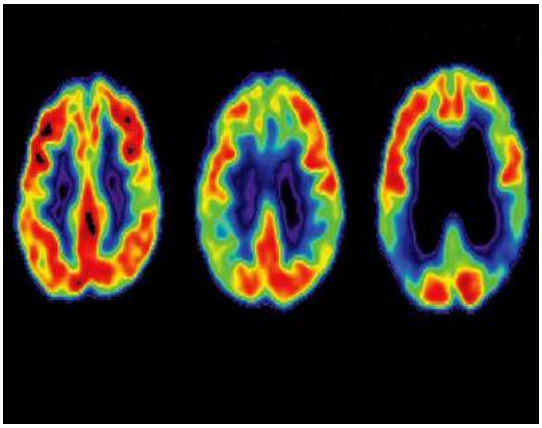
of neurons and synapses in the cerebral cortex and certain subcortical regions. This loss results in degeneration in the temporal lobe and parietal lobe, and parts of the frontal cortex and cingulate gyrus as also the brainstem nuclei, particularly the locus coeruleus in the pons.



Medications may temporarily improve or slow progression of symptoms. There is no treatment that cures Alzheimer's disease or alters the disease process in the brain, though there has been significant progress in

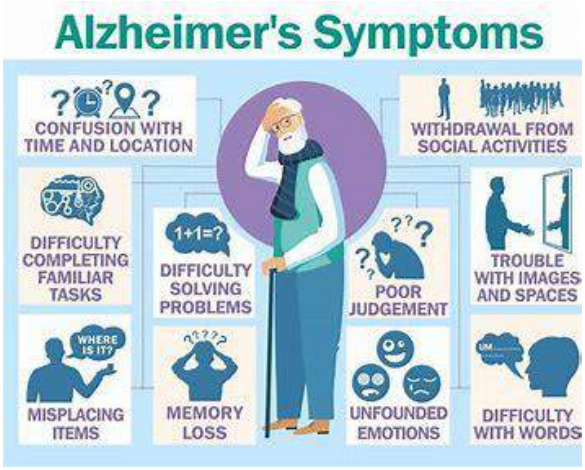
*Ronald Reagan's well-documented final battles with Alzheimer's disease were fought with the same conviction and courage that his many public battles were fought—**William L Jenkins***

recent years in developing and testing new treatments. Several medicines have been approved by the U.S. Food and Drug Administration to treat people with Alzheimer's.



Disease progression- mild, moderate and severe-
Over time, Alzheimer's disease causes neuron death and tissue loss throughout the brain-Getty Images

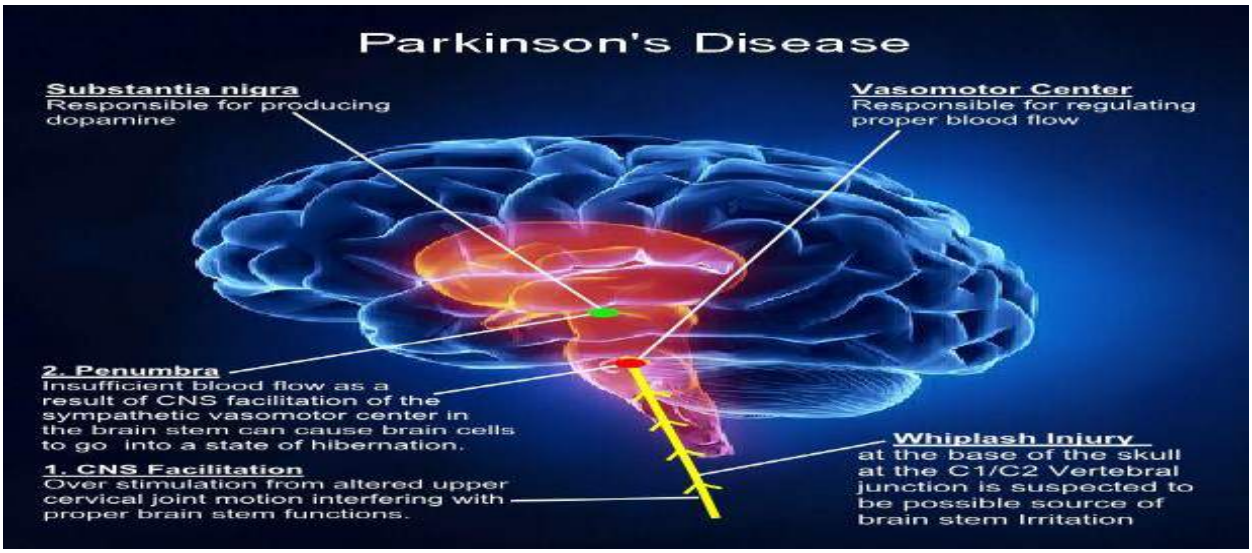
Affected people increasingly rely on others for assistance, often placing a burden on the caregiver. Good nutrition, physical activity, and engaging socially are known to be of benefit generally in aging, and these may help in reducing the risk of cognitive decline and Alzheimer's. Alzheimer's disease is currently ranked as the sixth leading cause of death in the United States, but recent estimates indicate that the disorder may rank third, just behind heart disease and cancer, as a cause of death for older people.



(Credit: ilove Qatar.net) **Parkinson's disease** is associated with slowness of body movements, tremors of

*'Though those with Alzheimer's might forget us, we as a society must remember them ----" **Scott Kirschenbaum,** Filmmaker*

hands, lips, jaw, legs which is present when that body part is at rest, stiffness of body and imbalance of body.



Symptoms of dementia type illnesses have been described earlier. There are many causes of dementia, and includes Alzheimer's disease, small multiple infarctions in critical brain areas, other degenerative diseases (Huntington's disease etc.) bleeding outside the brain in the skull, tumors in critical brain areas, normal pressure hydrocephalous and many more.

Amyotrophic lateral Sclerosis is a disease in which there is specie degeneration of cells of cerebral cortex and those of motor nuclei in brain stem and spinal cord. This results in slow and progressive loss of muscle tissue with weakness, flail limbs, choking on food and liquids.

9. Metabolic disorders of brain

Brain is very sensitive to changes in the blood parameters which nourishes it. If there is high blood sugar, low blood sugar, high urea or creatinine, high bilirubin, high ammonia, low sodium, low or high potassium, low magnesium or low oxygen level in blood or acidic blood (when pH of blood rises more than 7.4); all these can cause unconsciousness or coma and seizures. This requires careful assessment and treatment of patient.

Some mental disorders can also result from brain dysfunction. These include psychosis in which the patient

It takes up to five times more energy for a person with Multiple sclerosis (MS) to complete even the simplest task than it does for a person without MS— ***quotesgram.com***

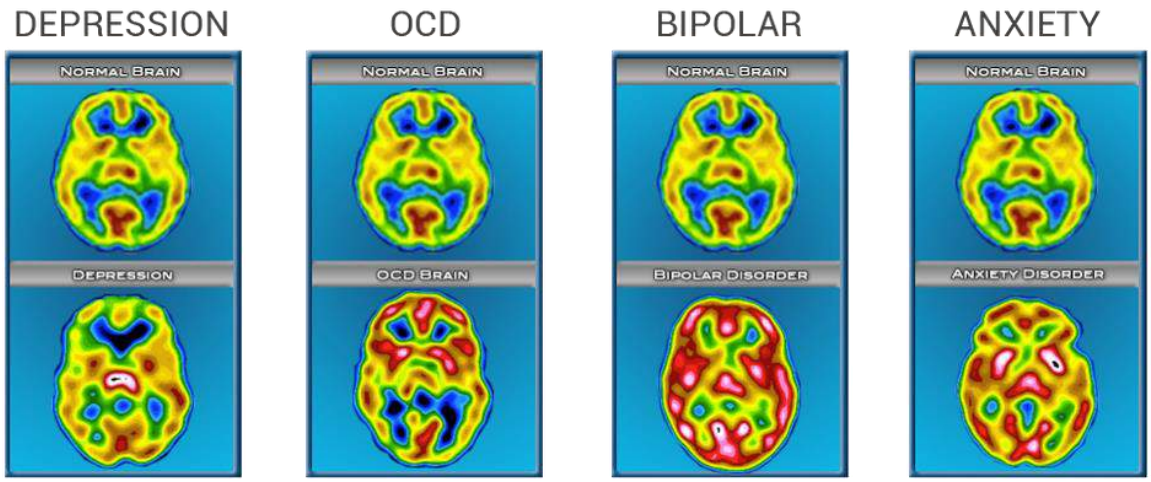
may become paranoid i.e. will think that his or her spouse is having illicit relations, or his children or neighbors might rob him. There may be paranoia of grandiosity and the patient may think he has become a king or a revered saint. In addition, there is another symptom which is hallucination, in which while awake, the person my see animals, people or children and may even talk to them.

Many of these symptoms are seen due to drug effect and also in people with dementia. Otherwise, they indicate pure psychiatric illness, for which they need to consult a psychiatrist.

How are brain disorders diagnosed?

The brain specialist (neurologist) is usually able to diagnose most of the brain disorders by listening to history, if narrated properly, by giving the details and chronology of symptoms. They may then examine the patient to further confirm the diagnosis. Your doctor might also need to study fluid from your brain and spinal cord. This helps them find bleeding in the brain, infection, and other abnormalities.

Many a time, depending on the symptoms, some tests are required to confirm the diagnosis. Apart from tests for general blood parameters like CBC, Liver Function Test, (LFT), Kidney Function Test (KFT), thyroid function test, Serum electrolytes, ammonia level etc. the doctor may require, specialized tests like examination of fluid which surrounds brain and spinal cord (cerebrospinal fluid, CSF) through a puncture done using a needle in the back at lumbar level. Examination of CSF is very useful when infection is suspected in the meninges i.e. meningitis or encephalitis (infection of brain). From this test we can see level of sugar proteins and cells and detect any organism which may be seen or cultured on culture medium.

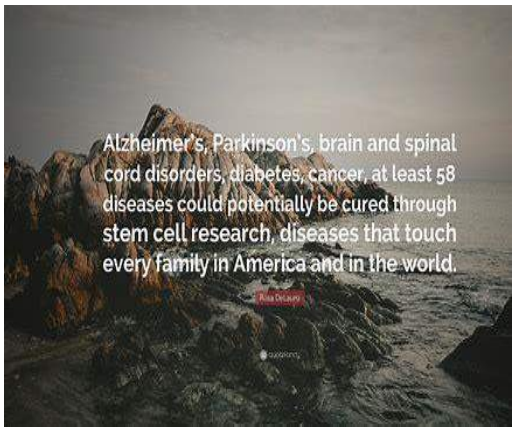


Brain scan of various disorders (Image credit: Haiku Deck)

It took 350 years, since the invention of the telescope, to enter the space age, but it has taken only fifteen years since the introduction of the MRI and advanced brain scans to actively connect the brain to the outside world---**Anonymous**

Other tests like CT scan or MRI scan are useful in analyzing many strokes, tumor, abscess, blood clot in traumatic injury or in infections forming masses.

Sometimes PET scan is done if a secondary deposit from a primary cancer from any site in body is suspected in the brain. Another test which is known as Electro-encephalogram (EEG) is done for determining the functional status, such as in epilepsy. It is similar to ECG which records heart activity. It is especially useful in the diagnosis of epileptic attacks and sleep disorders. For disorders of nerve and muscle they also perform nerve conduction tests and electromyogram (EMG) for disorders of muscle.



Risk factors and their management

What are the risk factors for brain disorders?

Brain disorders can affect anyone. But some factors are there, which if tackled in time, can save brain disorder. They are 1. Protection from repeated head injury or any severe head injury. Hence, head should be protected at all times with helmet, esp. for two-wheeler drivers and boxers

2. Control of high blood pressure and diabetes mellitus

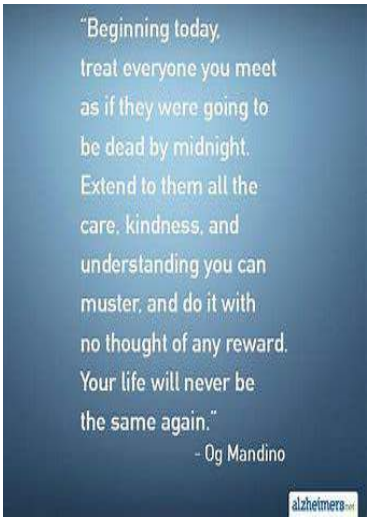
3. Control of cholesterol and lipid in blood and diet

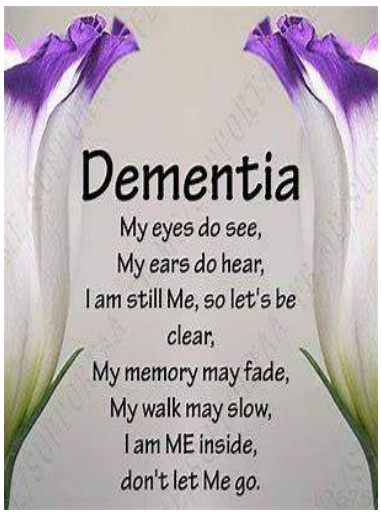
4. Regular exercise. It has been seen by means of elegant experiments that those who exercise regularly can prevent occurrence of Parkinson's disease or slow down its progression as it causes new synapses to grow

*While no one can change the outcome of dementia or Alzheimer's, with the right support you can change the journey------**Tara Reed***

5. Using mental capacity, i.e. If we use our brain we can prevent dementing illnesses such as Alzheimer's disease. It could be learning new language, new hobby, new activity like game, solving crossword puzzles, or Sudoku. Even playing games with children keeps the mind alert and prevents early dementia. That is why there is a slogan "USE IT OR LOSE IT".

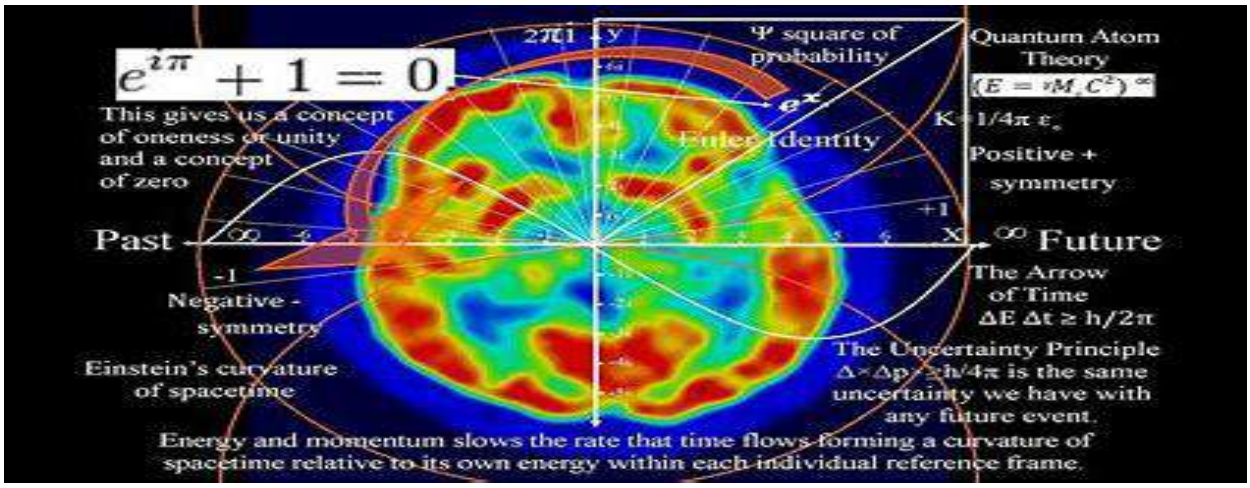
6. Healthy and active life style to prevent obesity ☐





Music imprints itself in the brain deeper than any other human experience---I regard music therapy as a tool of great power in many neurological disorders-Parkinson's and Alzheimer's---***Oliver Sacks***

SCIENCE: EXPLAINING CONSCIOUSNESS



"Millions of years of biological and cultural evolution have made it possible for our species to compute patterns in nature, be conscious of ourselves, and empathize with one another. Understanding how all of this occurs is a fascinating challenge". In this article we have compiled some of the latest views on consciousness, put forward by scientists.

According to Gerald M Edelman, the famous Neuroscientist and Nobel laureate, consciousness is 'the guarantor of all we hold to be human and precious'.

For a long time in human history, human beings were aware that they were conscious. Philosophical discussions on consciousness have engaged scholars since at least the time of Aristotle. They were fascinated, at the same time puzzled by it. They could not answer many fundamental questions relating to it like 'how is it possible for us to experience a complex combination of thoughts, emotions, sensations, memories and beliefs at the same time?'

Many scientists believed that the explanation for consciousness must lie in the realm of metaphysics. It was Francis Crick and Christof Koch who started searching for a scientific explanation, in the place of having only philosophical discussions on consciousness.

Today the 'majority of scholars accept consciousness as given, and seek to understand its relationship to the objective world described by science'.

It is only with the better understanding of the human brain in recent years that it has become possible to explore the scientific basis of consciousness. The primary focus now is on understanding the neural and psychological correlates of consciousness.

*Life is not a series of gig lamps systematically arranged; life is a luminous halo, a semi-transparent envelope surrounding us from the beginning of consciousness to the end—**Virginia Wolf***

What is consciousness? According to scientists **Consciousness** is a term that refers to the relationship between the mind and the world with which it interacts. It has been defined as: subjectivity, awareness, the ability to experience or to feel, wakefulness, having a sense of selfhood, and the executive control system of the mind (Ref: phys.org).

"Self-consciousness" is the awareness that the self exists. To put it simply, 'consciousness is our ability to acquire information about the world, to create a brain-model of the world around us, about perceiving changes to the environment using that model, using current sensory data combined with that model, and updating the model using the latest analysis'. Thus, we have a detailed model of ourselves inside the model of our world!

The basis of consciousness? Neuroscientists are involved in identifying the mechanisms in the brain required for conscious experience.

A study by Michelle Redinbaugh et al, researchers at the University of Wisconsin, Madison shows that, in macaques, the central lateral thalamus (CL) has a key role in the control of consciousness, through the modulation of specific cortico-cortical pathways. The experiment was described in a paper originally published in *Neuron, (*Neuron Vol 106, Issue1, 8April 2020, pages 66-75).

Scientists put macaque monkeys under anesthesia and then zapped their brains with electrodes at a frequency of 50 hertz. When the team happened to zap the central lateral thalamus, the sleeping monkeys *sat up, as if fully conscious,* and their brains showed patterns of activity typically seen during consciousness.

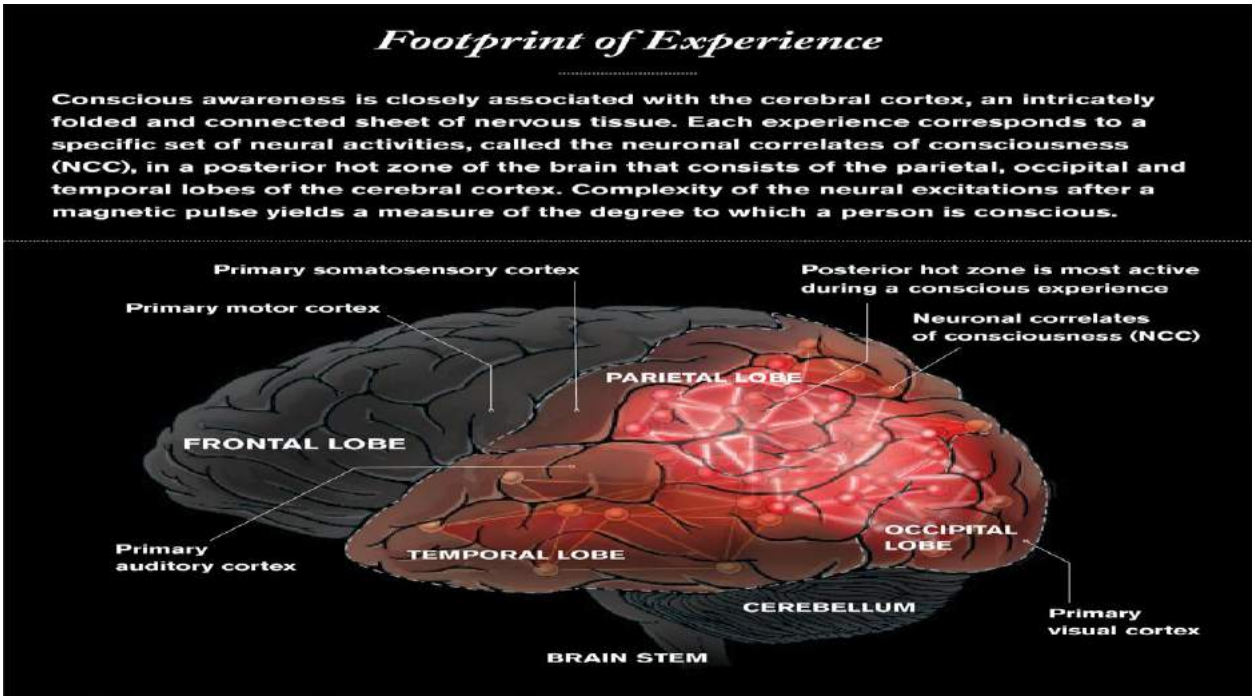
"The animal went from being deeply anesthetized to opening his eyes, looking around the room, and even reaching out for objects within only a few seconds of the stimulation turning on," according to Ms. Redinbaugh.

Journal Nature (www.nature.com -Nature reviews: Neuroscience, May, 2021) reviewed a paper by Gordon Shepherd and Naoki Yamasaki entitled 'Untangling the cortico-thalamo-cortical loop: Cellular pieces of a knotty circuit puzzle'. They had examined the patterns of connectivity between the major types of cortical and

*We are the cosmos made conscious and life is the means by which the universe understands itself--**Brain Cox***

thalamic neurons and how these cortico-thalamo-cortical loops relate to cortico-cortical circuits. Consciousness is thought to involve feed forward and feedback interactions between cortical layers and areas. *As the central lateral thalamus is connected to both superficial and deep cortical layers, it is well-positioned to modulate consciousness.*

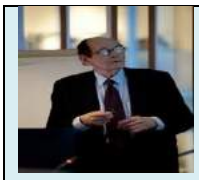
According to an article published in the Scientific American (June1 2018 issue), almost all conscious experiences have their origin in the posterior cortex of the brain (see illustration below). Neuroscientist Christof Koch, through a process of elimination concluded that parts of the brain such as the spinal cord, the cerebellum, and most, if not all of pre-frontal cortex, although enable consciousness, cannot be considered as the seat of consciousness. The 'unconscious homunculus' is responsible for creativity, intelligence and planning, much of which is unconscious. Studies on patients have revealed that a broad zone in the temporo-parietal-occipital region of the posterior cerebral cortex, in the back, is the 'red zone'. According to him "losing chunks of posterior cortex causes mind blindness". He is of view that what matters for consciousness is not so much the individual neurons, but the way they are wired together. His estimates show that the fraction of neurons involved are a few percent or less of the brain's 86 billion neurons.



***Credit*: Mesa Schumacher**

No problem can be solved from the same level of consciousness that created it----- ***Albert Einstein***

Cognitive neuroscientist Stanislas Dehaene has identified (Ref: theconversation.com) what he calls four signatures of consciousness – specific aspects of brain activity he deems necessary for normal consciousness. He focuses on what's known as the "P3 wave" in the dorso-lateral cortex (the part of the brain behind the top of the forehead). This, according to him correlates most reliably with normal conscious states. He considers long-range synchronized electric fields between different parts of the brain as another key signature of consciousness.



Gerald Edelman, Nobel laureate, explored the hidden universe of the mind in his classic 'Wider than the Sky'. Although it was published in 2004, his observations and assumptions on consciousness are as valid today, as they were when first published.

He says that to understand consciousness, we must have a biological theory of consciousness and provide supporting evidence for that theory.

Some of his observations on what constitutes consciousness, and how and why it functions are listed below.

1.Neural basis of consciousness, not consciousness itself, can cause things happen

2. Consciousness emerges from the organization and operation of the brain. Properties of conscience can emerge from the properties of the brain.

3. Consciousness *is a process not a thing*

4. The process of consciousness is a dynamic accomplishment of distributed activities of populations of neurons in many different areas of the brain.

5. A given neuron may contribute to conscious activity at one moment and not the next.

6.Consciousness is unitary or integrated in normal individuals

Everything is energy, your thoughts begin it, your emotion amplifies it, and, your action increases the momentum-unknown

7.The unitary scene will change and differentiate according to outside stimuli or inner thoughts, to yet another scene

8.All past experience is engaged in forming the integrated awareness of this single moment called the "remembered present'

9.Humans are conscious of being conscious

10.There is a distinction between primary consciousness (possessed by both humans and other animals) and higher order consciousness (ability to be conscious of being conscious) that exists only in man and to a minimal degree in higher primates

11. In Rapid Eye movement (REM) sleep, dreams are conscious states, but for long periods of sleep there is no evidence of consciousness.

12.In normal conscious states individuals experience *qualia* (particular experience of property) which are higher order discriminations.

13.All conscious events involve a complex of qualia.

14.Consciousness allows integration of the present scene with the animal's past history of conscious experience, that has survival value

15.How does the brain work? The brain was not designed; it evolved. Individual brains evolve to fit their surroundings

16.Neural Darwinism relates to neuronal group selection

17.Programming for consciousness will never create a conscious computer. Consciousness cannot be computed: it must be built into the structure of the system.

Qualia & and the mind Qualia are experiences *such as the vision of color, the sound of music and various other emotions in our mind* that we have learned over a lifetime.

As mentioned we carry a model of the world in our brains, new experiences are added each day to that model. When we perceive our world, and these experiences

Consciousness—is the phenomenon whereby the universe's very existence is made known----***Roger Penrose***

become a part of the model within us. Edelman calls it higher order discriminations.

How do neural processes, which are physical processes give rise to qualia----those seemingly non-physical (phenomenal) manifestations? Some of the views are summarized below.

According to www. answerroot.com consciousness is one of the very important functions of the mind.

So, normally, when we are conscious, there are many mental processes going on in a dynamic state – some become dominant for some time and some become marginal or even disappear for some time. But, whether we are doing nothing in particular, or concentrating on something, there is one mental process that is always working when we are conscious. Mental process functions to ***be consciously aware of*** and ***consciously experiences*** the functions of other mental processes and of itself.

An article in Scientific American: June1 2018 issue mentions that conscious awareness is mental awareness of a quale, and a conscious experience is a mental experience of a quale; therefore, *consciousness is the composite of all mental awareness and experiences of qualia***.** Because we can be consciously aware of and experience, our consciousness itself is consciously experienceable.

Dr. Chirapat Ukachoke in the basic **Theory of the mind** (ref: www.mindtheory.net**)** proposed that the mind and its phenomena of qualia and consciousness are non-material entities, with information and information processing as their essence.

According to him *"--Some neural processes have neural signals that mean, in the neural language, phenomenal manifestations, when these signals are read in the neural system, they will be interpreted as phenomenal manifestations----------. This is how qualia and consciousness occur with all their phenomenal manifestations in the physical brain"* --.

Like the mind, qualia are non-material, *informational* entities, *not mechanical entities.*

phy.org too explains that qualia are *special kinds of neural-process signaling pattern.* 'Non-material phenomenal qualia are neural signaling patterns, which always exist intrinsically in material neural processes – no novel, non-material entities arise or emerge from

*The intuitive mind is a sacred gift and the rational mind is a faithful servant—**Einstein***

material neural processes to be qualia. This explains not only what is qualia but also how non-material phenomenal qualia can arise from material neural processes.'

Neural process without qualia occurring and a neural process that performs that same function with qualia have different information in the processes; they have different signaling patterns. Therefore, they have different physical effects on other neural processes.

From the physical properties of the mind and those of the brain it can be concluded that the mind and the brain always exist, and function together and never occur alone without the other. They are a unity with each being the intrinsic, equivalent, but different (non-material vs material) aspect of this unity. *The mind is the composite of the information-processing processes of the brain.*

The Mind in Yoga

Consciousness in human beings flows in 5 layers of the body to reach the Atman (or Self) according to Vedanta philosophy. These 5 layers are called *koshas* or sheaths in yogic tradition--- 1. Annamaya kosha: the physical sheath 2. Pranamaya kosha: the sheath of prana (the vital air) 3. Manomaya kosha: the sheath of mind 4. Vijnanamaya kosha: the sheath of intellect 5. Anandmaya kosha: the sheath of bliss. The Yoga path of Self-realization is one of progressively moving inward, through each of these layers.

*Our bodies are the quanta and our minds are the qualia---together they form a physical entity capable of interaction with many forms in the universe----**Rajiv Kurapati***

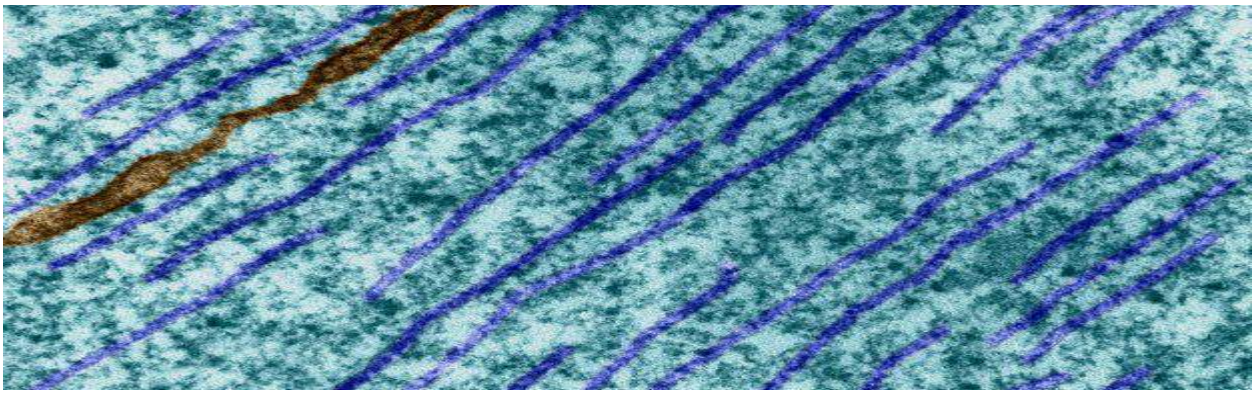
Quantum mechanics and consciousness Today some physicists think that quantum theory might be needed to fully understand how the brain works.

The quantum mind or quantum consciousness is a group of hypotheses proposing that classical physics cannot explain consciousness- pointed out a BBC news report dated 16-2-2017.

It proposes that quantum-mechanical phenomena, such as entanglement (a phenomenon observed at the quantum scale where entangled particles stay connected so that the actions performed on one of the particles affects the other, no matter the distance between two particles) and superposition (any two or more quantum states can be added together or 'superposed'), may play an important part in the brain's function and could explain consciousness.

Roger Penrose, well known scientist, in his famous book "Shadows of the Mind' forcefully put forward the argument that 'there is something in the conscious activity of the brain that transcends computation, and that it cannot be explained in terms of present-day science'.

He believes that quantum theory might be needed to fully understand how the brain works. He goes beyond neurons and examined cytoskeletons and micro-tubules, minute sub-structures lying deep within the neurons. Rather than the neurons, he considers those as the basic units of the brain. He argued that it is within them that the collective quantum effects necessary for the conscious states reside.



Microtubules inside a cell (Credit: Dennis Kunkel Microscopy/Science Photo Library)

The idea that quantum theory can be invoked to explain brain functions has always been met with skepticism.

*Consciousness poses the most baffling problems in the science of the mind. There is nothing that we know more intimately than the conscious experience, but there is nothing harder to explain----**David Charmers***

This is not surprising "as it does not sound wise to explain one mystery with another". Just as quantum objects can apparently be in two places at the same time, so can a quantum brain hold onto two mutually-exclusive ideas at the same time? Quantum effects such as superposition are easily destroyed, because of a process called *decoherence*, which is caused by the interactions of a quantum object with its surrounding environment.

Nerve signals are electrical pulses, caused by the passage of electrically-charged atoms across the walls of nerve cells. Physicist Max Tegmark calculated the quantum superpositions of the molecules involved in neural signaling. If one of these atoms was in a superposition and then collided with a neuron, Tegmark showed that the superposition should decay in less than one billion billionth of a second. It takes at least ten thousand trillion times as long for a neuron to discharge a signal. As a result, ideas about quantum effects in the brain are viewed with great skepticism.

Evolution & the brain Some neuro-scientists point out that qualia and conscious awareness and conscious experiences of the qualia occur in only in the latest-evolved neural processes, and never occur in the more primitive neural processes, such as in the brainstem, cerebellum, and basal ganglia, or over the whole brain scattered. This shows that they do not occur randomly, but are evolved.

The fact that qualia and consciousness still exist today indicates that they have been selected to remain in the evolutionary process and help increase the survival chance of the species that have them. This is the scientific explanation as to why consciousness exists in this universe.

Neural Darwinism

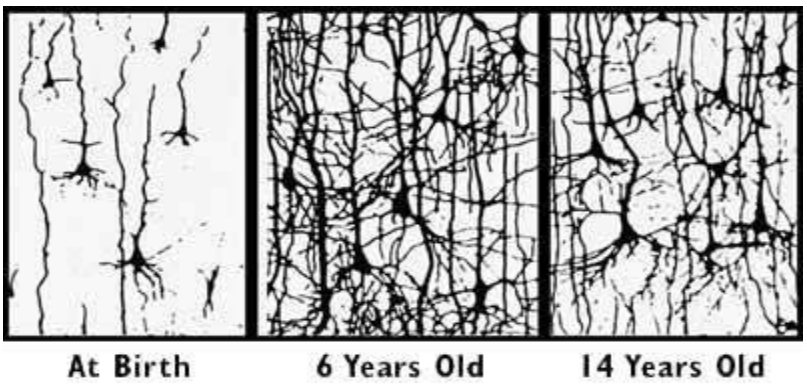
Although evolution is not intelligent, it is powerful. The power comes from natural selection.

Gerald Edelman postulated the theory of Neural Darwinism in 1987 - *the idea that individual brains evolve to fit their surroundings, growing stronger in the areas most needed.* Said he *"I hold the notion to be central, not only in considering how the brain evolved, but also in thinking about how it develops and functions".*

According to this theory, selective forces, both of development and experience, operate on neuronal groups rather than on single neurons (Ref. thebrain.mcgill.ca).

Consciousness is not a special type of computation—it is not a clever hack---***Christof Koch***

Highly complex mapping of the brain occurs through a selective process. First, an individual's genome generates varied neural networks. Then, from this primary neuronal repertoire that is defined by



Synaptic Density in the Human Brain

the genome (and distinct for each species), certain networks of neurons are selected that respond especially well to external stimuli that are important for the organism.

In this model, *there is no central supervisor that imposes coherence on our perceptions.* Instead, various maps are simply excited at the same time, activating millions of neurons in parallel, which in turn activate other maps that comprise millions of neurons as well.

And it is through this process of "re-entry" that perceptions, motor behaviors, conceptual thought, and even consciousness itself come into being (Re-entry is the basic mechanism of re-categorisation, the fundamental process by which the brain carves up the world into different things and recognises those it has encountered before).

According to www.consciousentities.com/edelman.htm re-entrant connections between neuronal groups in different parts of the brain co-ordinate impressions from the different senses to provide a coherent, consistent, continuous experience.

The neural correlates of consciousness (NCC)___Francis Crick (1916 – 2004),

along with James Watson, and Rosalind Franklin played a crucial role in deciphering the double- helical structure of DNA. His later research centered on

Consciousness does not just passively reflect the objective world; it plays an active role in creating reality---***Stanislav Grof***

theoretical neurobiology and attempts to advance the scientific study of human consciousness.

Christof Koch (born November 13, 1956) is a German-American neuroscientist is the president and chief scientist of the Allen Institute for Brain Science in Seattle. From 1986 until 2013, he was a professor at the California Institute of Technology. Koch collaborated with Francis Crick, for over eighteen years and initiated the modern search for the neuronal correlates of consciousness. His latest book, *The Feeling of Life Itself – Why Consciousness is Everywhere But Can't be Computed,* was published by MIT Press in 2019. In this book he has explained the Integrated Information Theory or ITT (See Box)

Integrated Information Theory (ITT)---Chief Postulates

1. Consciousness is defined as any subjective experience, from the most mundane to the most exalted-the feeling of being alive.
2. Consciousness is a fundamental property of any mechanism that has cause-effect power upon itself
3. Any experience exists for itself, is structured, is the specific way it is, is one (whole) and is definite
4. Consciousness exists intrinsically for itself, without any observer
5. For it to exist intrinsically, any set of physical elements must specify a set of 'difference that makes a difference' to the set itself
6. Any experience is structured, and it must be reflected in the mechanism that compose the system, specifying the experience.
7. In its current state it generates information to the extent that it specifies the state of a system that can be its possible cause in the past and its effect in the future
8. Any conscious experience is unified and holistic.
9. The system is irreducible-it cannot be reduced to two or more components, without losing something in that process.
10. Any experience is identical to the maximally irreducible cause effect structure associated with the system in that state
11. Experience is identical to that structure, not to its physical substrate.

Posterior cortex has a grid like connectivity of neurons, compared to a more random- access connectivity for the frontal areas of the cortex. One can visualize how the neurons/ neural net -works function, how some of them fire together and pass on information from one to the other, based on the above postulates.

The theory also predicts that many, and perhaps all, animals experience the sights and sounds of life. Koch argues that programmable computers will not have consciousness and even a perfect software mode of the brain is not conscious.(From the book "The Feeling of Life Itself" by Christof Kosh)

It is hard to see how one could begin to develop a quantum-theoretical description of brain action when one might well have to regard the brain as "observing itself" all the time! ***----Roger Penrose***

Panpsychism According to an article on **Panpsychism** published in Scientific American dated January 14, 2020**,** *consciousness pervades the universe and is a fundamental feature of it*.

The Panpsychist believe that physical science actually tells us absolutely nothing about *the intrinsic nature* of matter, whereas, consciousness, is the intrinsic nature of matter, although, nothing supernatural or spiritual.

"Physical science describes matter "from the outside," in terms of its behavior. But matter "from the inside"—i.e., in terms of its intrinsic nature—is constituted of forms of consciousness. We know that consciousness exists not from observation and experiment, but by being conscious. We, therefore, need both the science and the philosophy to get a theory of consciousness".

Conscious experience in non-human animals

According to Boris Kotchoubey (Ref: Frontiers in Psychology www.frontiersin.org dated 23-4-2018), human consciousness emerges on the interface between three components of animal behavior: communication, play, and the use of tools.

All three do not exclusively distinguish our close relatives, i.e., primates, but are broadly presented among various species of mammals, birds, and even cephalopods; however, their particular combination in humans is unique. The interaction between communication and play yields symbolic games, most importantly language.

When the three components meet in humans, they strengthen and mutually reinforce each other producing positive feedback loop. Therefore, although all three elements of human consciousness are present in many animal species (not necessarily human predecessors), there is no other species that plays, communicates and uses tools as much as humans do.

A team of Yale researchers (Ref: *Proceedings of the National Academy of Science* March 29) make the case that one non-human species—the rhesus macaque—also has a conscious awareness of the world around it. Some have claimed that "Our study shows that crows can be taught to control their vocalizations, just like primates can, and that their vocalizations are not just a reflexive response".

> *The total number of minds in the universe is one. In fact, consciousness is a singularity phasing within all beings—**Erwin Shrodinger***

Interestingly, the 2012 **Cambridge Declaration on Animal Consciousness** indicates that many scientists agree that "the weight of evidence indicates that

Do Plants have consciousness?

Some researchers argue that every living cell, both in plants and animals, are conscious; plants sense and adapt to changes in the environment; their membrane potentials and electrical signals are similar to those in animals; they too have a command center in the roots like the brain in animals, and that plants communicate with each other. The number of claims about presence of consciousness in plants have increased in recent years, and these have received wide publicity.

According to an article published in *Protoplasma*. 2021; 258(3): 459–476 and reported by www.ncbi.nlm.nih.gov such claims are misleading and have the potential to misdirect funding and governmental policy decisions.

The studies cited show that (1) plants have not been shown to perform the proactive, anticipatory behaviors associated with consciousness, but only to sense and follow stimulus trails reactively; (2) electro-physiological signaling in plants serves immediate physiological functions rather than integrative-information processing as in nervous systems of animals, giving no indication of plant consciousness; (3) the controversial claim of classical Pavlovian learning in plants, even if correct, is irrelevant because this type of learning does not require consciousness.

According to the researchers, 'consciousness is marked by an advanced capacity for operant learning about rewards and punishments and that image-based conscious experience is marked by demonstrably mapped representations of the external environment within the body. Certain animals fit both of these criteria, but plants fit neither'. The study concludes that claims on plant consciousness are highly speculative and lack sound scientific support.

Whether we agree with their views or not, it is clear that more research is needed in this area.

humans are not unique in possessing the neurological substrates that generate consciousness." It was signed at the Francis Crick Memorial Conference of Consciousness in Human and Non-Human Animals in the presence of Stephen

A debate over plant consciousness is forcing us to confront the limitations of the human mind—apple. News

Hawking in July, 2012 in Cambridge, U.K. by an international group of scientists including cognitive neuroscientists, neuro-pharmacologists, neurophysiologists, neuroanatomists and computational neuroscientists. The Declaration treats it as the same as the phrase, "subjective experience'.

It is clear that more studies are required to understand the nature of consciousness in other animals.

Measuring consciousness

How do we measure consciousness? Now, researchers have come up with an approach that uses the brain's response to magnetic stimulation to judge a person's awareness, reducing it to a numerical score they call *an index of consciousness.* Most of these approaches define a conscious brain as an integrated brain, where groups of cells in many different regions activate to form a cohesive pattern,

The brains of people in vegetative, partially conscious, or fully conscious states have differing profiles of activity as revealed by functional magnetic resonance imaging (fMRI), according to a report today (February 6, 2019) in *Science Advances*.

The results of the study indicate that, compared with patients lacking consciousness, the brains of healthy individuals exhibit highly dynamic and complex connectivity.

After computationally analyzing data from the fMRI scans, which generated roughly 400 images in approximately 20 minutes for each patient, four patterns were detected. For two of these patterns, the likelihood of their occurrence in a given individual's scan depended on diagnosis (ref: www.the- scientist.com). Healthy individuals, for example, were more likely than patients to display pattern 1—characterized by high spatial complexity and interregional connectivity indicating brain-wide coordination. Patients with UWS rarely displayed pattern 1, most often displaying pattern 4—characterized by low complexity and reduced interregional connectivity. The occurrence of patterns 2 and 3 were equally likely across all groups.

Marcello Massimini, a neurophysiologist at the University of Milan in Italy and his colleagues have tried to measure the brain's response with the aid of the Perturbational Complexity Index (PCI), which was reported in *Science Translational Medicine*.

My fundamental premise about the brain is that its workings-what we sometimes call 'mind'—are a consequence of its anatomy and physiology and nothing more—***Carl Sagan***

PCI looks at the brain's response to transcranial magnetic stimulation (TMS), where a magnetic coil is held up to the surface of the skull, generating a pulse to stimulate the neurons beneath and provoke a response that radiates through the brain. Thereafter, they turn that data into a numerical score between 0 and 1.

Those who were believed to be in a vegetative state (awake but completely unconscious), got very low scores (between 0.19 to 0.31). Subjects who had emerged from a coma had varying degrees of awareness and intermediate scores. Two of the patients had a condition known as locked-in syndrome: their cognitive abilities were normal, but they were unable to move. They received PCI scores of 0.51 and 0.62—as high as the waking, healthy subjects. The team claimed that without requiring any active participation from subjects, this index can reliably place them on a continuum between conscious and unconscious.

The way forward

In this article we have discussed only some of the emerging views on consciousness. Possibly, by the turn of the next century, or even earlier, scientists after conducting more studies into neuronal behavior, may be in a position to unravel the mystery of consciousness, both in sentient and non-sentient beings.

Ref: www.inverse.com; Sci.American;www.answerroot.com;www.mindtheory.net;www.nature.com;phys.org;www.sciencemag.org*; thebrain.mcgill.ca;* www.consciousentities.com/edelman.htm

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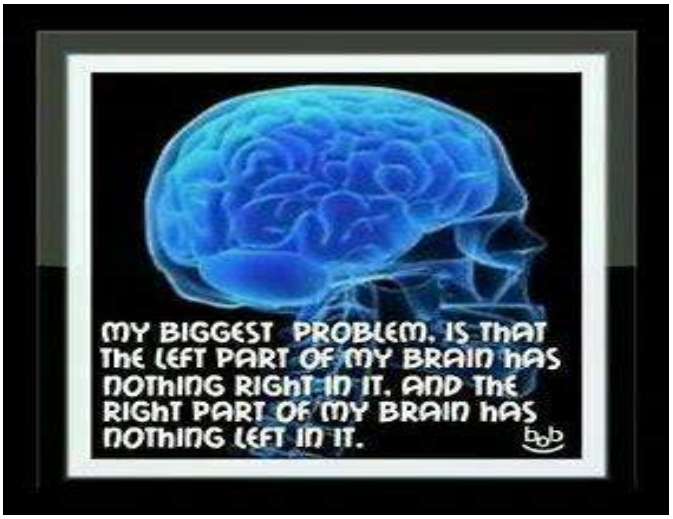


The task of science is to stake out the limits of the knowable, and to center consciousness within them—***Rudolf Virchow***

ECONOMICS: NEUROECONOMICS

Economists have been concerned about human behavior, as it provides a better understanding of human nature and behavior, while making economic decisions. As research into decision-making behavior has become more computational, economists have started paying attention to the scientific basis for human behavior.

The experimental approach to behavioral economics is a relatively recent innovation. As more and more information about the structure of the brain and behavior of neurons is being made available with the help of cutting-edge technology, economists have, in recent years, started linking human behavior with neural behavior. The efforts have led to the development of a new discipline called neuroeconomics.

In this article we discuss what is neuroeconomics, how it works, what are the tools used, what are its pros and cons and what are its future prospects.

Neuroeconomics According to Wikipedia neuro-economics is an emerging discipline that combines neuroscience, economics, and psychology; and uses research methods from cognitive neuroscience and experimental economics. "It is the application of neuroscientific methods to analyze and understand economically relevant behavior such as evaluating decisions, categorizing risks and rewards, and interactions among economic agents".

Neuroeconomics studies decision making 'by using a combination of tools from these fields so as to avoid the shortcomings that arise from a single-perspective approach'. It also incorporates new approaches from theoretical biology, computer science, and mathematics.

Behavioral economics and neuroscience evolved independently until the early 2000s, when research in each field began to include methods and results from the other. Eventually, this led to the emergence of neuroeconomics (www.weareworldquant).

How it works The new field of neuroeconomics looks at how economic decision-making actually happens inside the brain**.** In neuroeconomic research fMRI is used, firstly, to measure brain activity in the human brain at the time when economic

*Genetics is crude, but neuroscience goes directly to work on the brain and the mind follows-**Leon Kass***

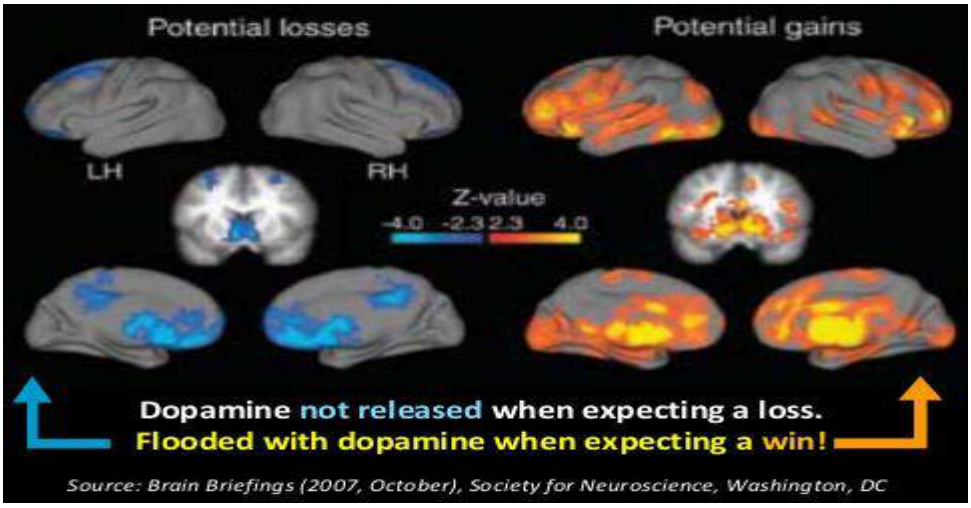
choices are made. Secondly, it tries to find out what motivates people to take a certain set of decisions by observing closely neurons at multiple levels of processing pathways. Thirdly, neuroeconomics draws on behavioral economics to consider psychological variables into economic and decision-making models.

'The foundations of economic theory were constructed assuming that details about the functioning of the brain's black box would not be known…. [But now] the study of the brain and nervous system is beginning to allow direct measurement of thoughts and feelings."

Why neuroeconomics?

1. Traditional *economic* theory assumes that human beings behave rationally- that they understand their own preferences, make perfectly consistent choices over time, and try to maximize their own well-being. Humans do not always work in the ways that economic theory would predict.
2. In mainstream economics, expected utility (EU) and the concept of rational agents are still being used to assess economic behavior. But economists view that economic behaviors are not fully explained by these concepts.
3. Economic models that accounted for the subtleties of the human brain, might be able to predict complex behaviors more accurately.
4. By determining which brain areas are active in which types of decision processes, neuro-economists hope to better understand the nature of sub-optimal and illogical decisions.
5. It can theoretically link the brain (the physical organ) with the mind (the human consciousness that thinks, feels, acts, and perceives) through an advanced computer to analyze these connections.
6. Using tools from various fields, neuroeconomics works toward an integrated account of economic decision making
7. Neuroeconomic research has been able to provide more insight into some behavior that could not be adequately explained by other methods
8. Neuroeconomics provides insight into why humans might not act to optimize utility and avoid financial difficulty. Typically, emotions profoundly influence individuals' decision-making.
9. Neuroeconomics is useful to business because it explores the brain processes that underlie decision-making. For example, why consumers prefer one product over another is particularly relevant for a business to understand.

The economic approach provides a valuable unified framework for understanding all human behavior--- ***Gary Becker***



Gambling and Dopamine- Understanding gambling, addiction-

How the field developed

The idea that understanding the brain can aid economics is not new; for over two decades behavioral economists have argued that psychology could be useful in economics. What is new is the use of technology: The functional magnetic resonance imaging (fMRI), has been in usage since the late 1980s; but only in the past few years has it been used to study economic decision-making.

Despite the early criticisms, neuroeconomics grew rapidly from its inception in the late 1990s through to the 2000s and later. According to Wikipedia a critical point in 2008 was reached when the first edition of the book 'Neuroeconomics: Decision Making and the Brain' edited by Paul W Glimcher and Ernst Fehr was published in 2013. The success of this publication sharply increased the visibility of Neuroeconomics and helped affirm its place in economic teachings worldwide.

The website scholarpedia.org noted that in 1998 less than 20 papers a year were published that included both 'brain' and 'decision-making' as keywords. In 2008 nearly 200 articles bearing those keywords have been published. Today, a number of centers for the study of neuroeconomics have emerged at universities throughout the world.

Tools The most common techniques used are related to brain imaging. Region-specific brain activity can be analyzed by measuring electrical activity in the brain by a technique using electroencephalogram (EEG) or by measuring blood flow using positron emission tomography (PET), or by measuring blood

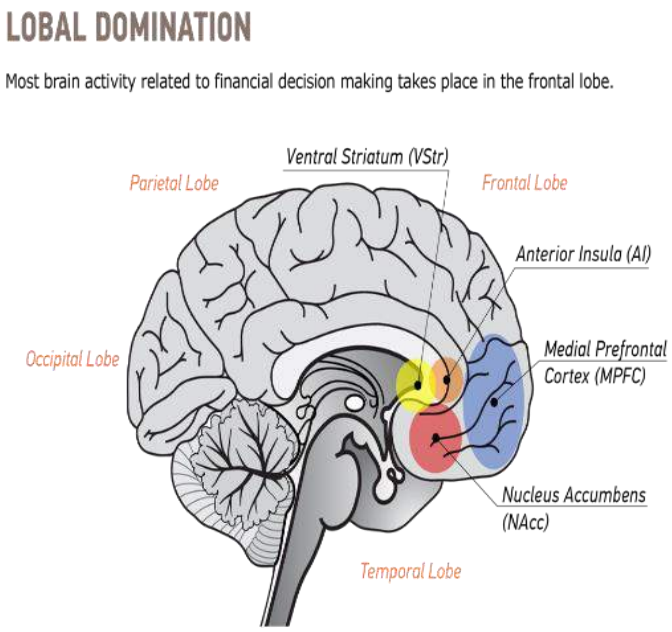
Behavior drives people-People drive business----Relatably.com

oxygenation through functional magnetic resonance imaging (fMRI). Spatial resolution in EEG is so poor that its use is limited.

Using these techniques, researchers have been able to identify and separate the layers in the brain that are responsible for specific tasks. Apart from these, researchers analyze humans with damaged brains and determine how their performance differs from that of persons with normal brains. "This evidence implies that the once-abstract term of "utility" has become an exact, quantifiable measure".

While most of these scientists are using human subjects in this research, others are using animal models where studies can be more tightly controlled and the assumptions of the economic model can be tested directly.

Brain areas The prefrontal cortex is generally involved in all reasoning and understanding, so it may be involved in determining the best course of action, when not all relevant information is available.



(Ref: weareworldquant.com)

The insular cortex is active in situations that involve known risks rather than ambiguity. In addition to the importance of specific brain areas to the decision-making process, there is also evidence that the neurotransmitter dopamine may also have a role to play. Dopaminergic

*The emotional brain responds to an event more quickly than the thinking brain---**Daniel Goleman***

neurons are strongly involved in the reward process and become highly active after an unexpected reward occurs.

Leaders in the field of Neuroeconomics

George Loewenstein (born August 9, 1955) is an American educator and economist. He is the Herbert A. Simon Professor of Economics and Psychology in the Social and Decision Sciences Department at Carnegie Mellon University and director of the Center for Behavioral Decision Research. He is a leader in the fields of behavioral economics (which he is also credited with co-founding) and neuroeconomics.

Ernst Fehr (born 21 June 1956 in Hard, Austria) is an Austrian-Swiss behavioral economist and neuro-economist and a Professor of Microeconomics and Experimental Economic Research, as well as the vice chairman of the Department of Economics at the University of Zürich, Switzerland.

Vernon Lomax Smith (born January 1, 1927) is an American economist and professor of business economics and law at Chapman University. Smith shared the 2002 Nobel Memorial Prize in Economic Sciences with Daniel Kahneman for his contributions to Behavioral Economics and his work in the field of experimental economics (Ref: en.wikipedia.org)

Challenges Application of neuroscience in business is not without challenges. Some of the skepticism expressed are listed below.

Of primary concern for business researchers in developing countries is the access to EEG and fMRI, since they are usually in the domain of neuroscientists from the medical faculty.

*We are not going to falsify all of traditional economics, but we are going to point to a whole range of biological variables that traditionally have not been included in the analysis. In economics this is a big change---**Colin Camerer, Caltech***

One strategy to overcome this dilemma is to use interdisciplinary research teams.

1. The design of experiments required by these projects, especially in the interpretation of data of the neuro-images, requires expertise which business researchers do not usually have.
2. The use of neuroscientific methods involving human subjects raises strict ethical issues to which business researchers are unaccustomed.
3. Some economists feel that the methodology of neuro-economics answers irrelevant questions, in that it ‘concentrates on what provides the most hedonic satisfaction to experimental subjects, rather than what economic outcome those subjects choose out of multiple options.
4. Criticisms have been voiced over the field's validity and usefulness. Some say that much of the neuroscience-assisted insights into economic modelling is "academic marketing hype".
5. Others point out that methodologically, many of the studies in neuroeconomics are flawed by their small sample sizes and limited applicability.
6. Traditional economists caution against the neuroeconomic approach that the use of non-choice data, such as response times, eye-tracking and neural signals that people generate during decision making. They say that those should be excluded from any economic analysis.
7. Other critiques have also included claims that neuroeconomics is "a field that oversells itself"; or that neuroeconomic studies "misunderstand and underestimate traditional economic models".
8. Neuroeconomics findings tend to confirm that emotions are an important factor in many economic choices. But thoughts and feelings are subjective.
9. Imaging studies point out only correlations between brain activity and behavior. One must be careful in drawing neuroscientific conclusions and making economic predictions.
10. Because their field is so young, and because they are pursuing different goals, economists and neuroscientists working in neuroeconomics sometimes seem to be talking about different things.

Forty years ago, it (economics) was mainly about large-scale phenomena, like inflation and unemployment. More recently, there has been a lot of focus on individual decision-making. I think the time has come to go beyond the individual and look at the inputs to individual decision- making. That is what we do in neuroeconomics—***David Laibson*** *(Harvard)*

11. In a similar vein, neuroscientists and psychologists have at times equated economic utility – the subjective value of a good or service – with the notions of reward and pleasure. These ideas may be related, but they are certainly not interchangeable.
12. Neuroeconomics is subject to the criticisms that plague psychology: that its experiments show what is already intuitively obvious, and its models are descriptive, not quantitative.
13. Questions about privacy and individual autonomy have also been raised. "As corporations learn to take further advantage of our weaknesses, we may soon be asking for government to take on the role of protector and guarantor of our privacy, happiness, and savings."

The Way Forward

Modern economists consider Neuroeconomics to be a promising step towards a more unified theory of human behavior. Scientists may provide answers to some of the questions debated by philosophers for centuries- Why do we make the choices we make? And why is it so hard to figure out what we really want?

We have seen that some economists question the very validity of neuro-scientific approach in economics. Currently, the applications and predictions of neuroeconomics are still largely unknown or under-developed. Only time can settle the basic questions raised about its utility. However, there is no doubt that more research in this field will help us at least in understanding how the brain works at neuronal level

Ref: www.ncbi.nlm.nih.gov; Malays J Med Sci. 2010 Apr-Jun; scholarpedia.org; insights.som.yale.edu; www.technologyrevie.com; en.wikipedia.org

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*Digital Darwinism is the evolution of consumer behavior when society and technology evolve faster than some company's ability to adopt—**Brian Solis***

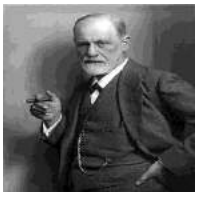
PERSONALITIES: EXPLORERS OF THE BRAIN & THE MIND

In this article we have included the names of some of the Neuroscientists who have contributed to our understanding of the brain and the mind. We have divided them into three categories---first, those who interpreted the human mind through psychoanalysis or psychological studies; the second, some of the Nobel Prize winners in the area of neuroscience, who studied the brains minutely and revealed how it works at micro level, and, thirdly, popular writers who enriched our knowledge of neuroscience by their fascinating accounts of the human brain and conscious experience.

1. In Search of the human mind

At a time when very little was known about the structure and functions of the human brain, it was left to some of the great minds of the last century to interpret the human mind and analyze human behavior through the methods of psychoanalysis and analytical psychology. Prominent among them were Sigmund Freud and Carl Jung, both medical men from Austria. Their theories today may not stand up to the rigors of scientific method, nevertheless, they have profoundly influenced our way of thinking for a very long time, and left their imprints in various fields, including science, education, culture and language. Their contributions are briefly mentioned here.

(1) Sigmund Freud



Sigmund Freud (1856-1939), the founding father of psychoanalysis, was a physiologist, medical doctor, psychologist and influential thinker of the early twentieth century.

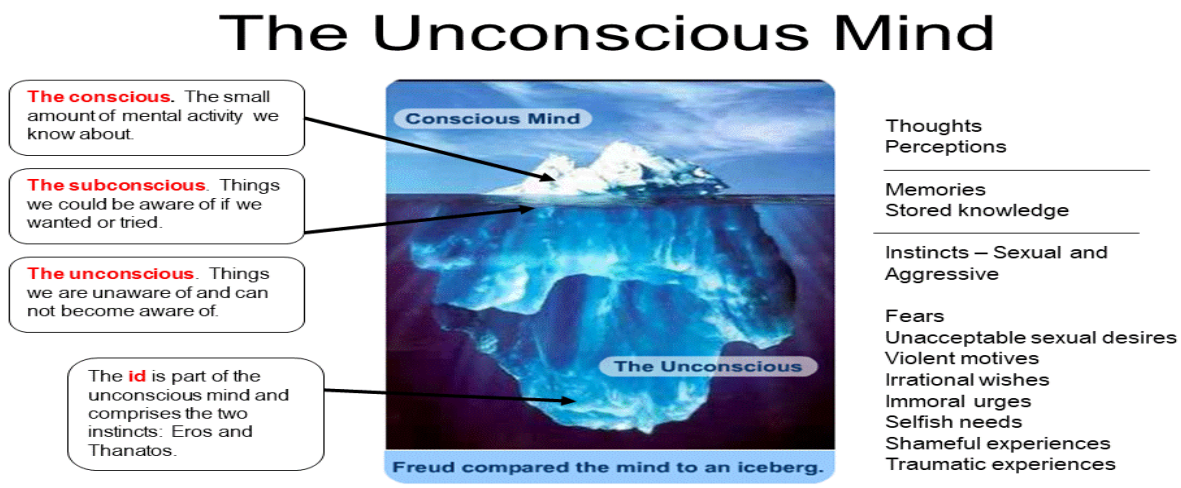
Freud was born in Freiberg, in Austria . He qualified as a doctor of medicine in 1881 at the University of Vienna. He became an affiliated professor in 1902. Freud lived and worked in Vienna. He set up his clinical practice there in 1886. In 1938, Freud left Austria to escape Nazi persecution. He died in exile in the United Kingdom in 1939.

> *Unexpressed emotions will never die. They are buried alive and will come forth in uglier ways----**Sigmund Freud***

Psychoanalysis is a clinical method for treating mental illnesses through dialogue between a patient and a psychoanalyst.

Freud believed that events in our childhood have a great influence in shaping our personalities, later in life. In *Studies in Hysteria* (1895) Freud proposed that physical symptoms are often the surface manifestations of deeply repressed conflicts. According to him the unconscious mind governs human behavior to a greater degree than generally believed. Therefore, 'the goal of psychoanalysis is *to make the unconscious conscious'.*

Freud, later, developed a structural model of the mind comprising the id, ego, and superego, entities which form the three essential parts of the human personality.



Credit: www.simplypsychology.org;

The id operated at an unconscious level according to the pleasure principle (gratification from satisfying basic instincts).

It comprises two basic instincts (or drives) which Freud called Eros and Thanatos.

Eros, or life instinct, helps the individual to survive; it directs life-sustaining activities. The energy created by the life instincts is known as libido. In contrast, Thanatos or death instinct, is viewed as a set of destructive forces present in all human beings. It is expressed as aggression and violence. Freud believed that 'Eros is stronger than Thanatos, thus enabling people to survive rather than self-destruct'. The ego develops from the id during infancy. The ego tries to satisfy the demands of the id. The **superego** develops during early childhood. 'It operates on the morality principle and motivates people to behave in a socially responsible and acceptable manner'.

The mind is like an iceberg, it floats with one seventh of its bulk above water---***Sigmund Freud***

Karl Popper (1963) the great scientist and philosopher stated that in order for a theory to be scientific, it needs to be falsifiable. He did not consider Freud's psychoanalysis theory to be falsifiable. Freud's theory is good at explaining, but not at predicting behavior, which is one of the goals of science. For this reason, Freud's theory is unfalsifiable - it can neither be proved true or refuted.

While many of his ideas and theories were not widely accepted by modern psychologists, he played a major role in the development of psychology. "Freud's universal and comprehensive theory of the mind probably will outlive the psycho-analytical therapy, and seems already to have placed him with greatest thinkers Charles Darwin and William Shakespeare -----".

(11) Karl Gustav Jung (1875 –1961), was a Swiss psychiatrist and psychoanalyst who founded analytical psychology. Jung's work has been influential in the fields of psychiatry, anthropology, archaeology, literature, philosophy, psychology and religious studies. Early in his career, Jung came to be associated with Sigmund Freud.

Jung's research and personal vision, however, differed from that of Freud which led him to establish analytical psychology as a comprehensive system, separate from psychoanalysis.

Among the central concepts of analytical psychology is individuation—the lifelong psychological process of differentiation of the self out of each individual's conscious and unconscious elements. Jung considered it to be the main task of human development. He created some of the psychological concepts like 'synchronicity, archetypal phenomena, the collective unconscious, the psychological complex and extraversion and introversion'.

Jung was also an artist, craftsman, builder and a prolific writer. He died on 6 June 1961 at Küsnacht after a short illness.

The collective unconscious contains the whole spiritual heritage of mankind's evolution, born a new brain structure of every individual—***Carl Jung***

11 NOBEL PRIZE WINNERS

According to Nobel Foundation, no less than 17 Nobel Prizes have been awarded in the area of neuroscience so far, with no less than 40 laureates so far. Readers may be surprised to note that four of the awardees are women. The first prize was given to Camillo Golgi and Ramón y CaJal in 1906 and the last one, to John 0'Keefe and May-Britt and Edvard I. Moser in 2014.

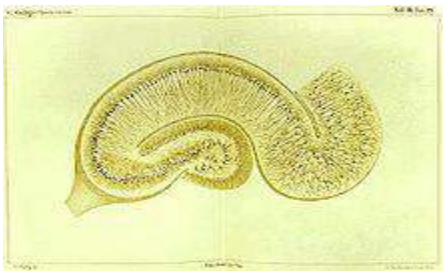
(A) 1906 - Camillo Golgi and Santiago Ramón y CaJal -in recognition for their work on the structure of the nervous system

Camillo Golgi was an Italian physician, biologist and pathologist who is considered to be the greatest neuroscientist of the nineteenth century. Several anatomical and physiological phenomena are named after him.

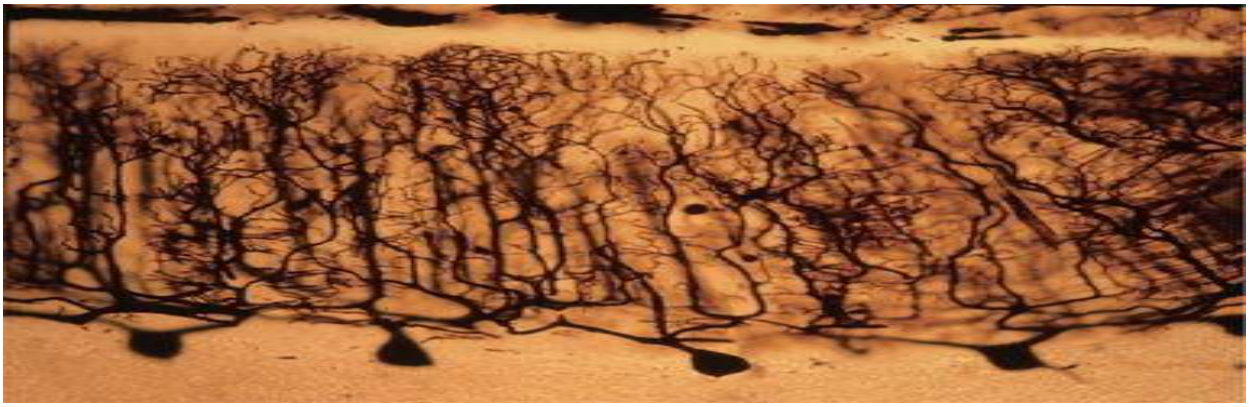
Golgi, with the aid of basic facilities, developed the silver nitrate method of studying nerve tissues. He introduced a revolutionary method of staining individual nerve cell structures called "the black reaction". In this method Silver nitrate selectively stains only a few cells (1%-5%), black, and completely spares other cells, allowing individual cells to stand out from the background, making it easy to study and analyze them. This helped in the discovery of a nerve cell that has many dendrites or nerve extensions.

This discovery supported the experiments that went on to establish the nerve cells as the rudimentary structural unit of the entire nervous system. This was a turning point in the advancement of modern neuroscience. Later, his experiments led to the discovery of the 'Golgi tendon spindle' or 'Golgi tendon organ' and the 'Golgi complex' or 'Golgi apparatus He also made extensive studies on cerebellum, hippocampus and the spinal cord, and made several important observations.

*I have never had reason, up to now, to give up the concept which I have always stressed, that nerve cells, instead of working individually, act together, so that we must think that several groups of elements exercise a cumulative effect on the peripheral organs through whole bundles of fibers-**Camillo Golgi***



Drawing by Camillo Golgi of a hippocampus stained with the silver nitrate method.



A slide showing sections from human cerebellum- (Reproduced from photo by prof. Lars 0lson)

Ramón y Cajal (1852 – 1934) was a Spanish neuroscientist, pathologist, and histologist specializing in neuroanatomy and the central nervous system. His original investigations of the microscopic structure of the brain made him a pioneer of modern neuroscience. Cajal was the first person of Spanish origin to win a scientific Nobel Prize.

Ramón y Cajal made several major contributions to neuroanatomy. He demonstrated experimentally that the relationship between nerve cells was not *continuous*, or a single system, but rather *contiguous*. This provided definitive

Like the entomologist in search of colorful butterflies, my attention has chased the gardens of grey matter cells with delicate and elegant shapes, the mysterious butterflies of the soul, whose beatings of wings may one day reveal to us the secrets of the mind ------***Santiago Ramon y Cajal***

evidence for the "neuron theory", now widely considered the foundation of modern neuroscience. *Cajal received the Nobel Prize for Physiology or Medicine for establishing the neuron, or nerve cell, as the basic unit of nervous structure.* This finding was instrumental in the recognition of the neuron's fundamental role in nervous function and in gaining a modern understanding of the nerve impulse.

Neurons – the atoms of perception, memory, behavior and consciousness – their diverse shapes, electrical behaviors, and their computational function can be noted within the mammalian brain, in particular in neocortex.

He famously stated that "The ability of neurons to grow in an adult and their power to create new connections can explain learning." This statement is considered to be the origin of the synaptic theory of memory. He was an advocate of the existence of dendritic spines, although he did not recognize them as the site of contact from pre-synaptic cells. He was a proponent of polarization of nerve cell function.

Hundreds of his drawings of brain cells are still in use, since the mid-20th century, for educational and training purposes (For details please refer to the Art & Architecture Section in this issue of Life Stream).

Interestingly, the issue under consideration at that time was "whether the nervous system represents a single whole or consists of connected nerve cells". Golgi, advocated the "reticular theory" or the nerve- net theory. His strongest opponent on this was Cajal, who already in the late 1800s advocated the neuron theory. But in the end Cajal's views prevailed. Almost all scientists studying the nervous system accepted the neuron theory as a doctrine.

(B) Women Nobel Prize Winners

Physiology or Medicine 1977

(B-1) Rosalyn Sussman Yalow (1921 – 2011) was an American medical physicist, and a co-winner of the 1977 Nobel Prize in Physiology or Medicine (together with Roger Guillemin and Andrew Schally) for development of the radio-immunoassay technique.

*A science of mind must reduce complexities (of behavior) to their elements. A science of the brain must point out the functions of its elements. A science of the relations of the mind and brain must show how the elementary ingredients of the former corresponds to the elementary functions of the latter---**William James***

She was the second woman (after Gerty Cori in 1947), and the first American-born woman, to be awarded the Nobel Prize in Physiology or Medicine.

Rosalyn Yalow together with her late co-worker, Solomon Berson, described in a series of papers between 1956 -1960 the radio-immunological assay method (or RIA) in detail. This brought about a revolution in biological and medical research. In addition, she and her co-workers, with the aid of RIA, were able to elucidate the physiology of the peptide hormones insulin, ACTH, growth hormone, and also to throw light upon the pathogenesis of diseases caused by abnormal secretion of these hormones. This was pioneering work at the highest level. It had an enormous impact. Ref: en.wikipedia.org

(B-2) Physiology or Medicine 1986

Rita Levi-Montalcini OMRI OMCA was an Italian Nobel laureate, honored for her work in neurobiology. She was awarded the 1986 Nobel Prize in Physiology or Medicine jointly with colleague Stanley Cohen for the discovery of nerve growth factor (NGF).
While investigating how the nervous system grows and develops, Rita Levi-Montalcini found that transplanting mouse tumors into chick embryos induced an enormous outgrowth of nerves. Levi-Montalcini's proposition that the tumor was somehow releasing a growth-promoting substance for nerves was against the generally accepted view. Further investigations, however, showed that this, so-called nerve growth factor, or NGF, is released by many types of cells looking for new nerve connections.

*Neuroscience over the next 50 years is going to introduce things that are mind-blowing---**David Eagleman***

(B-3) Physiology and Medicine 2004

Linda Brown Buck (born January 29, 1947) is an American biologist best known for her work on the olfactory system. She was awarded the 2004 Nobel Prize in Physiology or Medicine, along with Richard Axel, for their work on “olfactory receptors and the organization of the olfactory system". She is currently on the faculty of the Fred Hutchinson Cancer Research Center in Seattle. (en.wikipedia.org)

(B-4) Physiology and Medicine 2014

May-Britt Moser (born 4 January 1963) is a Norwegian psychologist and neuroscientist, who is a Professor of Psychology and Neuroscience at the Norwegian University of Science and Technology (NTNU). She and her then-husband, Edvard Moser, shared half of the 2014 Nobel Prize in Physiology or Medicine, awarded for work "for their discoveries of cells that constitute a positioning system in the brain" by the grid cells in the entorhinal cortex, as well as several additional space-representing cell types in the same circuit (Ref; en.wikipedia.org)

(111) NEUROSCIENCE WRITERS

It may be indeed difficult for many to believe that there are many eminent personalities in neuroscience and allied disciplines who could also write well. **Sigmund Freud,** apart from being a medical man, was also a prolific writer, publishing more than 320 different books, articles, and essays. *Studies on Hysteria* (1895) was co-authored by Freud and his colleague Josef Breuer. The book described their work and study of a number of individuals suffering from hysteria, including one of their most famous cases, a young woman known as Anna O. The book also introduced the use of psychoanalysis as a treatment for mental illness. Freud often

*There is a powerful force within us, an unilluminated part of the mind--separate from the conscious mind that is constantly at work molding our thought, feelings and actions---**Sigmund***

identified *The Interpretation of Dreams* (1900) as his personal favorite, which is considered a perennial classic in psychology. *The Psychopathology of Everyday Life*, 1901 is considered one of the major texts that outline Freud's psycho-analytic theory. *In Introduction to Psychoanalysis* 1917, Freud outlines his theory of psychoanalysis including the unconscious mind, the theory of neuroses and dreams.

Civilization and Its Discontents 1930 is one of Freud's best known and most widely read books. The book focuses on the tension between the individual and civilization as a whole. Other important works include Three Essays on the Theory of Sexuality (1905), Jokes and Their Relation to the Unconscious (1905), Totem and Taboo (1913) On Narcissism (1914), Beyond the Pleasure Principle (1920), The Future of an Illusion (1927) Moses and Monotheism (1939**)** (Ref: www.verywellmind.com)

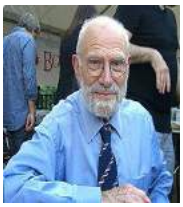
2. Like Freud, **Carl Jung** was also a prolific writer. According to website exploringyourmind.com "**---Carl Jung's books** go beyond a simple analysis of human behavior. He was a pioneer of deep psychology--. His work contains a wonderful alchemy of psychoanalysis, spirituality, religion, philosophy, and the dream world. Few personalities stir up interest like this great analyst of the human psyche".

The best of Carl Jung's Books include 1. Man and His Symbols 2. The Archetypes and The Collective Unconscious 3. The Relations Between the Ego and the Unconscious 4. Synchronicity: An Acausal Connecting Principal 5. Modern Man in Search of a Soul 6. Conflicts in the Child's Soul 7. The Psychology of the Transference 8. Psychic Energy and the Essence of Dreams 9. Writings on Spirituality and Transcendence 10. Memories, Dreams, Reflections 11. The Red Book.

3. **Oliver Wolf Sacks** (1933 – 2015) **"The poet laureate of contemporary medicine"**

   Among the 20th century writers in Neuroscience Oliver Sacks stands out. **Oliver Sacks** was a neurologist, naturalist, historian of science, and writer. Although he was born in Britain, and mostly educated there, he spent his career in

Above all, I have been a sentient being, a thinking animal, on this beautiful planet, and that in itself has been an enormous privilege and adventure-----***Oliver Sacks***



the United States. He believed that the brain is the "most incredible thing in the universe." He became widely known for writing best-selling case histories about both his patients' and his own disorders and unusual experiences. He captivated his readers through his unusual case studies. *The Man Who Mistook His Wife for A Hat, Musicophilia, An Anthropologist on Mars, Oliver Sacks' Memoirs and Hallucinations* are some of his more popular and best-selling books.

He published hundreds of articles (both scientific and articles for a general audience), not only about neurological disorders, but also insightful book reviews and articles about the history of science, natural history, and nature. His writings have been featured in a wide range of media; *The New York Times* called him a "poet laureate of contemporary medicine," and "one of the great clinical writers of the 20th century.

4. There were others in the field of neuroscience, especially Nobel Laureates, who shared their knowledge and insights about the human brain and its functioning through their books.

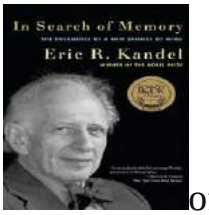
Gerald Maurice Edelman (1929 – 2014) was an American biologist who shared the 1972 Nobel Prize in Physiology or Medicine for work with Rodney Robert Porter on the immune system. According to him, the way the components of the immune system evolve over the life of the individual is analogous to the way the components of the brain evolve in a lifetime.

His later works were in neuroscience and in philosophy of mind. *A Universe of Consciousness: How Matter Becomes Imagination* is one of his acclaimed works. His other works include *Neural Darwinism: The Theory Of Neuronal Group Selection; Bright Air, Brilliant Fire: On The Matter Of The Mind; Second Nature: Brain Science and Human Knowledge* etc.

*"Many cognitive psychologists see the brain as a computer. But every single brain is absolutely individual, both in its development and in the way it encounters the world."— **Gerald Edelman***

His book *Wider Than the Sky: The Phenomenal Gift of Consciousness* is considered a classic. It is a concise and lucid account of the neural basis of consciousness. In this book he introduces the idea of Neural Darwinism, applying evolutionary principles to explain neural behavior.

5. Eric Richard Kandel (born November 7, 1929-aged 91) **is** an Austrian-born American medical doctor who specialized in psychiatry, a neuroscientist and a professor of biochemistry and biophysics at the College of Physicians and Surgeons at Columbia University**.** He was a recipient



of the 2000 Nobel Prize in Physiology or Medicine for his research on the physiological basis of memory storage in neurons. He has a keen interest in art as well as science, and published a book in 2012 titled *The* ***Age of Insight: The Quest to Understand the Unconscious*****.** His classic *In Search of Memory: The Emergence of a New Science of Mind* was awarded the 2006 Los Angeles Times Book Prize for Science and Technology. Kandel is also well known for the textbooks he has helped write, such as Principles of Neural Science, first published in 1981, and now in its fifth edition.

6. Roger Penrose Sir Roger Penrose (born 8 August 1931) is a British mathematician, mathematical physicist, philosopher of science and Nobel Laureate in Physics.

Penrose has made contributions to the mathematical physics of general relativity and cosmology. He has received several prizes and awards, including the 1988 Wolf Prize in Physics, which he shared with Stephen Hawking and one half of the 2020 Nobel Prize in Physics "for the discovery that black hole formation is a robust prediction of the general theory of relativity'.

*Has it ever struck you----that life is all memory, except for the one present moment that goes by you so quickly you hardly catch it going? It's really all memory---except for each passing moment---**Eric Kandel***

Penrose has written books on the connection between fundamental physics and human (or animal) consciousness. In *The Emperor's New Mind* (1989), he argues that known laws of physics are inadequate to explain the phenomenon of consciousness. Penrose and Hameroff have argued that consciousness is the result of quantum gravity effects in microtubules, which they dubbed Orch-OR (orchestrated objective reduction).
In his book *Shadows of the Mind* he applies quantum physics to explain consciousness, and, quantum entanglement about neural behavior.

7. Christof Koch is a German-American neuroscientist and is the president and chief scientist of the Allen Institute for Brain Science in Seattle. He is best known for his work on the neural basis of consciousness taken up in collaboration with Francis Crick**.** We discussed his contribution to neuroscience in an earlier article in this issue of Life Stream. Koch is a proponent of the idea of consciousness emerging out of complex nervous networks.

Some of his important works include Biophysics of Computation: Information Processing in Single Neurons 2004; Consciousness: Confessions of a Romantic Reductionist 9 Mar, 2012; The Feeling of Life Itself: Why Consciousness Is Widespread, but Can't Be Computed 2019.
Together, these neuroscientists have been able to let have a glimpse of nature at work at the minutest levels and open before us, bit by bit, the mysterious and magical world of neurons. □

Ref: en.wikipedia.org; www.nobelprizemedicine.org; faculty.washington.edu; neuroecology.wordpress.com; www.insidescience.org; www.thefamouspeople.com; www.simplypsychology.org; www.britannica.com; exploringyourmind.com

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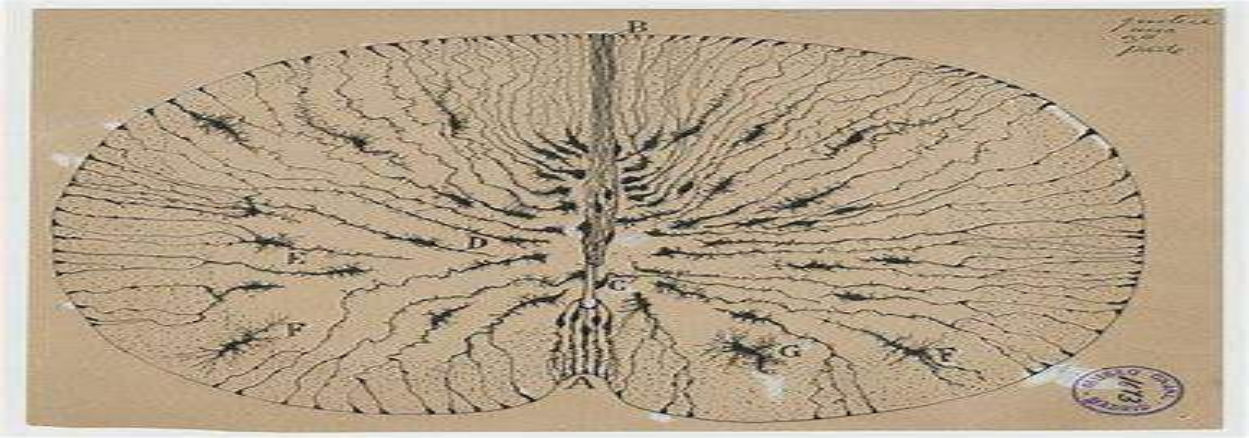
Consciousness is not a special type of computation—it is not a clever hack---***Christof Koch***

Art & ARCHITECTURE: THE BEAUTIFUL BRAIN



(Credit: pintrest.com)

Studies have shown that art enhances our brain function as well as our well-being. If this is true, then what happens when brain itself is the source of inspiration for art? Can neuroscientists themselves, through their dissections and drawings of the brain, create a unique world of art, hitherto unknown to us? The answer is yes. We know at least one such neuroscientist who excelled in something called 'brain art'. He is none other than Santiago Ramon Y Cajal (1852-1934), who is considered to be the founding father of Neuroscience.

Santiago Ramón y Cajal

Early life

Cajal was born on 1 May 1852 in the town of Petilla de Aragón, in northern Spain. He had an independent nature. As a child he was precocious and rebellious.

Cajal did not set out to be a scientist. In fact, he wanted to be an artist, but this was not considered a desirable profession in rural communities at that time in Spain.

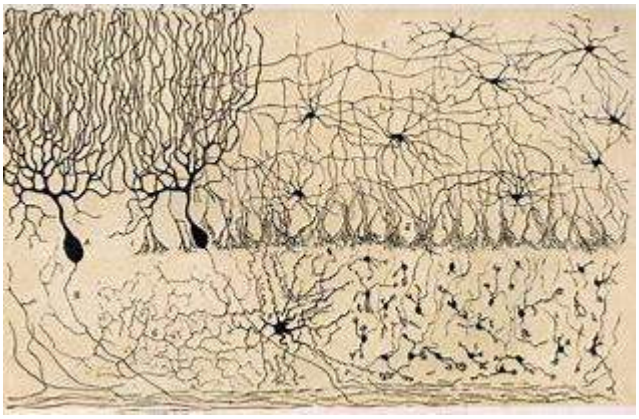
Cajal was drawn to art from an early age; in fact, he showed a maniacal urge to draw everything around him. His father neither appreciated nor encouraged these abilities. He, therefore, apprenticed Cajal to a shoemaker and barber, to inculcate in him discipline and stability.

When he was about fifteen his father did allow

I am convinced that art and science activate the same part of the brain-----***Frank Walczak***

him to enroll in the Academy of Arts. According to the director of the school, he was the most brilliant pupil ever. At sixteen, he fell in love with photography.

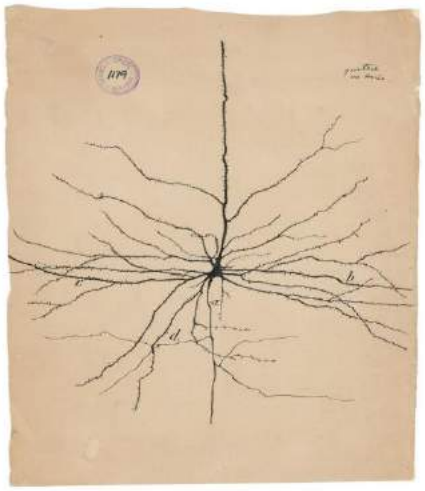
Over the summer of 1868, his father took him to graveyards to find human remains for anatomical study. Early sketches of bones inspired him to pursue medical studies. Cajal attended the medical school of the University of Zaragoza, where his father worked as an anatomy teacher. He graduated in 1873, aged 21.



Neurons in the Cerebellum-
(Credit: neuroscientificallychallenged.com)

Calyces of Held — synapses made by axons carrying auditory information and contacting neurons in a brainstem **structure called the trapezoid body**

*When I draw something, the brain and hands work together—**Tadao Ando***



The pyramidal neuron of the cerebral cortex

Cajal's contrbutions to Neuroscience Cajal made many seminal contributions to neuroscience (for details Pl. see the section on Personalities of this issue of Life Stream). He devoted his life to the anatomy of the **brain**, the body's most complex and mysterious organ. He made the most significant discovery that that the brain was made up of individual nerve cells or neurons, rather than a tangled single web. Cajal called the pyramidal neuron "the noble and enigmatic cell of thought." This was decisively proven by electron microscopy in the 1950s and forms the basis of neuroscience today.

Cajal was awarded the Nobel Prize in Physiology or Medicine in 1906, together with the Italian scientist Camillo Golgi "in recognition of their work on the structure of the nervous system."

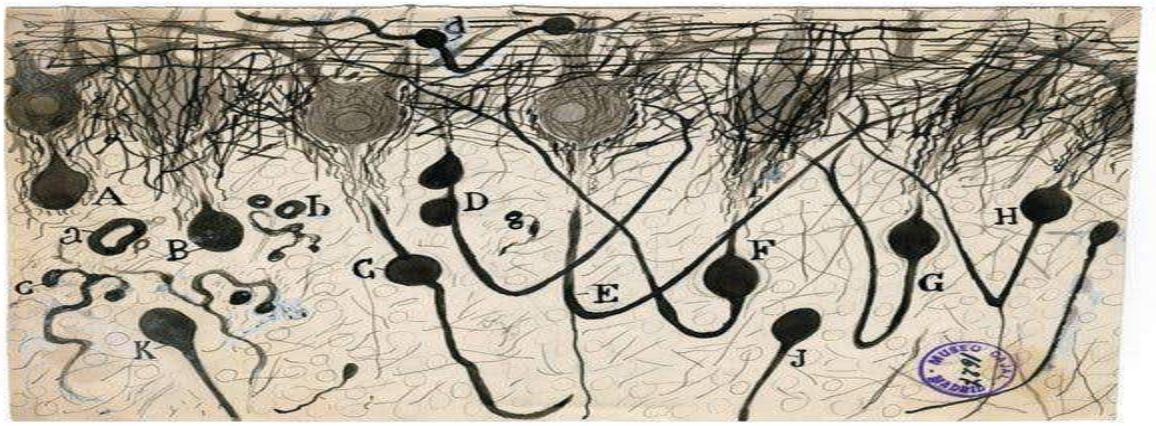
Neuroscientists consider Cajal as important to their discipline, as Einstein is to physics or as Charles Darwin or Louis Pasteur to theirs.

Cajal as an Artist Cajal was also an exceptional artist. With an artist's eye and a scientist's mind, Cajal was the first to see and illustrate what neurons really do. He developed his views mainly by examining thin slices of the brain under a light microscope.

His exquisitely detailed drawings changed our understanding of the brain and nervous system. Wrote Cajal in his Memoir "Realizing that I had discovered a rich field, I proceeded to take advantage of it, dedicating myself to work, no longer merely with earnestness, but with fury--- in proportion as new facts appeared in my preparations, ideas boiled up and jostled each other in my mind."

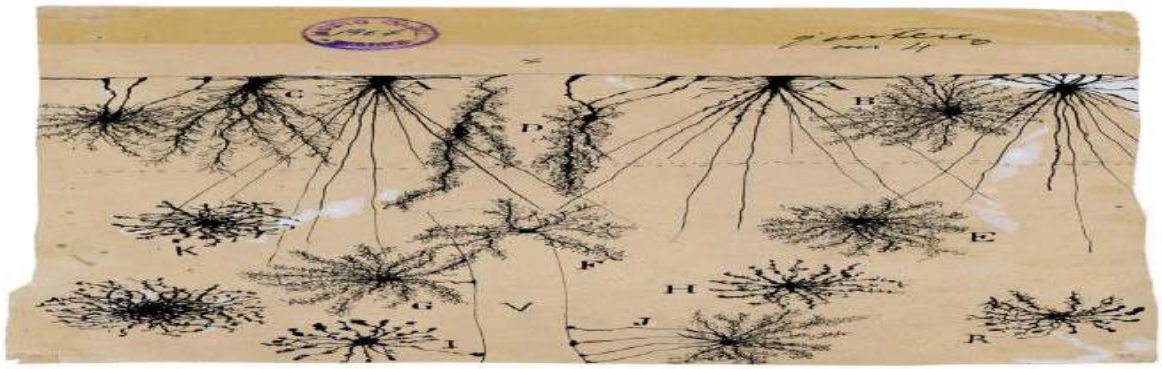
Creativity is intelligence having fun---***Albert Einstein***

Cajal's Drawings



"Axon of Purkinje neurons in the cerebellum of a drowned man," an ink and pencil drawing.

(Credit: Cajal Institute, Madrid)



Glial cells of the cerebral cortex of a child

Illustration: synapses made by axons carrying auditory information and contacting neurons in a brainstem structure called the trapezoid body

A man paints with his brain, not with his hands--- ***Michelangelo***

Cajal about drawing the brain

"Imagine entering a forest with a hundred billion trees, armed only with a sketchbook, looking each day at blurry pieces of a few of those trees entangled with one another, and, after a few years of this, trying to write an illustrated field guide to the forest. You won't get anywhere if you simply draw what you see every day; you're going to have to build up a mental inventory of rules for the forest, and then scrupulously try to fit what you see into that framework, or be flexible enough to allow what you see to reshape your stock of ideas".

Santiago Ramón y Cajal's drawings of the brain are as aesthetically pleasing, as they are scientifically accurate. During his lifetime Cajal produced more than three thousand drawings of the brain. Experts believe that they have never been equaled in their clarity and their ability to express fundamental concepts about the brain. – 'They are also works of art, shaped by his artistic training, his close observation of nature, and his expression of aesthetic values--- Armed with a rudimentary microscope by today's standards, and drawing implements more usually found in an art studio than a biology laboratory, Cajal set out to disentangle and catalogue the brain's neuronal wildlife'--.

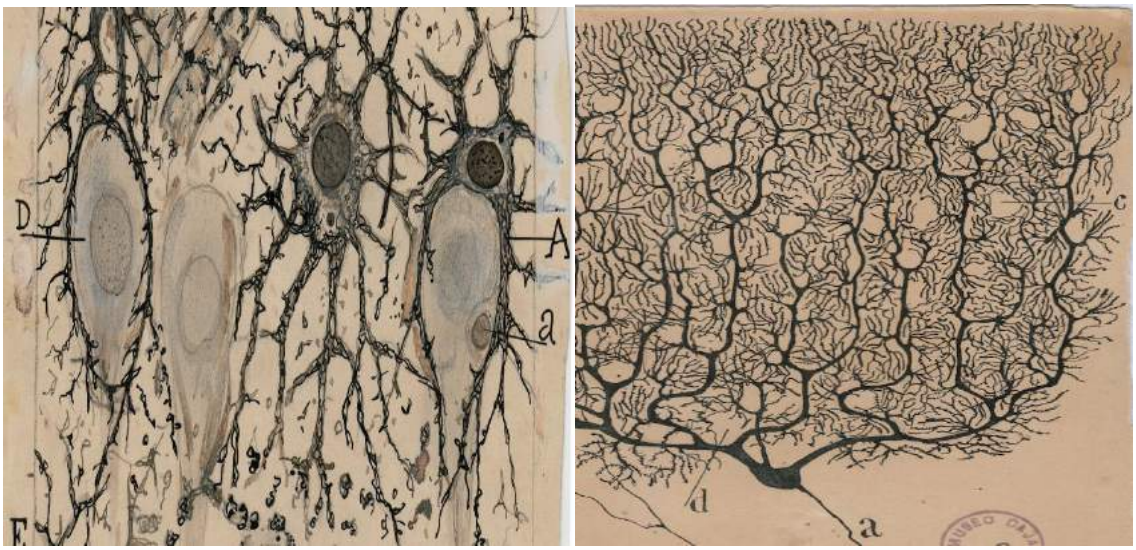
Another observation about his drawings were made in the website www.brainpickings.com thus 'When we look at his drawings today, we see not diagrams or arguments, but the first clear pictures of that remote frontier, drawn by the man who traveled farthest into its endless reaches'.

Cajal said, in his Advice for a Young Investigator (1916), "Drawing . . . enhances discipline and attention, for it forces us to observe the totality of the phenomenon and see details overlooked in ordinary observation." He wrote in his poetic autobiography, *Recollections of My Life*: "I finally chose the cautious path of histology, the way of tranquil enjoyments. I knew well that I should never be able to drive through such a narrow path [as microbiology] in a luxurious carriage; but I should feel myself happy in contemplating the captivating spectacle of minute life in my forgotten corner and listening, entranced, from the ocular of the microscope, to the hum of the restless beehive which we all have within us-----A graphic representation of the object observed guarantees the exactness of the observation itself".

Wrote New York Times "--Looking through the lens he saw with such acuity and drew so precisely

*---Science and Art equally are expressions of his (man's) plasticity of brain---**Jacob Bronowski***

(freehand) ----he also drew with such delicacy and vivacity that his drawings stand on their own as wonders of graphic expression, both mysterious and familiar—".



An astrocyte in the human hippocampus; A Purkinje neuron from the human cerebellum

Remembering Cajal A number of exhibitions and events have been organized in different parts of the world to pay homage to the memory of Santiago Ramon Y Cajal. *The Beautiful Brain: The Drawings of Santiago Ramón y Cajal* is the first museum exhibition to present and contextualize the amazing historical objects.

The exhibition travelled through North America, beginning 2017 at the Weisman Art Museum in Minneapolis, Minnesota and ended in April 2019 at the Auckland Art Museum in Chapel Hill, North Carolina, USA. In 2017, UNESCO (the United Nations Educational, Scientific and Cultural Organization) recognized Cajal's Legacy (which had been kept in a museum from 1945 to 1989) as a World Heritage treasure.

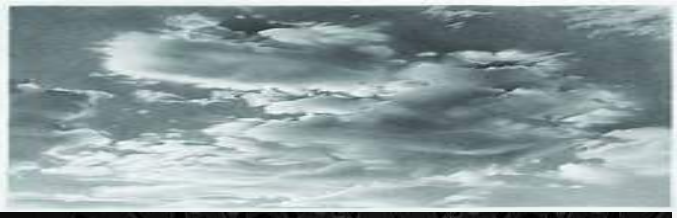
Project Encephalon organized Cajal Week to celebrate his 169th birth anniversary from 1 May to 7 May 2021.

A century after their completion, his drawings are still in use for educational and training purposes today. It is remarkable that they are still used in contemporary medical publications to illustrate important neuroscience principles, and continue to fascinate artists and visual art audiences.

Ref: en.wikipedia.org; www.healing-power-of-art.org; www.discovermagazine.com; www.nytimes.com; www.brainpickings.org/

Imagination is more important than knowledge. For, while knowledge defines all we currently know and understand, imagination points to all we might yet discover and create- ***--Albert Einstein***

POEM: THE BRAIN IS WIDER THAN THE SKY -----EMILY DICKINSON



The Brain—is wider than the Sky

632

The Brain—is wider than the Sky—
For—put them side by side—
The one the other will contain
With ease—and You—beside—

The Brain is deeper than the sea—

For—hold them—Blue to Blue—
The one the other will absorb—
As Sponges—Buckets—do—

The Brain is just the weight of God—
For—Heft them—Pound for Pound—
And they will differ—if they do—
As Syllable from Sound—

Emily Dickinson

Emily Elizabeth Dickinson (December 10, 1830 – May 15, 1886) was an **American poet.** Little-known during her life, she has since been regarded as one of the most important figures in American poetry.

'The Brain—is wider than the Sky' by Dickinson is a well-loved, complex poem that speaks on the importance and wonder of the human brain. In the poem, the speaker praises the human mind's capacity to imagine, perceive, and create, ultimately suggesting that the mind is boundless in its potential—and that this boundlessness links humanity to God. This is the starting point of one of **Emily Dickinson**'s great meditations on the power of human imagination and comprehension.
(Ref: poemHunter.com; poemanalysis.com/emily-dickinson; en. wikipedia.org)

"Perception of reality emerges from the brain and dissolves in the brain'---unknown

THE MIND MYSTERY - Sudha Shrotria

Analyzed by many minds

The human brain is of a distinct kind,

The edifice biologically same in everyone

Yet every human being similar to none;

All think and behave in a different way,

And though experts figure an answer

It is hard to say,

Why actions of some are perilous,

Complex and mysterious,

While some think good

Help each other

And behave as best as they could,

Why some act evil,

And choose to smother the good,

Loose their sanity

And work against humanity?

TRAVEL: MANSAROVAR----- THE MIND LAKE

The mythical Manasa lake is described as one created through the mind of Brahma.

(Wikipedia)

*Nestled among the Western Himalayan ranges of Tibetan Autonomous Region, the mystical freshwater Lake Mansarovar is the source of divine energy and bliss for pilgrims and visitors. Mt. Kailash and Lake Mansarovar are revered as the most sacred places in Hindu, Jain, Bon and Bodh religions. Every year, during May to October months, devotees and adventure seekers travel to Kailash Mansarovar in a large number***.**

Which is one place on earth which you would like to visit in your lifetime? It could most probably be Mansarovar (Sanskrit: Manas = Mind-in its widest sense as applied to all the mental powers- intellect, intelligence, understanding, perception, sense, conscience and Sarovar= a lake or "a large pond deep enough for a lotus"- *Wikipedia).* It is a high altitude freshwater lake fed by the Kailash Glaciers, near the 6638m tall diamond shaped Mount Kailash.

Location The Lake is located about 50 kilometers to the northwest of Nepal, about 100 kilometers east of Uttarakhand, and is in the southwest region of Tibet near China National Highway 219.

*Foreign experience increases both cognitive flexibility and depth and integrity of thought, the ability to make deep connections between disparate forms-**Adam Galinsky***

Lake Manasarovar lies at 4,590 m (15,060 ft) above mean sea level. It freezes in the winter. The Lake is situated near the source of the Sutlej, a large tributary of the Indus. Nearby are the sources of the Brahmaputra River, the Indus River, and the Karnali, an important tributary of the Ganges.

Dimensions: Lake Manasarovar is relatively round in shape with the circumference of 88 km (54.7 mi). Its depth reaches a maximum of 90 m (300 ft) and its surface area is 320 km^2 (123.6 sq. miles).

Rakshas Taal or demon lake is crescent moon shaped and is one of the highest salt water lake is located next to Mansarovar. It is thought to be associated with darkness and thus thought to possess negative energies. Mansarovar is connected to Lake Rakshas Taal by the natural Ganga Chhu channel.

Satellite view of lakes Manasarovar (right) and Rakshas Taal with Mount Kailash in the background

Historical: According to Wikipedia there is no mention of Manasarovar lake or its location in Vedic literature, or ancient Sanskrit and Prakrit texts. Though colonial era and modern texts state Kailash-Manasarovar to be among the most sacred sites of Indian religions, particularly Hinduism, this status is not found in early Indian texts, prior to mid to late 1st-millennium texts. Instead, the early Buddhist, Hindu and Jaina texts mention a mythical Mount Meru and lake *Manasa*. The mythical *Manasa* lake is described as one created through the mind of Brahma.

Tibetan records confirm that Buddhists considered the region now identified as Kailasa and Manasarovar to be their sacred place by late 12th-century. The significance of Lake Manasarovar and Mount Kailash to its north increases after

Travel has the potential to 'light up the brain' across a diverse range of neural pathways, leading to many health and cognitive benefits---***Joan parsons***

13th-century, given its mention in popular Hindu texts. Tulsidas (16th century) mentions both in his book *Ramacharitamanas.*

Credit: The Times of India

Between 1901 and 1905, southern Tibet became strategically important to the British Empire. The colonial era officials decided to encourage and assist religious pilgrimage to this lake and Kailash (Ref: Wikipedia)

Religious significance Lake Manasarovar and Mount Kailash are believed to be the abodes of Shiva. The Bon religion also associates it as the holy place of Zhang Zhung Meri , its sacred deity. Buddhists associate the lake as the mother principle, with Kailash as the father principle. In Jainism, Lake Manasarovar is associated with the first Tirthankara, Rishabha. As per Jain scriptures, Bhagwan Rishabhdev, attained nirvana on the Ashtapad Mountai.

What you can see

The beauty of Lake Manasarovar lies in the purity of its water -considered to be as pure as a sapphire to an extent that the deeper points are visible to the visitors. It continuously keeps changing its colors- from blue to bluish green and then to green or rarely into a rainbow of colors.

An array of five Buddhist monasteries are seen dotting the shores of the holy Lake, including, the renowned Chiu on the lake's Northwest shore, the others being Gossul, Seralung, Yerngo and Trugo. Thousands of devotees perambulate the Lake by foot.

*When I look back at my visit, I realize that Kailash's greatest contribution to me is in breaking me down, yet holding the essence of me up----**Sadguru***

Mount Kailash

Being touched by this energy, by this Grace, by the power of what is there at Kailash can transform a human being forever- Sadhguru

An imposing 21,778-feet tall, the magnificent and majestic Mount Kailash is more than just a mountain. "It's a legend. A revelation. An epiphany. A journey, that is both outwards and inwards. But more than anything, the journey to Kailash Manasarovar is a life-changing experience for the thousands of pilgrims who undertake it every year, catapulting them into uncharted inner frontiers like nothing else can. For a pilgrimage to this isolated, timeless, breathtaking and fascinating spiritual spot is like a journey within yourself". It is believed that every living soul in this eternal world is spiritually connected to the sacred mountain of Kailash.

(En.wikipedia.org)

Mt. Kailash is always covered with dazzling white snow perhaps that is why in Tibet it is called Gang Rin-Po-Che Which means 'Precious Jewel of Snow'.

How to reach The Yatra involves trekking at high altitudes of up to 19,500 feet above the sea level, under inhospitable conditions, including severe cold and rugged terrain. Only those who are physically and medically fit can undertake the journey; others may find the journey risky and hazardous.

The most popular among the trips is organized every year by the Ministry of External affairs. Now, there are two routes to undertake the Yatra in the MEA- organized trips-- **Route 1:** Lipulekh Pass (Uttarakhand); **Route 2:** Nathu La (Sikkim).

According to www.kailash-

*A mind that is stretched by a new experience can never go back to its old dimensions—**Oliver Wendell Holmes***

yatra.org, one of the quickest and most convenient ways to perform a trip to Mt. Kailash and Lake Mansarovar is the helicopter yatra from Lucknow. Preferably, for elders as well as people who are not able to take long drives to visit Kailash Mansarovar, a helicopter yatra to Kailash Mansarovar is the best option. This nine-day long helicopter tour takes you to Nepal-China border by flights from where Kailash Mansarovar can be visited by short and comfortable drives. Costs can be as high as Rs 1.85 lakhs per person (now it should be more).

Kailash Yatra by Helicopter can also be undertaken from Kathmandu. The pilgrims will be travelling from Kathmandu to Simikot by scheduled flight and then from Simikot to China border by a Chartered Helicopter ride. Lake Mansarovar and Mount Kailash will remain only some short drive away from here (cost: approximately Rs.1.95 lakhs-$ 3470).
Road journey involves a 14 days long trip which begins from Kathmandu with a rough and scenic drive to Keyrung, crossing Nepalese border at Rasuwagadi. The black top roads of Tibet leading to Lake Mansarovar and Mount Kailash offers scenic view of snowcapped mountains and great Tibetan plains (Cost: approximately Rs.1.55 lakhs- $2580)

Kailash-Mansarovar trips are organized annually by other tour operators and organizations too.

How Travel affects the brain Scientists used to believe that the brain can change only during childhood, but now it widely accepted that neuroplasticity, or the ability of the brain to change, is present throughout our lives.

The Global Coalition on Aging, in collaboration with the U.S. Travel Association, has released studies highlighting a clear connection between travel and wellbeing. According to a write up in www.lifehack.org, travel has the potential to 'light up the brain' across a diverse range of neural pathways, leading to many health and cognitive benefits. The complexities of travel are shown to sharpen travelers' brains. As people move into adulthood and retirement years, they focus more on routine activities, and often not have new experiences. Brains adhere to the "use it or lose it" rule. Pathways people use the most are strengthened, while those that are neglected become weak.

*Travel disrupts your routine and introduces novelty to your brain, which improves cognition and helps reactivate reward circuits--**unknown***

According Paul Nussbaum of the University of Pittsburgh traveling can stimulate your brain and encourage the growth of new connections within cerebral matter**.** He says that when you travel to a new location, your brain is forced to make sense of new stimuli. This triggers the production of new dendrites. □

Ref: en.wikipedia.org; www.mea.gov.in www.kailash-yatra.org; isha.sadhguru.org; www.speakingtree.in

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Credit: pinterest.com

*New sounds, smells. Language, tastes, sensations, and sights spark different synapses in the brain and may have the potential to revitalize the mind—**Brent Crane***

FOOD & DIET: BRAIN DIET

-- the effects of nutrients on brain function

(Credit: followgreenliving.com)

The connection between consumption of certain items of food, and cognitive processes and emotions, was known to human beings, over a long period of time. In fact, traditional systems of medicine like Ayurveda advocates that diet, in conjunction with other aspects of daily living, such as exercise, has a crucial role to play in our health and wellbeing. In Ayurveda *'Pathya'* (diet and exercise, lifestyle combined), is used as part of therapies and also in preventive health.

How dietary factors work Recent studies have confirmed the influence of dietary factors on neuronal function and synaptic plasticity. According to ***www.ncbi.nlm.gov,*** 'Dietary factors can affect multiple brain processes by regulating neurotransmitter pathways, synaptic transmission, membrane fluidity and signal-transduction pathways'.

Research studies help us to understand the molecular basis of the effects of food on cognition, and enables us to decide how best to follow a proper diet, in order to promote mental fitness. In addition, they show that 'well-established regulators of synaptic plasticity such as brain-derived neurotrophic factor, can function as metabolic modulators, responding to peripheral signals such as food intake'. These studies also show that several gut hormones that can enter the brain, or that are produced in the brain itself, influence cognitive ability.

The food that enters the mind must be watched as closely as the food that enters the body---***Pat Buchanan***

Why are dietary factors important?

1. Dietary factors influence specific molecular systems and mechanisms that maintain mental function.
2. Studies haves shown that there might be an association between abnormal metabolism (diabetes type II, obesity and metabolic syndrome) and psychiatric disorders. In a large study of patients with manic depression or schizophrenia, the rate of diabetes was found to be higher than in the general population (1.2% of people aged 18–44 years and 6.3% of people aged 45–64 years).
3. The brain consumes a vast amount of energy relative to the rest of the body. Therefore, the mechanisms that are involved in the transfer of energy from foods to neurons are likely to be fundamental to the control of brain function.
4. Metabolic disorders affect the management of energy in neurons, which can, in turn, affect synaptic plasticity.
5. Diet and exercise can affect mitochondrial energy production, which is important for maintaining neuronal excitability and synaptic function.
6. Disturbances in energy homeostasis have been linked to the pathobiology of several mental diseases
7. A diet that is rich in omega-3 fatty acids support cognitive processes in humans and

Alcohol is a good preservative for everything but the brains-
*--**Mary Pettybone Poole***

help regulate genes that are important for maintaining synaptic function and plasticity in rodents (See below).

8. Diets that are high in saturated fats increase the risk of neurological dysfunction, both in humans and animals.
9. According to the website www.jneurosci.org, Vagal afferents are an important neuronal component of the **gut–brain axis,** that allows bottom-up information flow from the viscera to the central nervous system (CNS). Vagal Afferent Signaling (VNS) modulates mood, and affect especially, anxiety and fear. The use of VNS has become a routinely approved procedure for the treatment of refractory partial-onset seizures and as a potential treatment for depression.
10. Several gut hormones or peptides, such as leptin, ghrelin, glucagon-like peptide-1 and insulin have been found to influence emotions and cognitive processes.
11. Ghrelin is an adipo-genic hormone that is secreted by an empty stomach; it acts as an appetite stimulant in mice and humans. The act of feeding can itself modulate cognitive processes on two levels, through neural circuits that connect the gut and the brain, and through the release of gut peptides into the bloodstream.
12. Insulin, which is considered a gut hormone that is produced in the pancreas, has also been found to alter synaptic activity and cognitive processing.
13. A number of innovative studies point to the possibility that the effects of diet on mental health can be transmitted across generations, by influencing epigenetic events.
14. Dietary manipulations are a viable strategy for enhancing cognitive abilities and protecting the brain from damage, promoting repair and counteracting the effects of aging.
15. Restricted eating, malnourishment, and excessive weight loss can lead to changes in our brain chemistry, resulting in increased symptoms of depression and anxiety (Centre for Clinical Interventions, 2018b)

A full belly makes a dull brain: The muses starve in a cook's shop-----***Benjamin Franklin***

Dietary components and cognitive abilities

Several dietary components have been identified that have effects on cognitive abilities as shown below: -

Select nutrients that affect cognitive function		
nutrient	**effects on cognition and emotion**	**food sources**
Omega-3 fatty acids (for example, docosahexaenoic acid)	Amelioration of cognitive decline in the elderly; basis for treatment in patients with mood disorders; improvement of cognition in traumatic brain injury in rodents; amelioration of cognitive decay in mouse model of Alzheimer's disease	Fish (salmon), flax seeds, krill, chia, kiwi fruit, butternuts, walnuts
Curcumin	Amelioration of cognitive decay in mouse model of Alzheimer's disease; amelioration of cognitive decay in traumatic brain injury in rodents	Turmeric (curry spice)
Flavonoids	Cognitive enhancement in combination with exercise in rodents; improvement of cognitive function in the elderly	Cocoa, green tea, Ginkgo tree, citrus fruits, wine (higher in red wine), dark chocolate

Saturated fat	Promotion of cognitive decline in adult rodents; aggravation of cognitive impairment after brain trauma in rodents; exacerbation of cognitive decline in aging humans	Butter, ghee, suet, lard, coconut oil, cottonseed oil, palm kernel oil, dairy products (cream, cheese), meat

Omega-3 fatty acids

Dietary consumption of omega-3 fatty acids is one of the best-studied interactions between food and brain evolution.

Omega-3 polyunsaturated fatty acids are normal constituents of cell membranes and are essential for normal brain functions. DHA **(**Docosahexaenoic acid) is a prominent component of neuronal membranes. As the human body is unable to synthesize adequate quantities of DHA, supplementing DHA through diet becomes necessary.

Studies show that deficiency of omega-3 fatty acids in rodents results in impaired learning and memory. Dietary deficiency of omega-3 fatty acids in humans has been associated with increased risk of several mental disorders, including attention-deficit disorder, dyslexia, dementia, depression, bipolar disorder and dieting. Another form of disordered eating, such as anorexia and bulimia similarly disrupt the natural order of eating. Higher incidence depression in countries such as the United States and Germany is explained by the higher consumption of saturated fatty acids, linoleic acid and *trans* fatty acids.

Trans fats/Saturated fats Epidemiological studies indicate that diets with high contents of *trans* and saturated fats adversely affect cognition. Studies on Rodents on the effects of "junk food", with high contents of saturated fat and sucrose, have shown a decline in cognitive performance and reduced hippocampal levels of synaptic plasticity, after only 3 weeks of dietary treatment.

The subtle energy of the food becomes your mind--- ***Upanishads***

Foods containing 'good fats'

Foods containing polyunsaturated fatty acids (nuts, seeds, fish, leafy green vegetables) and monounsaturated fatty acids (extra virgin olive oil, avocados, nuts) may reduce the risk of both depression and dementia. Extra virgin olive oil is a healthy source of fat in the diet and can help reduce cholesterol levels and blood pressure. Some studies have linked olive oil with a lower risk of ischaemic stroke, cognitive impairment and Alzheimer's disease.

Amino Acids Neurotransmitters in the brain, which regulate our moods, are made from amino acids. Some of these amino acids come from our food. For example, the neurotransmitter serotonin, is made from the amino acid tryptophan, found in milk, oats and other foods.

Vitamins and minerals The brain uses vitamins and minerals to help perform vital tasks. A vitamin or mineral deficiency can affect brain functions. Vitamins such as folate and B12 support the healthy function of the nervous system. Adequate levels of folate are essential for brain function, and folate deficiency can lead to neurological disorders, such as depression and cognitive impairment.
A study published in the American Journal of Epidemiology suggests that an adequate intake of vitamin E might help to prevent cognitive decline, particularly in the elderly.

Anti-oxidants Several 'anti-oxidants' have positive effects on neural function. For example, the curry spice curcumin, has been shown to reduce memory deficits in animal models of Alzheimer's disease and brain trauma. Curcumin is relatively non-toxic and has few side effects at doses greater than the low dose that has been tested in mice. Given the high consumption of curcumin in India, it is possible that it might contribute to the low prevalence of Alzheimer's disease in India. Dark chocolate contains high levels of antioxidants, although it is also high in sugar and fat.

*The exercise is king; nutrition is queen. Put them together and you've got a kingdom-**Jack Lalanne***

Easy ways to stimulate your brain.

1. Exercise for a healthier **mind**. ...
2. Read for intellectual stimulation. ...
3. Eat healthy --
4. Strive for good posture. ...
5. Get plenty of sleep to improve memory. ...
6. Play games or draw.
7. Listen to music or play an instrument.

...

The top brain foods

BBC in its website www.bbcgoodfood.com has listed the following as top brain foods.

1. Wholegrains

May improve concentration and focus. Wholegrains have a low-GI, which means they release their energy slowly into the bloodstream,

2. Oily fish-----May promote healthy brain function

The most effective omega-3 fats occur naturally in oily fish which include salmon, trout, mackerel, herring, sardines, pilchards and kippers. They contain active fats EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) in a ready-made form, which means that the body can use them easily. Plant sources include flaxseed, soya beans, pumpkin seeds, walnuts and their oils. The fats present in them are important for healthy brain function, the heart, joints and our general well-being.

3. Blueberries------May boost short-term memory

Studies carried out at Tufts University in the US suggests that the consumption of blueberries may be effective in improving or delaying short-term memory loss. The same effect can be achieved with other dark red and purple fruits, like blackberries, and vegetables like red cabbage which too contain anthocyanins.

4. Tomatoes ---May prevent free radical damage

Lycopene is an antioxidant found in tomatoes that helps protect cells against free radical damage to cells especially as in dementia and Alzheimer's. Similar protective phyto-nutrients, are present in papaya, watermelon and pink grapefruit.

Tell me what you eat, I will tell you who you are----- ***Leftbrain Buddha.com***

5. Eggs -----May delay brain shrinkage

Certain B vitamins – B6, B12 and folic acid – are known to reduce levels of a compound called homocysteine in the blood that are associated with increased risk of stroke and cognitive impairment and Alzheimer's disease. A study of a group of elderly patients with mild cognitive impairment found that after two years of intervention with high doses of B6, B12 and folic acid, there was significantly less brain shrinkage compared to a group given placebo treatment.

Other B vitamins including vitamins B1, B3 and choline play an important part in regulating normal brain function. Choline, which is rich in egg yolk, is essential for the memory-boosting brain chemical, acetylcholine.

B-rich foods include eggs, chicken, fish, leafy greens and dairy. Vegans can opt for plant milks and breakfast cereals, for vitamin B12 or consider a supplement. Other useful vegan sources of B vitamins include nutritional yeast, avocado, soya, nuts and seeds.

6. Blackcurrants--------May reduce anxiety and stress

Vitamin C has long been thought to have the power to increase mental agility, and some research suggests that a deficiency may be a risk factor for age-related brain degeneration, including dementia and Alzheimer's. Further, studies demonstrate that vitamin C may be useful in managing anxiety and stress. Sources of vitamin C include blackcurrants, red peppers, citrus fruits such as oranges and broccoli.

7. Pumpkin seeds -----May enhance memory and boost mood

Richer in zinc than many other seeds, pumpkin seeds supply this valuable mineral which is vital for enhancing memory and thinking skills. They also provide stress-busting magnesium, B vitamins and tryptophan, the precursor to the good mood chemical serotonin. Other useful food sources include beef, oysters, chickpeas and nuts, especially cashews and almonds.

8. Broccoli--------May improve brainpower

Broccoli is great source of vitamin K, which is known to enhance cognitive function and improve brainpower. Researchers have reported that because broccoli is high in compounds called glucosinolate. It can slow the breakdown of the neurotransmitter, acetylcholine,

*What you feed your brain determines your appetite- **Tom Ziglar***

which we need for the central nervous system to perform properly, and keep our brains and memories sharp. Low levels of acetylcholine are associated with Alzheimer's. Other cruciferous vegetables rich in glucosinolates include cauliflower, kale, cabbage and Brussels sprouts. Vitamin K is obtained from liver, hard cheeses and prunes.

9. Sage leaves------May boost memory and concentration

10. Nuts-----May help protect healthy brain function

Nuts are a great source of vitamin E along with leafy green vegetables, asparagus, olives, seeds, eggs, brown rice and wholegrains. Walnuts are excellent sources of protein and healthy fats. 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 which is good for both the heart and brain.

11. Tea and coffee----- Improves mental function

In a 2014 study published in The Journal of Nutrition, participants with higher caffeine consumption scored better on tests of mental function (www.health.harward.edu). Caffeine might also help solidify new memories, according to other research.

12. Beets------Stabilizes mental and emotional health

Beets contains betaine, which supports serotonin production in the brain. Beets also have a potent dose of folic acid in them, which stabilizes emotional and mental health.

Our brain is our garden, the roots are nurtured by the food we eat---***feedabrain.com***

Balanced diet

"Just as there is no magic pill to prevent cognitive decline, no single almighty brain food can ensure a sharp brain as you age".

The main components of a balanced diet are:

- Have five portions of fruits and vegetables per day
- Include in the diet carbohydrates from foods such as brown rice, potatoes, cereals and whole wheat pasta
- Take protein from foods such as oily fish, eggs and meat
- Limit your salt, sugar and alcohol intake.

Foods That Are Bad for Your Health

Just as there are good foods for better brain functions, there are certain items of food which can impair brain functions. Some of the bad foods are: -

1. White sugar/Sugary drinks/ most fruit juices/ Pastries, cookies, biscuits, doughnuts, muffins and cakes (obesity, hyperglycemia and poor brain focus)
2. Junk foods Most pizzas/French fries and potato chips (poor memory)
3. Fried/grilled foods (Poor cognition) A study, published in 2016 in the *Journal of Nutritional Science,* showed people who ate diets high in fried foods scored poorly on cognitive tests that evaluated learning, memory, and brain function. Conversely, those who ate more plant-based foods scored higher.
4. Refined carbs (high sugar levels) White rice, white bread, Sweetened breakfast cereals, white pasta, and other processed foods have a high glycemic index that may lead to high sugar levels. They also induce risk of depression

brainbalancecenters.com

in people who consume refined carbs.

5. Mercury in fish- (impair brain functions) Mercury found in fish such as tuna, shark, or swordfish is toxic to humans and impair brain functions. tuna—as well as swordfish, shark, king mackerel, and tilefish—has higher levels of mercury than many other types of seafood.

*It is the food which you furnish to your mind that determines the whole character of your life—**Emmet Fox***

And a study published in *Integrative Medicine*, shows that people with high levels of the heavy metal in their bloodstream had a 5 percent drop in cognitive function

6. Processed meat (develop dementia) Those who eat processed meats may run a greater risk of developing dementia, suggests an April 2020 study published in *Neurology*.
7. Excess alcohol (damage the brain) While the occasional glass of red wine can actually be healthy, drinking in excess can be toxic to your brain function, no matter your age. Research, including a study published in 2017 in *BMJ*, found that moderate drinking—defined by the researchers as about one to three drinks per day—can damage the brain. The hippocampus is particularly vulnerable.
8. 8. Aspertamine is an artificial sweetener found in many soft drinks and sugar-free products. It has been linked to behavioral and cognitive problems, though overall it is considered a safe product.

Role of Exercise Numerous studies have shown that exercise enhances learning and memory under a variety of conditions. Exercise helps 'to counteract the mental decline that is associated with aging, enhance the mental capacity of young adults, and facilitate functional recovery after brain injury or disease'. Studies that showed that exercise promotes neurogenesis in the brain of adult rodents and humans· Without exercise, excess calories can reduce synaptic plasticity and increase the vulnerability of cells to damage by causing free-radical formation.

Future No doubt, there is increasing general awareness about the types of food that have health benefits, the general principle being whatever food is good for the body is good for the brain too. But the sad fact is that despite awareness, people continue to indulge in food that have negative impact on health, especially mental health. Stricter regulatory mechanisms, more sensitive policies, teaching the subjects at school and college levels, improving mid-day meals, spreading awareness through sustained programs could help to a certain extent. But ultimately each of us is responsible for what we eat □

Ref: food and the human brain www.ncbi.nlm.gov; www.health.harward.edu; www.bbcgoodfood.com; www.eatthis.com

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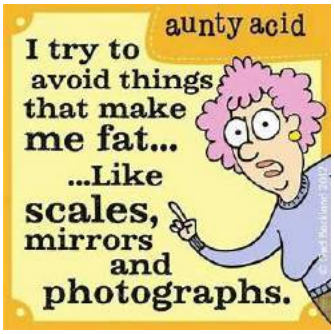
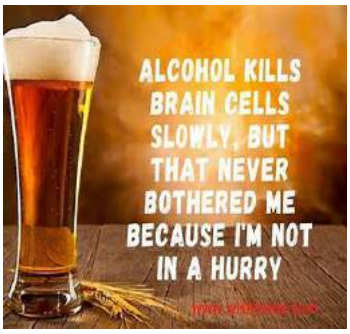
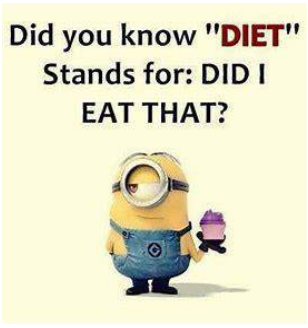
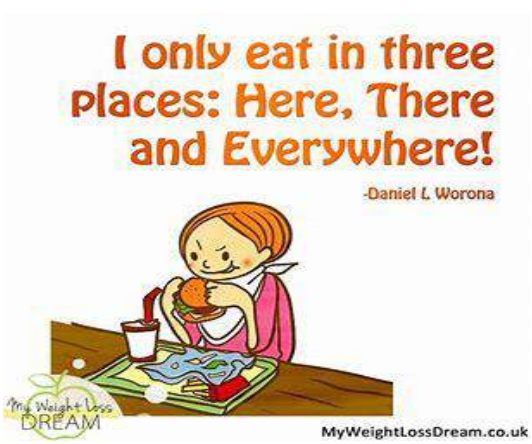
I think there is a part of my brain where food, language and memory all intersect and it's all powerful. I think I am not alone in this----***picturequotes.com***

FUN QUOTES





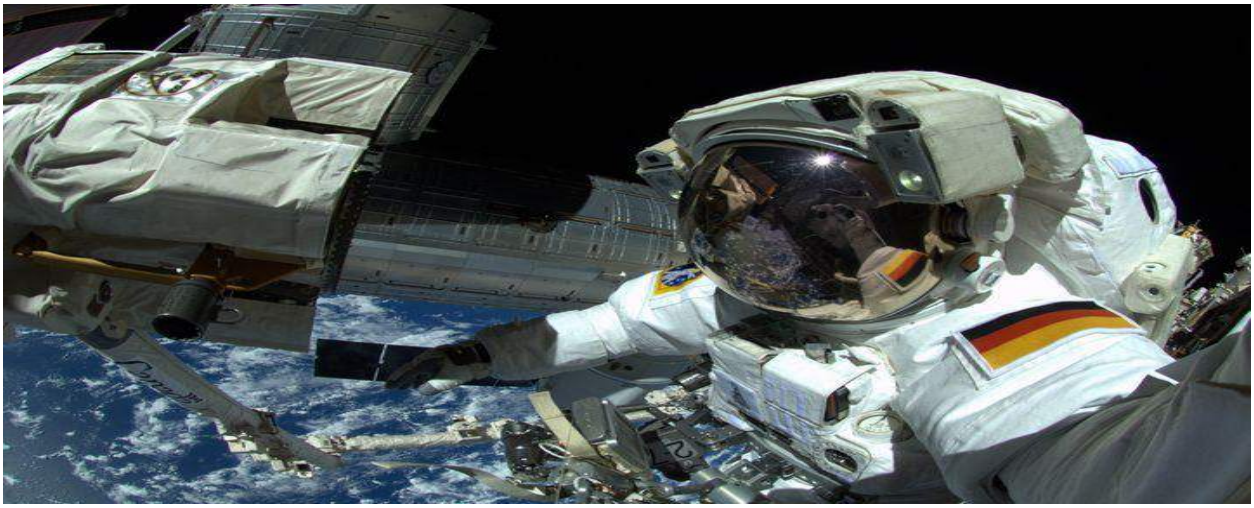




The doctor of the future will no longer treat the human frame with drugs, but rather will cure and prevent disease with nutrition----***Thomas Edison***

UNIVERSE: THE BRAIN IN SPACE

-----Effects of Spaceflight on the Brain and Human Behavior



CREDIT: GETTY IMAGES

Does being in space affect your brain? With space travel becoming more and more commercial, and increasingly sought by tourists and non- scientists, especially the rich and the famous, this question assumes much significance. As NASA plans for longer duration manned space flights, to planets such as Mars, concerns have been expressed regarding the risks associated with prolonged stay in the space.

We discuss here the details compiled from various sources about the effects of space travel on our brain and behavior.

Manned Space Missions Starting with the flight of Yuri Gagarin aboard Vostok 1 and Allan Shepard (USA) aboard Mercury-3 in 1961, China, Russia, the United States and former Soviet Union have conducted human spaceflights using thirteen different spacecraft series. With the launch of Inspiration-4 on 16 September 2021, there have been altogether 349 human space flight launch attempts so far. Since Yuri Gagarin over 500 astronauts and cosmonauts have visited space. Humans traveled to the Moon nine times between 1968 and 1972 as part of the United States' Apollo program, and have had a continuous presence in space for 20 years and 321 days on the International Space Station (ISS).

> *The inner space is so much more interesting, because outer space is so empty—**Theodore Sturgeon***

Model of Vostok spacecraft (Wikipedia) The first cooperative human space flight project between the United States and the Soviet Union took place in 1975. The Apollo-Soyuz Test Project opened the way for future joint manned flights. US-Mir shuttle mission was a collaboration between US and Russia leading to the formation of the present International Space station. Currently, the United States, Russia, and China are the only countries with public or commercial human spaceflight-capable programs.

Non-governmental spaceflight companies have been working to develop human space programs for space tourism or commercial in-space research purposes. The first private human spaceflight launch was a sub-orbital flight on Spaceship- 1 on June 21, 2004. The first commercial orbital crew launch was by Space-X in May 2020, transporting NASA astronauts to the ISS.

Neil Alden Armstrong **(August 5, 1930 – August 25, 2012)**
was **an American astronaut and aeronautical engineer**
and the first person to walk on the Moon.

SpaceX founder and CEO Elon Musk took a ride to suborbital space with Richard Branson, the billionaire founder of the Virgin Group, on July 11, 2021, flying on the first fully crewed spaceflight of Virgin Galactic's VSS Unity space.

*What you see in your outer space is a reflection of what you think in your inner space---**Aleksandra Zaric***

Elon Musk is developing a vehicle named Starship that will be a fully a reusable transport system capable of carrying up to 100 people to the Red Planet.

Research

The website ncbi.nih. govt reports that the current information concerning the effects of actual spaceflight on the brain was obtained on rats and mice flown on five missions of Soviet/Russian biosatellites, NASA Neurolab Mission STS90, and International Space Station (ISS). Some of the important findings of these Missions are analyzed here.

The Neurolab Mission

Neurolab was a NASA space **mission** dedicated to study the nervous system with multinational collaboration. *NASA had launched 15 voyages of the Spacelab module using the space shuttle by the late 1990s. The last Spacelab flight launched in 1998 was dedicated to exploring the effects of weightlessness on the brain and nervous system, especially* balance, sensory integration, sleep, blood pressure control, and the nervous system. The chief findings of Neurolab Mission are discussed below.

Weightlessness

According to scientists the brain has an "internal model" of how gravity works. 'In weightlessness, when the usual clear gravitational sense of up and down disappears, the balance system adapts and establishes a new way to interpret the changed environment'. As a result, the astronauts often have difficulty with balance, after they return to the Earth. "Gravity hurts" said Viktor Alexandrov, astronaut.

Your mind is like a parachute: if it isn't open, it doesn't work---***Buzz Aldrin***

Weight-bearing muscles show profound changes when they have no weight to bear. On Neurolab, an antigravity muscle called the soleus grew poorly in rats 8 days old at launch. Another study found that antigravity muscles were more impaired than muscles used for other tasks. This suggests that weight-bearing activity is essential for muscle development; without it, production of key proteins is slowed.

Research showed that in the rats that had been on the flight, synapses were more numerous in the parts of the brain related to hind limb movement. The data from Neurolab suggested that the flight rats, although deficient in their righting reflex,

Astronaut Bruce McCandless II, participating in a historic spacewalk, is a few meters away from the cabin of the Earth-orbiting space shuttle Challenger on Feb. 7, 1984 (Credit: bing.com)

may be enriched in other areas as a result of the three-dimensional environment in which they grew up.

These discoveries demonstrated that weightlessness could have altered the astronauts' nervous systems, and that weightlessness produced integral changes in the brain itself. They also confirmed how adaptable the brain is. Neurolab studies help us understand what happens to people with disorders that affect balance, such as vertigo, which can occur with strokes and trauma.

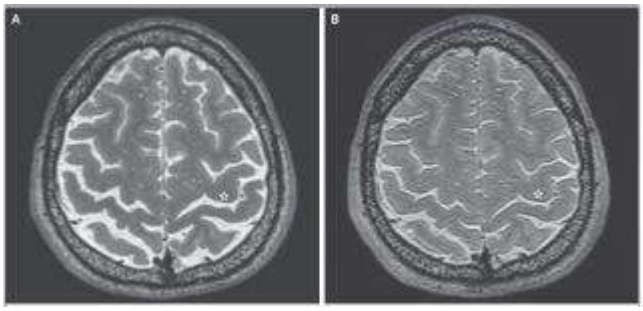
Sensory Integration

According to pubmed.ncbi.nlm.nih.gov more than half of astronauts returning from long-duration missions on the International

Do you think the emptiness of space will ever crumble away? Mountains will crumble, but the emptiness of space, which is one universal essence of mind, the vast awakener hood, empty and awake, will never crumble away because it was never born---Jack Kerouac

Space Station report neuro-ocular structural and/or functional changes, including optic disc edema, optic nerve sheath distension, globe flattening, choroidal folds, or hyperopic shifts. This spaceflight-associated neuro-ocular syndrome (SANS) represents a major risk to future exploration class human spaceflight missions, including Mars missions.

Vision, balance, and sense of position work together to help maintaining equilibrium, movement, and navigation. In space, they lose much of the information



An MRI of an astronaut's brain before (panel A) and after (panel B) a long-duration space fight. (Image credit: The New England Journal of Medicine ©2017)

that the inner ear provided on Earth about movement. This may be compensated by a greater dependence on vision. The study showed that rats and astronauts use visual cues to override the disorientation weightlessness can produce. Said one scientist who was on board in Neurolab---" My brain had adapted in space, and now was ranking visual information much more highly than on Earth" --.

Sleep and Circadian Rhythms Space travel is often associated with poor sleep. This is specially so in short missions. Sleeping medications are among the most common drugs taken in flight.

Neurolab studies therefore, included a comprehensive look at sleep, circadian rhythms, and performance on the space shuttle, including a complete double-blind trial of the hormone melatonin for use in space.

Wrote one of the Astronauts ---"On Neurolab, we did not have a consistent 12 hours each of light and darkness; the sun rose or set every 45 minutes, and the light levels inside the shuttle were dim and often erratic. This made it difficult to keep the body's circadian rhythms linked to the activity schedule on board the shuttle" --

The results showed that

*Mars has been flown by, orbited, smacked into, radar examined, and rocketed onto, as well as bounced upon, rolled over, shoveled, drilled into, baked and even blasted. Still to come: Mars being stepped upon-**Bizz Aldrin***

of the studies the

astronauts had less sleep, and sleep of poorer quality, than on the ground; the reason being their circadian rhythms were out of synchrony with the day and night cycle on the shuttle.

Another study found that, in weightlessness, snoring practically disappeared, probably because without gravity there is no force pushing the tongue or tissues in the neck into the airways.

There was less of a phase of sleep known as the Rapid Eye Movement, or REM, during the mission. Studies upon return to Earth showed that REM sleep increased. It is possible that the brain was making up for lost REM time.

A hormone called melatonin rises and falls on a 24-hourcycle. The spike in its concentration and falling asleep are said to be linked. Therefore, Melatonin might be a way to correct changes in astronauts' circadian rhythms and improve their sleep although some other study showed that Melatonin had no effect.

Blood Pressure Astronauts often have difficulty with blood pressure control after a flight. The brain uses the autonomic system to regulate blood flow by slowing down or speeding up the heart or by constricting or dilating the arteries. It turns out that blood pressure regulation does not change significantly in space.

The ultrasound scan revealed no alteration in the regulation of brain blood flow. After the flight, however, the cardiovascular systems all had to work harder to keep blood pressure constant.

Balance- One of the astronauts who was a part of the Mission wrote **"**Small changes in head position produced exaggerated sensations of motion. Also, my gait was unsteady".

Studies of fish showed that the lack of gravity in flight had caused an increase in sensitivity of the fish's gravity sensors. But by 30 hours after returning, their responses were the same as those of the control fish that had stayed on Earth. This was also true with humans too.

Development in Space A cluster of Neurolab experiments looked at the effect of weightlessness on the development of

*One of the biggest challenges experienced in space is the effect of microgravity. Researchers found that brain adapts to gravitational changes by changing space---**NASA***

gravity sensors and balance systems. One study by Michael Wiederhold and his team showed that snails reared in weightlessness developed more and 50 percent larger gravity-sensing crystals than their Earth-based counterparts.

Crickets brought on board as eggs and at several larval stages produced normal balance organs in space, but the connections these balance organs made further up in the nervous system were different. A study in rats showed similar results.

Perhaps the most striking results were observed in the studies on the development of complex movements, such as walking. These rats may possibly need gravity to develop a normal righting reflex.

Spaceflight experiments showed a dramatic increase in the synapses between hair cells on a study on rats on board. Although the number declined by day 14, Neurolab rats still had more synapses overall than control rats on the ground which is a routine way in which the brain adapts to its environment.

Neurolab studies showed that the brain has astonishing adaptability. The developing nervous system adapts to the influences it receives at particular times in development. After a critical period, however, the opportunity for wide-ranging adaptation fades; changes made during the adaptive period appear to be permanent.

Lessons learned

Some of the research by Neurolab led to important findings about how our brain functions. Neurogenesis (the birth of new neurons) continued throughout life;

- Individual neurons fire together in a highly synchronized way, disruption of which may lead to brain disorders.
- Many of the disturbances that astronauts experience, both in space and upon re-entry, have parallels in common brain disorders.
- The body's internal clock was identified in the brain, and how it operates in accordance with a 24-hour day.
- Both embryonic and adult brains contain stem cells, suggesting that some brain damage may be repaired.
- How the brain adapts to an environment such as weightlessness is important as space exploration moves forward.
- The Neurolab results suggest that only adults should venture into space right now. Long-term

Gravity on earth provides a force that keeps our bones and muscles working. In the microgravity of space, our bones and muscles are not taxed, so they begin to atrophy--- ***Sunita Williams***

colonization of space stations or other planets may have to wait for artificial gravity.

International studies

An international team of Russian and Belgian researchers, which included scientists from the HSE University, RAS Institute of Biomedical Problems, Federal Center of Treatment and Rehabilitation, Lomonosov Moscow State University, Gagarin Cosmonaut Training Centre and several Belgian research organisations, used functional magnetic resonance imaging (fMRI) to measure functional brain connectivity in a group of eleven cosmonauts. The researchers performed brain fMRIs on the cosmonauts before and after space missions lasting on average six months, and then compared their data to those of healthy volunteers who had stayed on Earth.

The team reported their finding that space travel has a significant impact on the brain; that cosmonauts demonstrate changes in brain connectivity related to perception and movement, and that adaptation to microgravity and related changes in motor activity can cause the modifications of functional connectivity, between the brain areas.

Recent Studies

According to a write-up dated 14-4-2020 published in in website www.space.com Astronauts have been reporting issues related to vision after traveling to space. Some experience retinal hemorrhage and other structural changes to their eyes.

Medical evaluations on ground showed swelling of their optic nerves which might have been caused by increased "intracranial pressure," or pressure in the head, during spaceflight.

A study led by Dr. Larry Kramer, a radiologist at the University of Texas Health Science Center at Houston, reported that there was evidence to show that this pressure does, in fact, increase in microgravity (Ref.www.firstpost.com May 16, 2021).

The team performed brain MRI (magnetic resonance imaging), on 11 astronauts (10 men and one woman) both before and after they traveled to space and for up to a year after their return. These MRI images showed that, with long-duration exposure to microgravity, the brain swells and cerebrospinal fluid, which surrounds the brain and spinal cord, increases in

*Our entire biological system, the brain, and the earth itself, work on the same frequencies---**Nikola Tesla***

volume. These findings support the theory that spaceflight increases pressure in the head, which researchers think, could be tied to issues with astronaut vision.

Kramer said that when one is in microgravity, fluids such as blood no longer moves towards the lower extremities but rather redistributes headwords**.** "That movement of fluid toward your head may be one of the mechanisms causing changes we are observing in the eye and intracranial compartment," he added. While chronic exposure to intracranial pressure during spaceflight is a possible factor, the exact causes remain unknown.

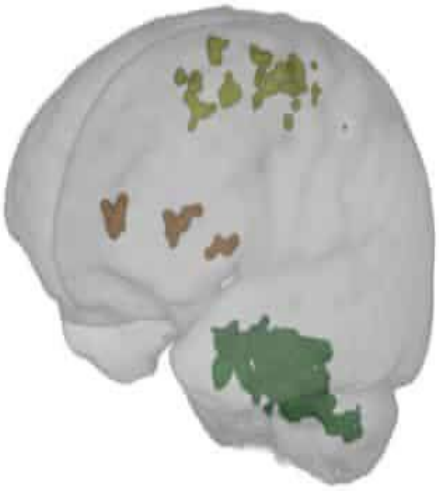
Scientists have found that the pituitary gland, became compressed and it changed in height and shape which is a sign of increased pressure in the head. The researchers also found that these effects, the swelling of the brain alongside the compressing pituitary gland and the pressure in the head, was still present a year after the astronauts returned from space.

Researchers at the University of Antwerpen, Liege and Leuven in Belgium have devised the 'Brain-DTI' study to learn more about how astronauts' brains adapt to spaceflight. "The scans from the astronauts are like lighthouses, illuminating points where problems can be in patients on Earth. Principle Investigator was Professor Floris Wuyts.

An article published on October 25, 2018 in www.nationalgeographic.com too reported the study of Russian space travelers led by scientists at the University of Antwerp, published in the *New England Journal of Medicine*. It documents the impacts of space travel on cosmonauts who each spent roughly 189 days on the International Space Station.

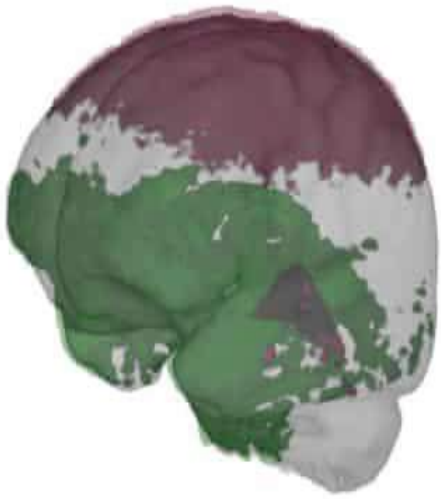
The team captured images of 10 male cosmonauts' brains using magnetic resonance imaging before and after each mission. They repeated the scans seven months later for seven of these cosmonauts.

Weightlessness was wonderful, and I was surprised at how natural it felt---Ron Garan



Net brain tissue increases in three major motor areas after spaceflight: primary motor cortex (yellow), basal ganglia (orange), and cerebellum (green)

Illustrations by Steven Jillings and Ben Jeurissen (University of Antwerp) using MRtrix3 (www.mrtrix.org)



Spaceflight causes a volume redistribution of cerebrospinal with less volume in upper (red) and more in lower parts of t brain (green)

Illustrations by Steven Jillings and Ben Jeurissen (University of Antwerp), using MRtrix3 (www.mrtrix.org)

The latest study suggests that the excess cerebrospinal fluid seems to compress the grey matter in the brain. After seven months on Earth, the brain returned to the earlier position, although some effects reportedly lingered.

The white matter, although initially seemed to be unchanged, but in the months after the cosmonauts' return to Earth, the volume seemed to shrink, the reason being the easing of pressure, and consequent escape of water.

An article published in The Guardian newspaper dated on 4th September, 2020 reported that Analysis of brain scans finds increase in white and grey matter in regions involved in physical movement in the same study; the scans also picked up microstructural changes in three brain regions, namely the primary motor cortex (which sends movement signals to muscles), the cerebellum (which plays a role in fine movements) and the basal ganglia (an area that helps to initiate movements). Some of the changes

*It is possible to preserve your physical and psychological health throughout a mission similar in length to a flight to Mars and back----**Valeri Polyakov, Russian cosmonaut***

were still evident seven months after the cosmonauts returned to Earth.

According to the article, the findings will feed into a project run by the Russian Space Agency, Roscosmos, and the European Space Agency, to understand the impact of spaceflight on the human brain and how to mitigate any unpleasant effects.

How Space flight affects human psychology Astronauts have to undergo rigorous physical, mental, and academic training before space travels. Anxiety disorders,

"Beautiful view. Magnificent desolation."
Buzz Aldrin is an American former astronaut, engineer and fighter pilot.
Aldrin made three spacewalks including -as pilot of the 1966 Gemini 12 mission, and, as Lunar Module Eagle pilot on the 1969 Apollo 11 mission.
As the Lunar Module Pilot of the *Apollo 11* mission, Aldrin became the second astronaut to walk on the Moon on July 21st, 1969. Aldrin's first words on the Moon were "Beautiful view. Magnificent desolation."
He has been accorded numerous honors, including the Presidential Medal of Freedom in 1969.
However, he battled Depression and Alcohol Addiction after the Moon Landing.
"Exhausted and unsure of his future, he struggled with his inner demons"
His autobiographies *Return to Earth* (1973), and *Magnificent Desolation* (2009), recount his struggles with clinical depression and alcoholism in the years after leaving NASA.
(Ref: en.wikipedia.org; www.universetoday.com)

mood disorders, and undesirable personality traits are some of the most common reasons for disqualification during the selection process of ESA, Canadian Space Agency (CSA), and NASA astronauts. Even then psychological problems are reported by astronauts.

Most common are adjustment reactions to the novelty of being in space, with symptoms generally including transient anxiety or depression. Psychosomatic reactions also have been reported, where anxiety and other emotional states are experienced physically as somatic symptoms.

Astronauts are advised to keep calm during space flights. Astronauts are told how to deal with stress and other conditions that might impair the way they perform and the way they interact with

other members of the crew. They are helped by addressing loneliness, and providing better connections with life back home.

The way Forward

There is no doubt that in future human brain and behavior will be a focus area of research during space travel. The experience gained from space flights since 1961 will be of guidance to the astronauts.

At present the spaceships being used are technologically far advanced and superior to anything we have seen so far. Spaceships designed for better, safer, longer and speedier travel will be the new norm. Astronauts will be more comfortable in performing tasks and maneuvering the machines. Spaces missions will be designed in such a way that there will be minimum impact of low gravity and other features specific to outer space on the human body and the mind.

Today cutting- edge research is being carried in the area of Neural Science with the help of more and more sophisticated tools. The path-breaking discoveries being made in the field of neuro-science will impact space travel in an unprecedented way. Unravelling of the mysteries of the brain, especially the neural basis human behavior too will have a lasting impact on space travel.

On the other hand, research into functioning of the brain under space conditions will be a further addition to the knowledge gained on the ground. Difficulties being faced by astronauts will help us in our understanding of brain disorders. Thus, the huge investments made on Space Missions will be of value to the mankind as a whole.

Ref: www.ncbi.nlm.nih. govt; www.firstpost.com; www.the guardian.com; www.dana.org/ www.livescience.com

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*It is easy to sleep floating around---it's comfortable. But you have to be careful that you don't float into somebody or something----**James Irwin***

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***LIFE STREAM** is a quarterly magazine on holistic life published by a group of people who are committed to spreading the message of living in harmony with nature.*

LIFE SCIENCE FOUNDATION

Service in Trusteeship

ABOUT US

The Life Science Foundation is a Not- for- Profit Public Charitable Trust registered on 30th December, 2009. It is a unique initiative by two officers belonging to the Indian Administrative Service (Bihar cadre) namely S. Jalaja and A.N.P. Sinha (IAS-1974) who have retired as Secretaries to Government of India. Their long experience with Governments at the National and State levels have instilled in them the will to continue to serve people, although from a different platform. Service through the medium of a public charitable Trust is in keeping with the Gandhi's ideal of Trusteeship.

OUR VISION

The term Life science encompasses all aspects of life from Right to life- an inalienable right of every human being- to the interconnectedness of the entire web of life. Our vision, therefore, is to promote holistic understanding of life and its purpose, and improvement of quality of life of all.

OUR MISSION

Our mission is to improve quality of life through policy formulation, applied research and real life action. The Gandhian ideals of Sarvodaya and Trusteeship will be the guiding spirit.

OUR AIMS AND OBJECTIVES

To accomplish the above vision and mission, the Foundation will initially have the following aims and objectives. In course of time, more could be included:

1. To promote strategic thinking and suggest policy interventions on holistic and sustainable development.

2. To promote holistic health care system based on simple living, preventive healthcare, and both modern and traditional health systems.

3. To undertake studies, research and action-oriented projects pertaining to holistic life

4. To undertake pilot projects of good governance including e-governance and eventually support the governments in adopting and up scaling successful pilots. .

5. To work towards promoting quality of life of vulnerable sections of population, including women and children.

6. To promote all- round human resource development.

7. To design self- sustaining livelihood projects which minimise subsidies and donor- dependency.

8. To undertake other activities which are conducive to pursuit and fulfilment of the vision, Mission and Objectives of the Foundation.

9. Network with institutions and agencies to achieve the above objectives..
