AMJ Australasian Medical Journal [AMJ 2024;17(9):1238-1243]

Anatomy and Physiology of Brain

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RESEARCH

Please cite this paper as: Akram M, Sfera A. Anatomy and Physiology of Brain. AMJ 2024;17(9):1232-1243.
https://doi.org/10.21767/AMJ.2024.4058

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Abstract

The human brain is the most complex organ in a human's body. A nerve center controlling any thought processes, coordinating muscular actions as well as processing sensory information, makes it work. It connects it with the rest of its areas, trillions of synapses, and the rest with about 86 billion neurons through complex networks. This review entails some simple physiological brain features that include functional domains, neurochemical signaling, and structural structure. The three major macro-regions utilized for unique functions include the cerebral cortex, cerebellum, and brain stem. Higher-order cognitive functions like language, logic, memory, and visual processing are performed by the frontal, parietal, temporal, and occipital lobes of the cerebral cortex. The brain stem controls autonomic activities, breathing, and heart beating. The cerebellum coordinates for performance in motor and balance functions. Neurotransmitters are released at synapses to allow the transmission of impulses between neurons, and neurotransmission is a vital physiological process. Above all, very important neurotransmitters control operations at the neurons' side. These are simple reflexes and complex actions using glutamate as the excitatory neurotransmitter and gamma-amino butyric acid, or GABA, as the inhibitory neurotransmitter. These neurotransmitters are mainly involved with regulatory functions such as regulation of reward mechanisms and mood, besides neuropeptides and neuro-modulators, like serotonin and dopamine. It depends upon neuro plasticity, wherein the brain can reconfigure itself because of new connections between the neurons. Injury, environment, experience, and more modulate the plastic and versatile ability of this particular system. BBB is a protective interface regulating the chemical flux from circulation into the brain to maintain homeostasis. The brain learns and responds to stimuli after some physiological interactions. Therefore, cognitive functions continue through life. Knowing about brain physiology is known to be useful for a comprehension of solutions to neurological problems and therapeutic approaches. The fact being so, research effort, therefore, will continue into the mysteries of activities of the brain to unveil the basic mechanisms underlying alertness, emotion, and consciousness.

Key Words: Motor Function, Cognitive Function, Blood-Brain Barrier, Cerebellum, Learning and Memory

Introduction

The flow of cerebral spinal fluid is allowed by the ventricles. The matrix of ependymal cells along with blood arteries at the surface of the ventricle is termed choroid plexus. This indicates that the ependymal cells of the choroid plexus prepare cerebrospinal fluid. The close association of ependymal cells with blood arteries shows that there is a component known as blood-brain barrier[1]. It is just developed due to the reason that the brain has high oxygen and glucose requirements while blood carries various chemical contents harmful to it as well[2]. BBB of capillaries is due to basal membrane and tight endothelial cells; in choroid plexus the BBB is due to tight junctions between ependymal cells image of the brain stem from the posterior side[3]. The projecting form of the human brain, extending forward over the medulla oblongata; it is the second most superior structure. The pons transmits many signals between the cerebrum and the cerebellum-sleep, hearing, taste, posture. A small tightly folded area, located at the back of the brain, is called the cerebellum, posterior to the pons. It's also hemispheric, but again with a flattened area in the middle which is called the vermis. The grooves are called sulci, and the folds are called folia. The characteristic impression given by the white matter is the arbor vitae, or "tree of life." The cerebellum participates in tactile perception, special perception, and muscular coordination and some coding and planning functions.

Thalamic nuclei: The principal role of this group of nuclei is to relay sensory impulses. More will be said about them in Sensory Units. Other thalamic nuclei are associated with emotions and memory. A group of nuclei under the thalamus is termed hypothalamus. Because the hypothalamus is mainly concerned with endocrine system regulation, we will reserve the details for the Endocrine System study[4]. Other nuclei of the hypothalamus regulate many autonomic functions including emotions, biological rhythms, consumption of food and water, and thermoregulation amongst others. The largest anatomical structure of the human brain is the cerebrum. Lobes comprise the cerebrum[5]. The frontal lobe starts from the frontal bone and extends till as far as central sulcus. It is connected with including memory, mood, emotion, social judgment, aggression, planning, foresight, and voluntary motor processes. The parietal lobe is the top portion of the brain. Between the central sulcus and the parieto-occipital sulcus, the right and the left side of the top part of the brain is bounded. It receives and integrates most sensory information[6]. The temporal lobe on each side manages all that concerns the sense of hearing and smell, learning and memory too as visual recognition and emotional behavior is also found below the parietal lobe and the lateral sulcus[7] The occipital lobe is the farthest from the back of the skull contains the center for vision. The outer lobes or insula are inferior to the group of cortex that comprises the frontal and the temporal lobes[8].

CSF is produced by the ependymal cells that line the ventricles and run along them, covering the whole brain. There exists an inter ventricular foramen located in the mid-brain and which acts as a site to which the lateral ventricles drain. It passes down through the cerebral aqueduct towards the fourth ventricle. Then by passing either of the two openings or passing through a hole at the center, CSF fills the subarachnoid space and eventually gets reabsorbed[9]. This is where CSF is reabsorbed and subsequently drains into the venous circulation.

Meninges are attached tissue covering and partially protecting the brain just as they do the spinal cord[10]. The outermost layer encasing the skull bones, the innermost layer resting against neural tissue form three membranes referred to as dura mater, arachnoid mater, and pia mater. The dura mater splits in to two layers forming the meningeal layer, and attached to the bones of skull in its outermost layer. Whereas at some localities at the place of dural space, blood collecting or sinus is also possible to take place, while sometimes along with it subdural or alternatively a sub arachnoid space are also found to take place.

Meninzes: Cerebrospinal fluid, or CSF for short, is a colorless fluid that fills spaces surrounding the outer part of the brain. It is continuously created and circulated through the ventricular system where it is constantly being absorbed again. There are two basic ways by which CSF both floats and supports the brain: buoyancy and by removing the waste products and nutrients carried in chemical balance of the brain. The areas of the forebrain generally involve complex mental activities. Most of these regions were established based on the experiments involving the patients that have lesions in such regions who were found to have a deficit in one of this functions[11].Brain lateralization is the area between the left and right hemispheres, which controls most activities. Despite the right hemisphere retaining abilities in spatial and haptic behaviors, the left hemisphere generally is stronger in motor mathematical and linguistic skills. This body part that connects both hemispheres is referred to as the corpus callosum. That consciousness, thought knowledge and memory awareness, is labeled as cognition[12].It is generally defined as the integration of the motor and sensory systems. The majority of the brain regions used in thinking is in the cerebral lobes. Hippo cam pal region is one of the major centers for the production of memory[13].

Motor Function

It cannot perform its daily life without the use of motor skills. Motor skills are the movements our bodies undertake while going about doing daily things such as moving around, picking things, writing, talking, and so on. The development of motor skills in adult begins at birth and develops well in childhood and even progresses to young adulthood. There are two main types of motor skills that include gross and fine motor ability. All these have to be achieved for smooth mobility. Gross motor skills involve limbs, legs, and parts of the trunk during movement. Fine motor skills comprise minor muscle groups just like in hand and wrist movements. Another category apart from gross and fine motor skills includes closed, open, serial and discrete motor. Those that can be performed in a controlled as well as predictable environment have been classified as closed motor skills. Open motor skills: These are used in an unordered, predictable environment. The discharge is fast and goal oriented. Serial skills are actually a series of separate movements. A more detailed description of these different types of talent can be seen below. It is on these boundaries defining the organization and production of movement that has been approached by the study of motor control with an incredibly wide range of disciplines, including psychology, cognitive science, biomechanics, and neuroscience. While describing human movement control during early days of the 19th and 20th century, various models of motor control surfaced. Not very specific is what one learns in acquiring particular skills and what would be the best techniques for the development of abilities. Theories of Motor Control to be addressed Generation of Reflexive, Automatic, Adaptive, Voluntary Movements Generation of Effective, Well-coordinated, Goal Oriented Movement Patterns; Using systems of Input, Output and Central Processing; also levels of the nervous system. This will very simply provide an approach to a motor control systems approach integrating neurophysiology, biomechanics, and principles of motor learning-solutions based on the interaction between the patient, the task, and the environment. This consideration from the relation between the task and the environment while designing our treatments is going to become all the more crucial in enabling our patients to achieve their own objectives. Although it is learned complex process yet, it occurs within the central nervous system as an outgrowth from experience or training to perform one skill that may be novel but entails modification of the central nervous system. Motor learning facilitates the production of new skills, such as movement, or of skills consisting of some amount of movements to flow or be performed efficiently. This is an essential process in the instantiation of controlled movement and in fine-tuning simple movements such as reflexes. Research into motor learning measures the components that may constitute motor programs, including the sensitivity of error detection processes and the strength of movement schemas. Motor learning is practice, feedback, and knowledge of results-dependent. The skills through which a person walks, rides on a bicycle, surfs, jumps, sprints, and even weight lifts are motor skills. Here, a person performs voluntary movements of his or her joints and body parts for some kind of an intended goal. Movement scientists refer to the whole process of acquiring and applying those skills as motor learning and control or skill acquisition. For the most part, exercise and rehabilitation of those capabilities following total knee replacement or stroke therapy depend on research into motor learning and control. According to Roller et al., after the body has received sensory input about surroundings and interpreted it then selected the best movement plan which will enable the accomplishment of the task goal. Technique is complete Motor neurons of CNS in the brain stem and spinal cord carry out this act. This act is then conveyed to the muscles by postural and limb synergies. However, in the head, there is integration of motor units; hence they are activated in an orderly sequence[14].

Cognitive Function

Perhaps, this is only because digital evaluation of cognitive functioning deserves special attention as the most advanced in application in clinical research and healthcare, hence easily available owing to several commercial initiatives. This is partly because classical paper-based cognitive tests, a little similar to questionnaires for patient reports, have proved to be relatively easy to digitalize and can be administered by PCs, tablets, and smart phones. Indeed, at times it has promoted the emergence of digitalized creativity that has even made more enjoyable the cognitive exams in comparison with their equivalent counterpart traditional paper-and-pencil assessment. Other than performance-based cognition measures, many of the above tools have been proven to be either a direct manifestation of cognitive function or cognitively related. The most common of these, however, has been text or speech data for the extraction of language features that represent or correlate with cognitive function. Indeed, speech feature experiments that depend on those experiments to get the features have shown that speech may be a good marker of important cognitive decline in Alzheimer's patients years before diagnosis.

According to, cognition is the ability to perceive and react, process and understand, decide, and produce appropriate responses to the environment. Although most SMI patients-major depressive disorder, spectrum schizophrenia, and bipolar disorder-have compromised cognitive functioning that can result in several concomitant impairments, including socially and occupationally, as well as the often-mourning reduced quality of life. Probably one of the most acceptable goals of treatment when dealing with these common disorders is the cognitive functioning improvement of patients. Even though exercise has been found to affect cognition in clinically meaningful ways, psychotropic medication has comparatively few effects on cognition in most patients with SMI. Cognitive functioning refers to the strategies about learning and memory as well as the thought processes of an individual. Although some portion of such age-related decline would be within cognitive ability, greater extreme transformation is very likely to be concurrent with the destruction of one or another type of physiological functioning. However, mild cognitive impairment does not damage that functionality in the critical sense-permitting a person to operate appropriately any everyday activity those performances serve as the core of appropriate, effective behavior in everyday life. Disability may also not vary or decline. At times, it can be in its worst forms whereby an individual may be developing towards dementia. This will change the personality, behavioral trends, and the cognitive performance of an individual. Some of the lifestyle interventions include exercising on a regular basis, healthy dieting, treatment of body and psychiatric condition, and even sleeps. Improve cognitive function. Some of the pharmacological interventions include enhanced cognitive abilities. Other non-pharmacological interventions include non-invasive brain stimulation or cognitive rehabilitation training. This is known as mild cognitive impairment, abbreviated as MCI, where there is partial loss of memory or disruption of cognitive function. Such individuals begin shortly to lose things or even to become senile. Mild cognitive impairment does not incapacitate an individual's ability to perform his day-to-day activities; however, it brings enormous and conspicuous changes in that person and in the family members. According to 2023 Trusted Source, mild or even severe cognitive impairment can also be termed as cognitive decline. This weakness may also be one of the earliest signs but this may not have a relation to some particular disease. It can be permanent or simply progressive. According to the estimates by the National Institute on Aging of older persons aged 65 years or more who have moderate cognitive impairment, 10 to 20 percent ultimately developed dementia in a year. However, symptoms of mild cognitive impairment are usually not progressive[15].

Blood-Brain Barrier

The BBB is a border semipermeable, which comprises endothelial cells selectively regulating flow solutes and chemicals into the circulatory and central neurological systems from harmful or undesirable substances in the blood. The blood-brain barrier might be defined as the astrocyte end feet surrounding the capillary, pericytes that reside imbedded in the basement membrane of the capillary, and endothelial cells composing the capillary wall. This transport is active and selective for many nutrients, ions, organic anions, macromolecules including glucose and amino acids required for neuronal activity and indeed some small molecules that diffuse pacifistically. It excludes the diffusion of large or hydrophilic molecules, pathogens as well as blood solutes, but allows small nonpolar molecules and hydrophobic ones like (O_2, CO_2, hormones) to pass to the cerebrospinal fluid. The barrier cells actively transport metabolic products across the barrier cells consisting of glucose in combination with specific transport proteins. This means that all the pathogens and the immune cells, antibodies, and signaling molecules cannot be able to penetrate the CNS, hence it protects the brain from the peripheral immunological reactions. The inner lining of the blood vessels of the brain is covered with a barrier, known as BBB. It's rather a critical part in the functioning of the nervous system as well as the brain. Although the term "barrier" was used, it is basically covered, and as a function, it acts to act like a filter; it allows useful contents in while keeping dangerous ones out. It is also endothelium layer of special cells found inside blood arteries which regulates which of the chemical molecules come into the brain or go out from the brain, naturally made by or needed by the body. Now, in the brain it is different. The endothelial cells fill up the blood arteries in the brain from inside their walls creating the blood-brain barrier. As they pack so tightly together, there is little or no room between them in which anything can filter through unless assisted. It is composed of lipids as their outer membrane. Small enough, some molecules can be squeezed through the blood-brain barrier. Other molecules are permitted to do this due to their solubility in lipids which enables them to pass through the blood-brain barrier unrepelled. Other molecules are just too small or too soluble and cannot get across the blood-brain barrier individually. Large molecules are just too big to fit through the interlocking endothelial cells of the blood-brain barrier. Since lipid-based cell membranes repel water-soluble molecules, for large or water-soluble molecules, such as nutrients, to be able to cross the blood-brain barrier, one transport mechanism must exist. More drug classes can penetrate the blood-brain barrier but the list above contains mostly pharmacological classes that can do so. Because the list of substances that can penetrate the blood-brain barrier is huge, drugs in those classification categories listed above represent only a small fraction of all substances that can penetrate the blood-brain barrier. With computer programming and highly complex algorithms, it has been possible to know or even predict which chemical substances can penetrate the blood-brain barrier. Such approaches have led to a list of about 5,000 chemical drugs, or pharmaceuticals that either may or can cross this blood-brain barrier. The system is no system, but the blood-brain barrier is perfectly tight. Inflammation can compromise its integrity. And probably as a secondary effect of other diseases, therefore the dangerous chemicals or pathogens can penetrate through to the brain; it could also make some treatments, for instance antibiotics as penicillin, more active in treatments for the infection in the brain. Both acute and chronic diseases are associated with a disruption of integrity of the blood-brain barrier[16].

Cerebellum

Sited at the back of the skull, almost at a line equal to or above the surface where the spinal cord articulates with the cerebrum is that part of the brain referred to as cerebellum. The origin of the term "cerebellum" originates from Latin terminology meaning little brain. Long many scientists for many years believe that the little brain would work in a p

acy manner on muscular contractions. It is the latest in technical advancement that the scientists have been enlightened on better matters. Today, scientists know very few ideas about most aspects of the cerebellum, especially about its interaction with the rest of the neurological system. Over 200 years ago, researchers started noticing the cerebellum in damaged humans and animals. They determined that such an individual could not stand upright or sit upright or sit up or even stretch out to grab something because their arms would not stretch out to seize the thing they stretched to reach for. The scientists soon realized that damage to the cerebellum was far beyond over. They also discovered that deficits could take away the ability of a person to learn new words or skills. Damage to the cerebellum could impair judgment as to whether the size or distance of an object in question would allow for more precision. This might also impair your sense of time. For instance, individuals whose cerebellum has been impaired often cannot tap their fingers in rhythm and repeat it rhythmically several times. The tapping is normally too early or too late amongst beats. For over six decades, scientists assumed that the largest portion of the cerebellum was meant to control muscle contraction. Technologically, this highly recent innovation acquired much more knowledge about the cerebellum than what the experts previously knew. Much of the parts of the cerebellum, especially the connectivity with the rest of the nervous system are not well understood by several species of scientists, but technological advancement also fostered the understanding of the cerebellum among experts. Now researchers can now view the activity in the brain of a human individual carrying out specific tasks. They have so far discovered that the activity of the cerebellum is task-related. They also established the connectivity with emotion and decision-making and the cerebellum. There are people who were born with no cerebellum, or agenesis of the cerebellum. This is a very rare disease. Most suffering humans develop mild symptoms of the disorder and, therefore, can walk and live like other mortals. Some serious manifestations can keep them under full-scale medical care throughout their lives. Only within limits can people surmount substantial diseases or traumas to assault the cerebellum. Often long-term effects do happen. The nervous system includes the nerves, spinal cord, and brain. These are unique cells known as neurons. Even though the cerebellum accounts for only 10% of the total space in the brain, it houses close to half of all the neurons contained in the entire body. The cerebellum is also incredibly heavy. It is composed of an accordion sheet of brain tissue. When flat, it is almost no more than 3 by 4 feet. The more facts that pop up about the topic we learn much more about the function of the cerebellum in the brain. Developments in the knowledge of medical science and technology have enabled doctors to identify and cure many diseases affecting the body with much precision. But the small, mighty part of the brain, which is this, requires a lot of scientific study. The cerebellum lies above the medulla oblongata beneath and posterior to the cerebral hemispheres. It allows muscle responses to occur in coordination with sensory input. The signals from the cerebellum indicate the degree of contraction and the timing for every individual fiber, fine-tuning the balance and posture so large masses of muscles can move smoothly and with coordination in voluntary movements. Therefore, the cerebellum is seen as an integrator of impulses from the muscle positional sensors and the labyrinths of the ear.

In many ways, the cerebellum is very similar to the brain, in that it has two lateral hemispheres joined by the vermis or midline portion. Each hemisphere of the cerebellum has three lobes and a white matter core centrally with gray matter superficial cortex. This is the first of the structures formed in the cerebellum. Nerve impulses from the vestibules of the ear go to the flocculonodular lobe, from the spinal cord, to the front lobe, and from the cerebrum, to the posterior lobe, which forms last. All of these nerve impulses are dealt with in the cerebellar cortex. There are three pairs of bundles of nerve fibers. These are superior, middle, and inferior peduncles which are connected with midbrain; it connects cerebellum with it and both the sides interchange their messages between cerebellum[17].

Learning and Memory

To give them a more general applicability at least for now, we broadly define learning and memory knowing is acquired through "learning", and knowing is stored in "memory" as long as a lifetime remembering one's name or as short as a few seconds as, for example, ordering pizza by phone. There are two things you should remember. First, memory and learning are not immediately visible. All such states must be inferred from behaviour. It therefore logically follows that simply placing a subject in a learning environment-for example, by repeatedly pairing a stimulus with a reinforcement-is not evidence, in itself, of the claim that learning has occurred. Instead, one must infer the occurrence of learning only when some change is found in behaviour[18]. Since behavioral confirmation is demanded, then brain plasticity cannot be. It should be a substrate of memory and learning rather than deciding whether something has been learnt. Other causes of a change in behaviour-if they exist other than information acquisition and storage-are eliminated because learning and memory are based on behaviour. These include changes in the general level of arousal or activity of the subject, history of exposure to drugs, capability of sensing, and ability of motor action. Much of the research into brain learning is on association between two or more stimuli, experiences, or events-that is, association learning. For example, when there are patterns in experience such as sound predicting another event, then one can make an association so that the sound forecasts-and perhaps remind of or conjure up a picture of-the second event. That is the classical example-when hearing a car horn, the next anticipation is to see it. In this fairly passive role of consumers of inputs, possibly the best predictors those individuals and other animals might have about events and even their own behavior could be by exploiting the fact that such predictive associations are random yet constant[19]. Such laboratory models of natural contingencies include classical, or Pavlovian, conditioning, in which the stimulus is always followed by the experience, and instrumental/operant conditioning, in which a behavior is always followed by some event, such as a reward. To make them broadly applicable for now, we define learning and memory as follows: knowledge is acquired through "learning," and knowledge is stored in "memory" for as long as a lifetime (remembering one's own name), or as short as a few seconds (like ordering pizza by phone). There are two things you should remember. First of all, memory and learning are not immediately visible. They can only be inferred from behavior. Thus the fact that placing a stimulus in a learning environment-for example, the repeated presentation of a sound followed by a reward-proves nothing about the belief that learning has actually occurred. Instead, one must infer learning from changes in behavior[20]. Because demand itself bars the existence of being, it is impossible to ascribe this to brain plasticity because it acts as a subtended substrate of memory and learning, rather than something one could use as proof of learning. Other potential explanations for the behaviour change — again, acquisition and storage of information excepted need to be ruled out since behavior per se carries no independent implication regarding causality about learning and memory. These are non-specific changes of arousal level or activity of the patient, drug exposure history, sensory ability and motor function capacity[21].

Conclusion

The anatomy of the brain as evidence of the complexity as well as diversity. The networked plus specialized regions which make up the outline of the structural layout stand in great co-ordination of the structural layout, cognitive ability plus sensory information in regions. Notable diversity of neurotransmitters identified forms the basis of neurotransmission driving not just neuronal communication but also moods and behaviors. Furthermore, the fantastic neuronal plasticity of the brain underlines the extent to which it is plastic in its experience and obstacles in a manner that learning and environment do play a particularly key role in the development of neural connections. Thus, blood-brain barriers constitute very crucial parts of ensuring healthy brains and optimal workings of such a complex system. This is also indispensable not only because it contributes toward a more profound understanding of human behavior and cognitive ability but also in providing worthwhile formulations for remedial measures regarding neurologic conditions as well.

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Received: *24-Oct-2024, Manuscript No. AMJ-24-4058;* ***Editor assigned:*** *25-Oct-2024, PreQC No. AMJ-24-4058(PQ);* ***Reviewed:*** *28-Oct-2024, QC No. AMJ-24-4058;* ***Revised:*** *29-Oct-2024, Manuscript No. AMJ-24-4058(R);* ***Published:*** *31-Oct-2024*