Chemistry of Human Brain and Brain Health

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Human brain is the most complicated part of the body which controls every process that regulates the body. It is the command center for the nervous system. Nervous system is a complex network of nerves and specialized cells called neurons. Brain along with the spinal cord form the Central Nervous System (CNS) and the neurons throughout the rest of the body form Peripheral Nervous System (PNS). Neurons use electrical impulses and chemical signals, called neurotransmitters, to convey information throughout the CNS and PNS.

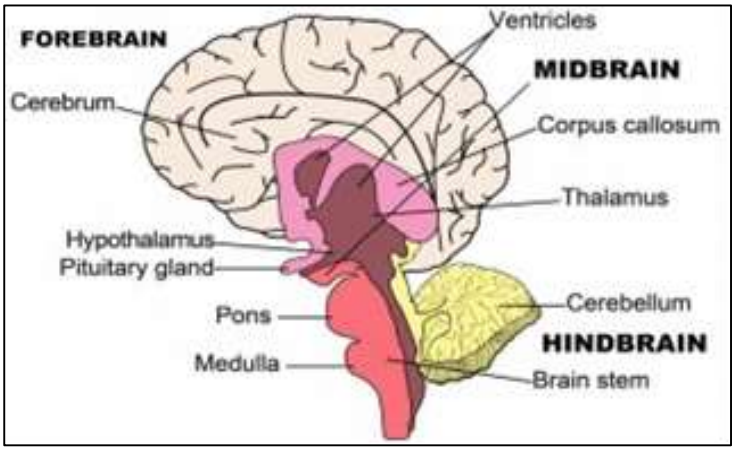

Fig.1: Anatomy of human brain

These chemical messengers of the body are located in a portion of the neuron known as the axon terminal and are stored within thin-walled sacs called synaptic vesicles. Each vesicle can contain thousands of neurotransmitters. As a message or signal moves along a neuron, the electrical charge of the signal causes the vesicles to combine with the membrane of the neuron. Those messengers are then released from the axon terminal into a fluid-filled space that's between one neuron and the next target cell (another neuron, muscle cell or gland) and called synaptic junction. Each type of neurotransmitter lands on and ties up with a specific receptor on the target cell just like a key that can only suit its partner lock. Neurotransmitter then triggers a change or action in the target cell like an electrical signal in another nerve cell, a muscle contraction or the release of hormones from a cell in a gland.

After delivery of messages, the molecules must be cleared from the synaptic junction. They do this in one of the three means namely by the process called diffusion where the neurotransmitters fade away or by reuptake where those messengers reabsorbed and reused by the neurone that released it or by degradation where they are broken down by enzymes within the synapse and thus it can't be recognized or bind to the receptor cell.

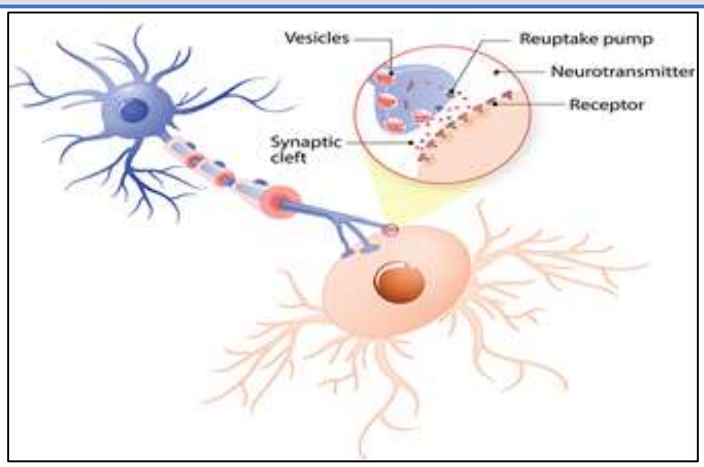

Fig.2: Anatomy of neuron

Some of the better-known categories of neurotransmitters based on their chemical nature are:

I. **Amino acid neurotransmitters:**
These neurotransmitters are involved in most functions of the human nervous system. Glutamate, GABA and Glycine are under this category.

i. **Glutamate:** It plays a crucial role in cognitive functions like thinking, learning and memory.

Fig.3: Chemical structure of Glutamate

ii. **Gamma-aminobutyric acid (GABA):** It regulates brain activity to prevent problems in the areas of anxiety, irritability, concentration, sleep, seizures and depression.

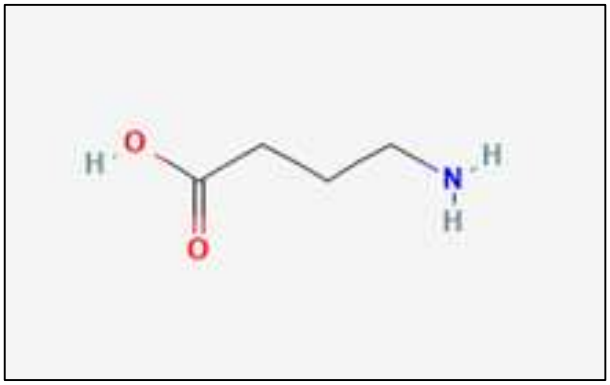

Fig.4: Chemical structure of GABA

iii. **Glycine:** Glycine is involved in controlling auditory processing, pain transmission and metabolism.

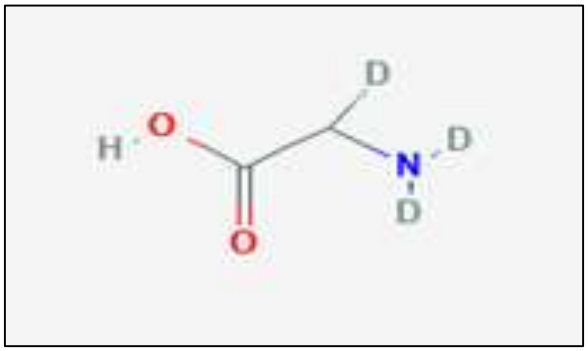

Fig.5: Chemical structure of Glycine

II. Monoamine neurotransmitters:

These neurotransmitters regulate consciousness, cognition, attention and emotion. Serotonin, Histamine, Dopamine, Epinephrine, Norepinephrine are of this category.

i. **Serotonin:** Serotonin helps regulate mood, sleep patterns, anxiety, appetite and pain.

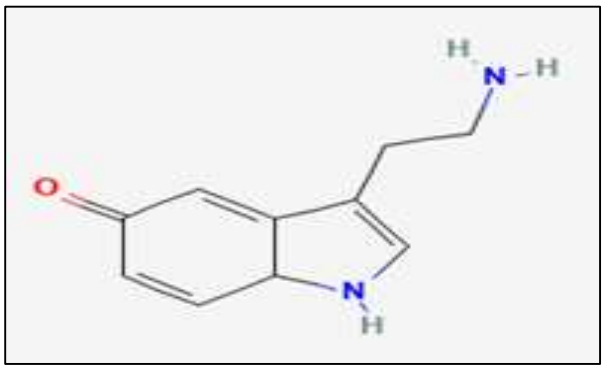

Fig.6: Chemical structure of Serotonin

ii. **Histamine:** Histamine regulates body functions including wakefulness, feeding behaviour and motivation. Histamine plays a significant role in asthma, bronchospasm, mucosal edema and multiple sclerosis.

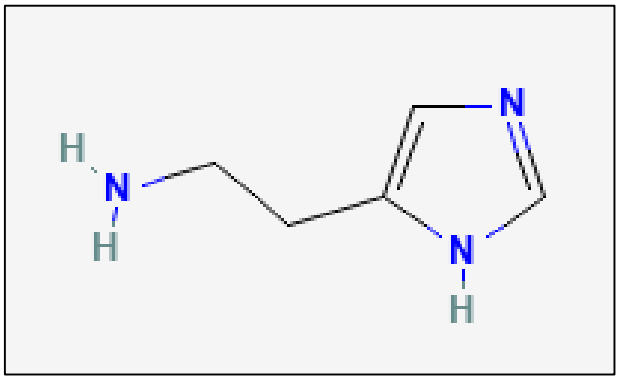

Fig.7: Chemical structure of Histamine

iii. **Dopamine:** Dopamine mediated a critical role in the body's reward system, which incorporates emotion, happiness, attaining intense arousal and learning. Dopamine also helps with focus, concentration, memory, sleep, mood and motivation.

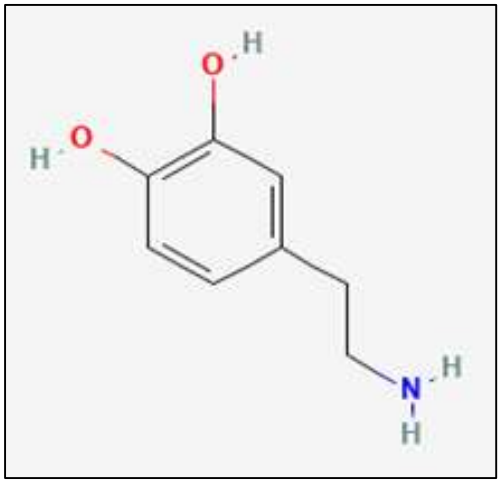

Fig.8: Chemical structure of Dopamine

iv. **Epinephrine:** Epinephrine also called adrenaline and norepinephrine are behind the body's commonly named "fight-or-flight response" to fear and stress. These neurotransmitters stimulate the body's response by increasing the heart rate, breathing, blood pressure, blood glucose and blood flow to the muscles, as well as elevate attention and focus to allow someone to act or react to different stressors.

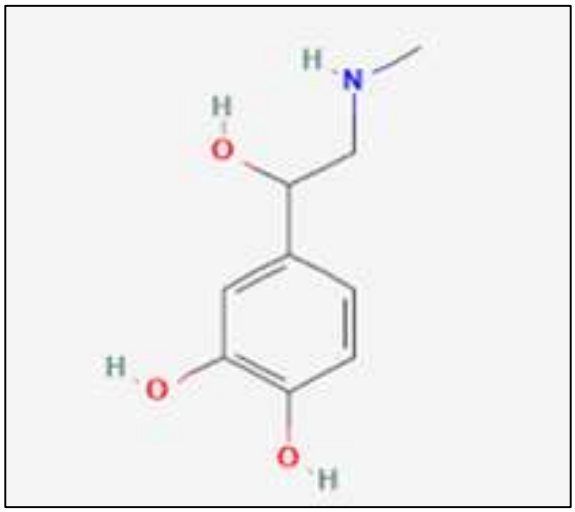

Fig.9: Chemical structure of Epinephrine

v. **Norepinephrine:** Norepinephrine (also called noradrenaline) elevates blood pressure and heart rate. It's most widely known for its effects on alertness, arousal, decision-making, attention and focus.

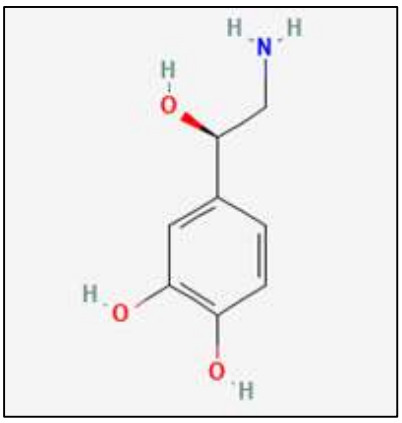

Fig.10: Chemical structure of Norepinephrine

III. Peptide neurotransmitters:

Peptides are polymers or chains of amino acids. Endorphins and Acetylcholine fall into this category.

i. Endorphins: Endorphins are body's natural pain killer. They perform a role in the perception of pain. Release of endorphins reduces pain, as well as causes "feel good" feelings.

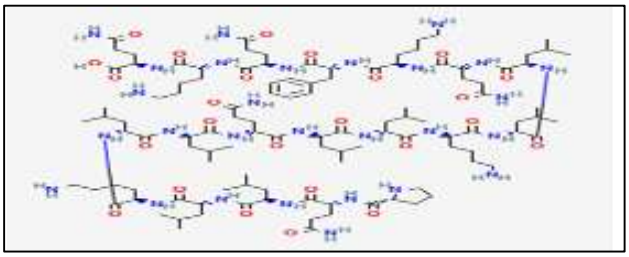

Fig.11: Chemical structure of beta Endorphin

ii. Acetylcholine: Acetylcholine is secreted by most neurons in body's autonomic nervous system regulating heart rate, blood pressure and gastrointestinal motility. Acetylcholine plays a significant role in muscle contractions, memory, motivation, sleep and learning.

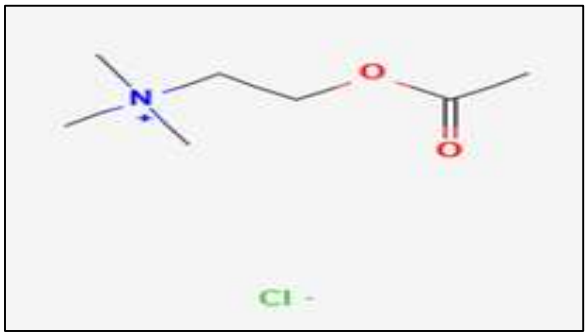

Fig.12: Chemical structure of Acetylcholine

Some of the consequences of chemical imbalances in brain are:

- **i.** Excessive epinephrine can result in hypertension, diabetes, heart disease and other health issues.
- **ii.** Acetylcholine levels are associated with health problems including Alzheimer's disease, seizures and muscle spasms.
- **iii.** Low levels of endorphins may lead to fibromyalgia and some types of headaches.
- **iv.** Imbalances in glutamate levels are connected to Alzheimer's disease, dementia, Parkinson's disease and epilepsy.
- **v.** Diseases associated with serotonin imbalance include Seasonal Affective Disorder (SAD), anxiety, depression, fibromyalgia and chronic pain.
- **vi.** Dysfunctions of the dopamine system can cause bipolar disease, schizophrenia, Parkinson's disease, Restless Legs Syndrome (RLS) and Attention Deficit Hyperactivity Disorder (ADHD).

These imbalances can be corrected by pharmaceutical drugs which can block the enzyme that degrades messengers. Public awareness must be generated to solve the problem to a greater extent.

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