

# Neurotransmitters and their Impact on Mental Illness

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**Abstract:** Neuro transmitters play an important role in balancing our daily life. The impacts of neuro transmitters influence physical and mental behaviour. The neurons inside of the central and peripheral nervous system are responsible for all human activity. A neurotransmitter is a chemical that is released by a neurons terminal button. Neurotransmitters have either an excitatory or an inhibitory effect on the other nearby neurons. Neurotransmitters are very important part of the CNS because they allow communication to occur inside neurons as well as between neurons. This article reviews about the four primary neurotransmitters - acetylcholine, dopamine, GABA and serotonin, their impact on mental illness and rebalance them effectively.

**Keywords:** Neurotransmitters, central and peripheral nervous system, excitatory effect, inhibitory effect

## 1. Introduction

Neurotransmitters are chemical messengers that transmit signals from a neuron to a target cell across a synapse. Target cell may be a neuron or some other kind of cell like a muscle or gland cell. Necessary for rapid communication in synapse. Neurotransmitters are packaged into synaptic vesicles – presynaptic side of a synapse.

## 2. Definition

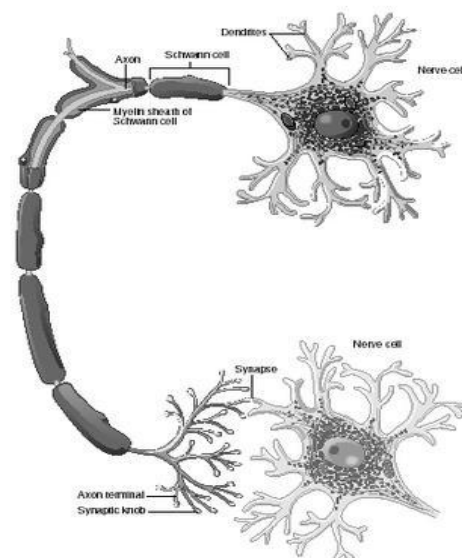
Neurotransmitters are chemicals located and released in the **brain** to allow an impulse from one nerve cell to pass to another nerve cell.

## 3. Description

There are approximately 50 neurotransmitters identified. There are billions of nerve cells located in the brain, which do not directly touch each other. Nerve cells communicate messages by secreting neurotransmitters. Neurotransmitters can excite or inhibit neurons (nerve cells).

The human brain is composed of roughly 86 billion neurons. These cells communicate with each other via chemical messengers called neurotransmitters. Some common neurotransmitters are Acetylcholine, Norepinephrine, Dopamine, Serotonin and Gamma amino butyric acid (GABA). Acetylcholine and Norepinephrine are excitatory neurotransmitters while Dopamine, Serotonin, and GABA are inhibitory neurotransmitters. Each neurotransmitter can directly or indirectly influence neurons in a specific portion of the brain, thereby affecting behaviour.

## 4. Structure of Neuron



Neurotransmitters are chemicals that transmit messages from one nerve cell (neuron) to another. The nerve impulse travels from the first nerve cell through the axon—a single smooth body arising from the nerve cell—to the axon terminal and the synaptic knobs. Each synaptic knob communicates with a dendrite or cell body of another neuron, and the synaptic knobs contain neurovesicles that store and release neurotransmitters. The synapse lies between the synaptic knob and the next cell. For the impulse to continue traveling across the synapse to reach the next cell, the synaptic knobs release the neurotransmitter into that space, and the next nerve cell is stimulated to pick up the impulse and continue it, in a structure called the postsynaptic membrane of another nearby neuron.

Once the neurotransmitter is picked up by receptors in the postsynaptic membrane, the molecule is internalized in the neuron and the impulse continues. This process of nerve cell communication is extremely rapid.

Once the neurotransmitter is released from the neurotransmitter vesicles of the presynaptic membrane, the normal movement of molecules should be directed to

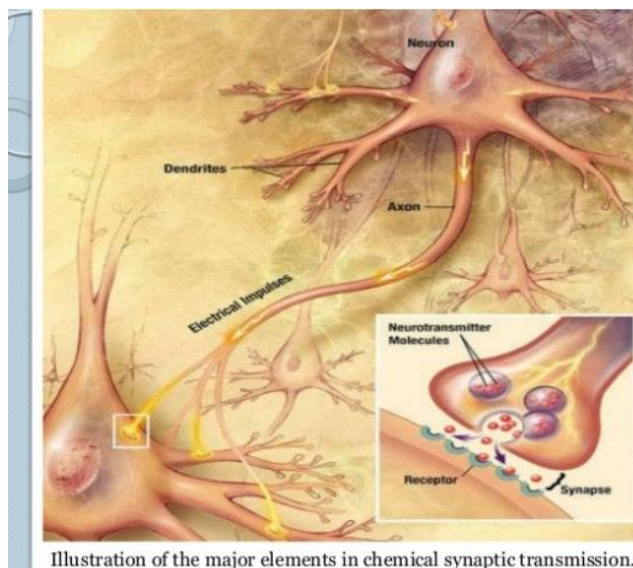
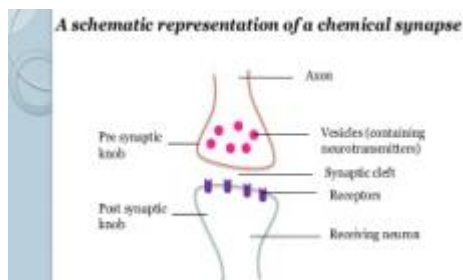
receptor sites located on the postsynaptic membrane. However, in certain disease states, the flow of the neurotransmitter is defective. For example, in depression, the flow of the inhibitory neurotransmitter serotonin is defective, and molecules flow back to their originating site (the presynaptic membrane) instead of to receptors on the postsynaptic membrane that will transmit the impulse to a nearby neuron.

The mechanism of action and localization of neurotransmitters in the brain has provided valuable information concerning the cause of many mental disorders, including clinical depression and chemical dependency, and in researching medications that allow normal flow and movement of neurotransmitter molecules.

### 5. Mechanism of Impulse Transmission

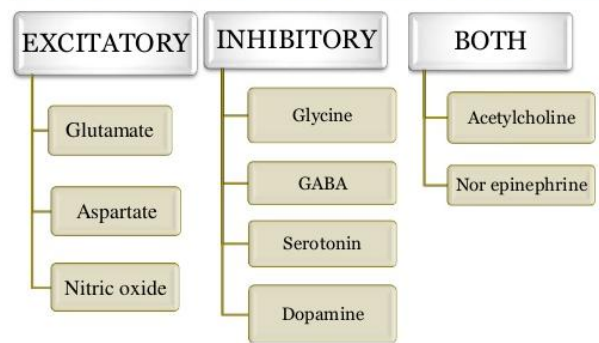
A nerve impulse travels through a nerve in a long, slender cellular structure called an axon, and it eventually reaches a structure called the presynaptic membrane, which contains neurotransmitters to be released in a free space called the synaptic cleft. Freely flowing neurotransmitter molecules are picked up by receptors (structures that appear on cellular surfaces that pick up molecules that fit into them like a "lock and key") located

### 6. Chemical Synapse



### 7. Types of Neurotransmitters

#### TYPES OF NEUROTRANSMITTERS

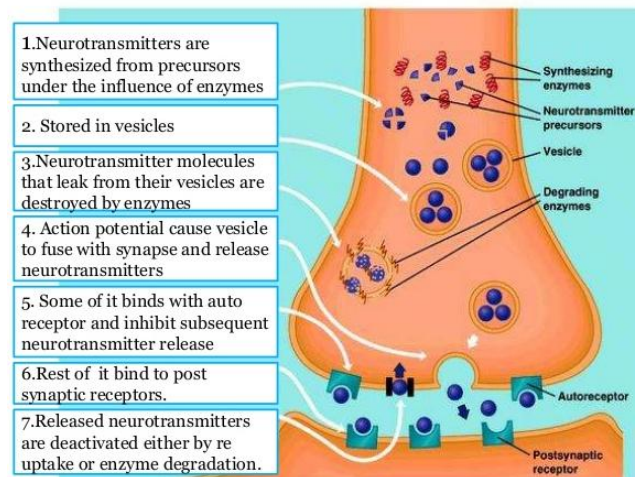


### 8. Know Your Neuro Transmitters

Many brain and memory supplements include ingredients such as aminoacids,herbs and vitamins that are designed to boost the production of one or more neurotransmitters.

- 1) If you don't know which neuro transmitters you need to boost,you might well taking substances that could make your imbalance even worse
- 2) When all neuro transmitters are important ,the big four are SEROTONIN,DOPAMINE,ACETYLCHOLINE and GABA.

#### ► Seven Processes in Neurotransmitter Action



### 9. Causes of Neuro Trans Mitter Depletion

- 1) Chronic stress
- 2) Poor diet
- 3) Environmental toxins
- 4) Drugs
- 5) Alcohol,Nicotine and Caffeine can cause neuro transmitter depletion.

### 10. Neurotransmitters in CNS

Cholinergics	Location/Function	Implications For Mental Illness
<b>1.ACETYL CHOLINE</b> was the first neurotransmitter discovered in 1921 by Ottolowewi (German biologist)	<b>ANS:</b> sympathetic and parasympathetic nerve terminals, parasympathetic post synaptic nerve terminals <b>CNS:</b> Cerebral cortex,hippocampus,limbic structures and basal ganglia	<b>INCREASED LEVELS-</b> Depression  <b>DECREASED LEVELS-</b> Alzheimers disease,Huntingtons disease and

	<b>FUNCTIONS:</b> Sleep,arousal,pain,perception,movement, memory.	parkinsons disease.
<b>II. Monoamines</b> <b>A.NOREPINEPHRINE</b> Is strongly associated with bringing our nervous system into "high alert"	<b>ANS:</b> Sympathetic post synaptic nerve terminals <b>CNS:</b> Thalamus,hypothalamus,limbic system,hippocampus,cerebellum,cerebral cortex. <b>Functions:</b> Mood,cognition,perception,locomotion,cardio vascular functioning,forming memories, sleep and arousal.	<b>DECREASED LEVELS-</b> Depression  <b>INCREASED LEVELS-</b> Mania,anxiety and schizophrenia.
<b>B. DOPAMINE</b> generally involved in regulatory motor activity in mood, motivation and attention	Frontalcortex, limbic system, basal ganglia, thalamus, posterior pituitary and spinal cord.  <b>FUNCTIONS</b> Movement and co-ordination,emotions,voluntary judgement and release of prolactin.	<b>DECREASED LEVELS</b> Parkinsons disease and depression  <b>INCREASED LEVELS</b> Mania and schizophrenia
<b>C.SEROTONIN</b>	Hypothalamus,thalamus,limbicsystem,cerebral cortex,cerebellum,spinal cord <b>FUNCTIONS</b> Sleep and arousal,libido,appetite,mood aggression,painperception,coordination,judgement.	<b>INCREASED LEVELS</b> Mania and schizophrenia and anxiety.  <b>DECREASED LEVELS</b> Depression and parkinsons disease.
<b>D.HISTAMINE</b>	<b>FUNCTIONS:</b> Wakefulness,painsensation and inflammatory response	<b>DECREASED LEVELS</b> Depression
<b>III. Amino acids</b> <b>A.GAMMA-AMINOBUTYRIC ACID (GABA)</b>	Hypothalamus,hippocampus,cerebellum,basal ganglia,spinal cord. <b>FUNCTIONS:</b> Slowdown body activity.	<b>DECREASED LEVELS</b> Huntingtons disease,anxiety disorders,schizophrenia and various forms of epilepsy.
<b>B. GLYCINE</b>	Spinal cord and brain stem <b>FUNCTIONS:</b> recurrent inhibition of motor neurons.	Toxic levels leads to glycine encephalopathy. <b>Decreased Levels</b> are correlated with spastic motor movements.
<b>C.GLUTAMATE ASPARTATE</b> It is an amino acid and mostly found as an excitatory neurotransmitter in brain	Pyramid cells of the cortex, cerebellum and the primary afferent systems: hippocampus, thalamus, hypothalamus and spinalcord.	<b>Increased Levels-</b> huntingtons disease, temporal lobe epilepsy, spinal cerebellar degeneration, cognition, memory and learning

## 11. Neurotransmitters, Mental Disorders, and Medications

### 11.1 Schizophrenia

Impairment of dopamine-containing neurons in the brain is implicated in **schizophrenia**, a mental disease marked by disturbances in thinking and emotional reactions. Medications that block dopamine receptors in the brain, such as **chlorpromazine** and **clozapine**, have been used to alleviate the symptoms and help patients return to a normal social setting.

### 11.2 Depression

In depression, which afflicts about 3.5% of the population. Depression is treated with antidepressants that affect norepinephrine and serotonin in the brain. The antidepressants help correct the abnormal neurotransmitter activity.

A newer drug, **fluoxetine** (Prozac), is a selective serotonin reuptake inhibitor (SSRI) that appears to establish the level of serotonin required to function at a normal level.

### 11.3 Alzheimer's Disease

**Alzheimer's disease**, which affects an estimated four million Americans, is characterized by memory loss and the eventual

inability for self-care. The disease seems to be caused by a loss of cells that secrete acetylcholine in the basal forebrain (region of brain that is the control center for sensory and associative information processing and motor activities). Some medications to alleviate the symptoms have been developed, but presently there is no known treatment for the disease.

### 11.4 Generalized Anxiety Disorder

People with **generalized anxiety disorder** (GAD) experience excessive worry that causes problems at work and in the maintenance of daily responsibilities. Evidence suggests that GAD involves several neurotransmitter systems in the brain, including norepinephrine and serotonin.

### 11.5 Attention-Deficit/Hyperactivity Disorder

People affected by **attention-deficit/hyperactivity disorder** (ADHD) experience difficulties in the areas of attention, overactivity, impulse control, and distractibility. Research shows that dopamine and norepinephrine imbalances are strongly implicated in causing ADHD.

### 11.6 Others

Substantial research evidence also suggests a correlation of neurotransmitter imbalance with disorders such as



borderline personality disorders , schizotypal personality disorder , avoidant personality disorder , social phobia , histrionic personality disorder , and somatization disorder

## 12. Drug Addictions

Cocaine and crack cocaine are psychostimulants that affect neurons containing dopamine in the areas of the brain known as the limbic and frontal cortex. When cocaine is used, it generates a feeling of **confidence and power**. However, when large amounts are taken, people "**crash**" and suffer from physical and emotional exhaustion as well as depression. Opiates, such as heroin and morphine, appear to mimic naturally occurring peptide substances in the brain that act as neurotransmitters with opiate activity called endorphins. Natural endorphins of the brain act to kill pain, cause sensations of pleasure, and cause sleepiness. Endorphins released with extensive aerobic experience. It is believed that morphine and heroin combine with the endorphin receptors in the brain, resulting in reduced natural endorphin production. As a result, the drugs are needed to replace the naturally produced endorphins and **addiction** occurs. Attempts to counteract the effects of the drugs involve using medications that mimic them, such as nalorphine, naloxone, and naltrexone.

Alcohol is one of the depressant drugs in widest use, and is believed to cause its effects by interacting with the GABA receptor. Initially anxiety is controlled, but greater amounts reduce muscle control and delay reaction time due to impaired thinking. Alcohol inhibits glutamate receptor function. This causes dis co-ordination, slurred speech, staggering, memory disruption and black-out.

## 13. Neurotransmitters Imbalances Can Cause Wide Spread of Other Health Problems Listed Below

- **BRAIN FOG:** loss of mental focus, ADD, ADHD, impaired memory, poor decision making
- **Fatigue**
- **Insomnia:** difficulty falling asleep, staying asleep or both.
- **Pain :** migraine, fibromyalgia
- **Obesity:** metabolic syndrome, insulin resistance and diabetes.

### 13.1 Mood Disorders

- Depression, mood swings, irritability
- Anxiety
- Panic, obsessions, ptsd.
- Behavioural disturbances
- Addictions, binge eating, compulsions, impulsivity, gambling, autism
- Hormonal imbalances-PMS
- Oestrogen dominance, low testosterone, hypothyroidism.

## 14. Balance Your Neurotransmitters to Take Control of Your Life

- 1) Is there an area of your life where you feel out of control?

- 2) Are you a shopaholic, chocoholic, caffeine addict, or worse?
- 3) Do you get depressed for no apparent reason, feel overwhelmed by life, have trouble sleeping, or have negative thoughts that you just can't shake?

If you answer yes to any of these questions, it's very possible that you have a neurotransmitter imbalance.

## 15. Serotonin- The "Happiness Molecule"



Of all the neurotransmitters, serotonin definitely gets the most attention. Serotonin is called the "happiness molecule" because it's so essential for a positive mood. Symptoms of low serotonin include carbohydrate cravings, binge eating, insomnia, anxiety, negativity, digestive disorders, low self-esteem, low libido, and hypervigilance.

Men and women express somewhat different symptoms of low serotonin. Women are much more likely to experience mood disorders and carbohydrate cravings, whereas men are more likely to be impulsive, have ADHD, and drink alcohol in excess.

Low serotonin levels are linked to the most common mood disorders of our time — depression, anxiety, eating disorders, insomnia, obsessive compulsive disorder, and seasonal affective disorder.

The most commonly prescribed antidepressants are selective serotonin reuptake inhibitors (SSRIs) which are believed to help depression by increasing serotonin levels.

### 15.1 Serotonin Boosting Supplements

**" It is important to re-emphasize that the natural antidepressant serotonin can only be increased in the body and brain by the ingestion of one of its two precursor aminoacids.**

**Tryptophan is the amino acid precursor, or building block of serotonin.**

It is found mainly in protein rich food like meat, eggs and fish.

**Tryptophan supplements:**

Eating carbohydrates alone-with no protein-at some of your meals or snacks allows tryptophan to enter your brain and

boost serotonin levels there. Another surprise is that tryptophan supplements work better than tryptophan found in food to increase serotonin. Curcumin and turmeric supplements raise serotonin levels Omega 3 supplements also increase serotonin levels Herbs that increase serotonin levels are plant parts-seeds, berries, roots, leaves, bark and flowers are used medicinally. Eggs, cheese, pineapples, tofu, nuts and seeds also raise serotonin levels.

### Probiotic Supplements

Probiotic are good bacteria found in fermented foods like yogurt, kefir and unpasteurized sauerkraut.

### Other ways to boost serotonin

- 1) Sunshine
- 2) Exercise
- 3) Positivity
- 4) Sufficient sleep

### Here are several tips for naturally boosting serotonin with the body ecology program

- 1) Get enough vit b6
- 2) Spinach
- 3) Turnip greens, garlic, cauliflower
- 4) Mustard greens
- 5) Celery, fish
- 6) Poultry
- 7) Eat body ecology recommended grain-like seeds
- 8) For protein meals :high tryptophan (like turkey, sunflower seeds and pumpkin seeds)
- 9) Include fermented foods and drinks in your diet
- 10) Get plenty of exercise
- 11) Get massage and other forms of body work (massage increases serotonin by 28% and decreases cortisol (the stress hormone)
- 12) reduce stress
- 13) eliminate sugar if you have low serotonin, you may have intense cravings for sugar. this is your body's way of trying to increase serotonin because eating sugar produces insulin which helps tryptophan go into your brain.
- 14) focus on emotional healing.

## 16. Dopamine — The “Motivation Molecule”

Dopamine has been coined the “motivation molecule.”



It provides the drive and focus needed to do what needs to be done.

Dopamine has another important role as the brain chemical in charge of the body's pleasure-reward system. Dopamine is released when your needs are about to be met and delivers a feeling of satisfaction when you have accomplished your goals. If you've lost your zest for life or find yourself engaging in self-destructive behaviors to get your kicks, you may be low in dopamine.

Signs of low dopamine include apathy, low energy and motivation, low libido, and inability to experience pleasure. Dopamine deficiency can manifest as a lethargic and apathetic form of depression unlike serotonin-based depression which is usually linked to anxiety.

Many people self-medicate with addictive substances like caffeine, alcohol, sugar, nicotine, and recreational drugs to increase dopamine. Others get their dopamine hit from excesses of all kinds — too much shopping, sex, gambling, video games, and thrill-seeking behaviors. Fortunately, addictions and risky behaviors are not the only way to increase dopamine! You can increase dopamine naturally with the right foods, supplements, and lifestyle activities.

### 16.1 Dopamine Boosting Supplements

The amino acid **tyrosine** is a major building block of dopamine and must be present for dopamine synthesis. Tyrosine can be found in most animal food products, other foods that increase dopamine include **avocado, greenleafy vegetables, apples, beets, chocolates, oat meal, nuts and seeds.**

**Coffee and green tea** increase dopamine. **Citicoline supplements, Bacopa supplements, healthy lifestyle activities like physical exercise and meditation increase dopamine.**

**Apples contain Quercetin** to prevent neuro degeneration and boost dopamine.

**Kale...Rich in folate**, to trigger dopamine production.

**Bananas including the amino acids tyrosin** boosts dopamine.

**Strawberries and Blueberries** include tyrosine like bananas.

**Green tea** contains **Polyphenols** good for brain and heart function

Dopamine is released when your needs are about to be met and delivers a feeling of satisfaction when you've accomplished your goals. Caffeine is easily abused and addictive tendencies are a hallmark of low dopamine. There are plenty of supplements that increase dopamine naturally. A good one to start with is acetyl-L-tyrosine, a highly absorbable form of tyrosine that readily crosses the blood-brain barrier into the brain.

Other supplements that increase dopamine include citicoline, curcumin, Mucuna pruriens (velvet bean or cowhage), phosphatidylserine, and Ginkgo biloba. Bacopa

monnieri, a traditional Indian Ayurvedic herb, helps regulate dopamine production up and down as needed.

This makes bacopa an excellent choice for balancing dopamine levels especially for those who suspect they have too much dopamine. Healthy lifestyle activities like physical exercise and meditation increase dopamine. And since dopamine is released when you accomplish a goal, taking on new challenges helps raise dopamine levels. So, break down your long-range plans into short-term goals. Then, every time you tick an item off your “to do” list, you’ll get a little dopamine boost.

## 17. Acetylcholine — The “Molecule of Memory and Learning”



Acetylcholine, the first neurotransmitter to be discovered, is essential for learning and memory. Symptoms of acetylcholine deficiency are typical of “senior moments” — struggling to remember, focus, follow plots, and find the right words — regardless of age.

Acetylcholine levels drop by as much as 90% in Alzheimer’s patients. Acetylcholine activity is the target of Alzheimer’s drugs, which attempt to slow the progression of cognitive decline by blocking the breakdown of this brain chemical.

### *How to Increase Acetylcholine*

If you are low in acetylcholine you may find yourself craving fatty foods. The best way to increase acetylcholine is to stop eating a low-fat diet.

The precursor to acetylcholine is choline, a nutrient found mainly in high-fat dairy products, fish, meat, and poultry.

The best sources of choline *by far* are egg yolks and whole eggs.

Brain literally starts working with enough dietary fat. If you’re a coffee drinker, consider switching to tea which slows the breakdown of acetylcholine. The alpha GPC (L-alpha-glycerol phosphoryl choline) form, which occurs in human breast milk, readily enters the brain to improve memory and cognition. Meats, Dairy, Poultry, Fish contains high level of choline, Liver, chocolates, peanut butter, Brussels, sprouts and broccoli, eggs, Animal proteins, seafood, dairy, plant source of choline. Another form of choline that increases acetylcholine is citicoline.

Citicoline also increases blood flow to the brain, brain plasticity and the capacity to grow new brain cells. It is used

therapeutically to treat a wide variety of serious brain disorders including age-related cognitive decline, dementia, and Alzheimer’s.

Other supplements that naturally increase acetylcholine levels are huperzine-A, derived from Chinese club moss, and galantamine, derived from the snowdrop flower. The last tip for increasing acetylcholine is to avoid anticholinergic drugs.

These are drugs that destroy acetylcholine and are surprisingly common. A good rule of thumb is that any medication that starts with “anti” is **likely to affect your acetylcholine levels such as antibiotics, antihistamines, and antidepressants.**

## 18. GABA — “Nature’s Valium”



*This brain chemical normally puts the brakes on brain activity on an as-needed basis, but when you’re low in GABA your mind gets stuck in the “on” position.*

GABA (gamma-aminobutyric acid) is a relaxing neurotransmitter that’s been dubbed “nature’s Valium.”

Typical symptoms of low GABA are being easily stressed out, overstimulated, and overwhelmed. Other signs and symptoms of low GABA are lying awake with racing thoughts, feeling dread for no particular reason, and experiencing heart palpitations, cold hands, and shortness of breath. Low GABA is associated with anxiety disorders and panic attacks, as well as physical disorders with an emotional component such as irritable bowel syndrome and fibromyalgia.

### **How to Increase GABA**

You may be drawn to unhealthy ways to increase GABA such as reaching for high carbohydrate foods, alcohol, or drugs to relax. But there are healthy foods and supplements that will do the trick. Almonds, bananas, broccoli, brown rice, citrus fruit, beef, liver, fish, lentils, nuts, oats, organ meats, spinach, tyramine rich foods and whole grains are among the best foods for increasing GABA.

You may be drawn to unhealthy ways to increase GABA such as reaching for high carbohydrate foods, alcohol, or drugs to relax. But there are healthy foods and supplements



that will do the trick.

Fermented foods like unpasteurized yogurt, kefir, sauerkraut, kimchi, and miso also raise GABA levels. GABA supplements are available, but are of limited use since GABA is too large a molecule to cross from the bloodstream into the brain. Instead, consider taurine, an amino acid that activates GABA receptors in the brain and encourages the formation of GABA. Probiotic supplements that contain *Lactobacillus rhamnosus* markedly improve GABA levels.

Picamilon is considered a smart drug among college students who use it to boost memory, focus and brain power. In 2015, the Food and Drug Administration decided it was more drug-like than supplement-like and pulled it from the shelves, so it is no longer readily available in the US

All kinds of exercise can increase GABA, but yoga in particular stands out. One study found that just a single one-hour session of yoga increased GABA levels by 27%.

## 19. Recent Developments

A team of scientists from University of Barcelona in 2011, has discovered that D-aspartic acid (d-asp) is a novel neurotransmitter that could potentially be used in the fight against neurological diseases such as Parkinson's and schizophrenia.

According to a new study led by researchers at the Ohio state university Comprehensive Cancer Center in 2011, doses of a neurotransmitter dopamine might offer a way to boost the effectiveness of anticancer drugs and radiation therapy

## 20. Conclusion

The ability of nervous system to orchestrate complex behaviours, learn and remember depends on communication between vast no: of neurons. They play an important role in control and co-ordination of body. Many neurological diseases and mental disorders are due to improper functioning of neurotransmitters.

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## Author Profile

**Seethalakshmi** received general nursing and midwifery in child Jesus school of nursing Tirichirapalli. Received post basic B.Sc. (N) nursing and M.Sc (N) degree in psychiatric nursing in K.G College of nursing. Worked as staff nurse in child Jesus hospital tiruchy district from 2000-2002. Worked as an assistant lecturer in PSG College of nursing from 2009-2011. At present working in KMCR&E Trust, department of psychiatric nursing, Coimbatore.