

Neurotransmitters: These are the chemicals produced by the body to control and regulate nervous system functioning. Neurotransmitters are produced by the neurons in the axon terminal buttons (bulbs) and stored in the synaptic vesicles. Their action is local when released into synapses to affect adjacent neurons, muscles, or glands. The action of these chemicals is due to the three-dimensional shape of the chemical molecules. Receptors at various sites only allow for particularly shaped molecules to trigger changes at the cellular membranes that then allow for channels in the membranes to open and allow ions to enter. This, in turn, alters the electrochemical charge of the cell relative to the surrounding environment, resulting in action potentials and neural transmission. It should be noted that both neurotransmitters and neuromodulators trigger decidedly varied reactions depending on their site of action. As many as 200 are postulated, but we will discuss only a few of the better known and most prominent in detail.

Neurotransmitter	Known or Suspected Effects
Serotonin	Affects mood, sleep, appetite, sensory perception, temperature regulation, pain suppression, impulsivity, and aggression; may play a role in some psychological disorders, such as depression
Acetylcholine (ACh)	Affects muscle action, cognitive functioning, memory, REM (rapid-eye-movement) sleep, emotion. Suspected role in Alzheimer's disease
Dopamine (DA)	Affects movement, attention, memory, learning, and emotion. Plays a role in both schizophrenia and Parkinson's disease.
Norepinephrine (NE) (or noradrenaline)	Affects learning, memory, dreaming, emotion, waking from sleep, eating, alertness, wakefulness, reactions to stress
Epinephrine (or adrenaline)	Affects emotional arousal, memory storage, and metabolism of glucose necessary for energy release
GABA (gamma aminobutyric acid)	Neural inhibition in the central nervous system; Tranquilizing drugs act on GABA to decrease anxiety

Acetylcholine

Voluntary Muscle Control
Arousal, Cognition and Memory

Primarily found in neurons of the motor cortex (frontal lobes) and the somatic nervous system.

Blocking acetylcholine results in muscle paralysis, including the diaphragm.

Curare, insecticides, and nerve gases have their effects by way of blocking normal acetylcholine functioning.

Certain cholinergic pathways active during REM sleep.

Implicated in Alzheimer's Disease.

Endorphins and Enkephalin

Control and Regulate the Perception of Pain

Primarily found in neurons of the somatosensory cortex (parietal lobes), the medulla and the somatic nervous system.

The action of endorphins allows the body to continue functioning despite being at or beyond the normal thresholds of endurance or pain.

The action of endorphins in the hypothalamus and nucleus accumbens can generate euphoria.

Opiate drugs are very similar chemically and mimic these effects.

GABA (Gamma Aminobutyric Acid)

Primary Inhibitory Neurotransmitter

Primarily found in neurons of the frontal lobes adjacent to the limbic system.

The liberating effects of alcohol are due to sedation and suppression of neurons in the frontal lobe that utilize GABA to inhibit impulsive action.

Minor tranquilizers reduce anxiety by enhancing the action of GABA.

Epinephrine (Adrenaline)

Arousal, Excitation, Anxiety, Fear and Rage
Reactions to Stress and Threat
Readiness for Combat or Flight

Primarily found in neurons of the hypothalamus, amygdala and the sympathetic branch of the autonomic nervous system.

Some of the effects from stimulants involve epinephrine.

Norepinephrine (Noradrenaline)

Calming Effects, Relaxation, Routine Bodily Functioning
Storage of Memories Having Emotional Content
or Meaningful Significance

Primarily found in neural pathways originating from Locus Coeruleus

and the parasympathetic branch of the autonomic nervous system.

Involved in the inhibition of incoming sensory input, particularly pain.

Chemically related to Dopamine, which is oxidized by an enzyme to produce norepinephrine.

Excesses in the brain are implicated in mania.

Most major tranquilizers (reserpine, chlorpromazine) decrease usable amounts of norepinephrine and dopamine.

Lack of sufficient usable norepinephrine in the brain implicated in depression.

Antidepressants (MOA inhibitors, tricyclics such as imipramine) increase usable amounts of norepinephrine and dopamine.

Dopamine

Two Major Pathways - One Involves Motor Control

Neurons in the substantia nigra, caudate nucleus and cerebellum:

Initiation of muscle movement.

Muscle control related to posture, gait and regulation of opposing muscle groups.

Reflexive responses.

Lack of usable dopamine affects these by causing an inability to control the initiation and cessation of movement resulting in tremors and motor/speech tics such as those found in Parkinson's patients and cases of Tardive Dyskinesia.

Excess of usable dopamine affects these functions in the form of rigidity such as the catatonia sometimes found in schizophrenia.

Two Major Pathways - One Involves Attention and Emotion

Neurons in the frontal and temporal lobes:

Ability to focus attention and concentrate.

Ability to sort/filter sensory inputs and information.

Excess of usable dopamine affects these functions in the form of hallucinations (especially auditory) and delusions common in schizophrenia and sometimes found in cocaine and amphetamine addicts.

Neurons in the frontal lobes, amygdala and hypothalamus:

Regulation of impulsivity.

Neurons in the reward/punishment centers of the

hypothalamus and nucleus accumbens:

Ability to experience pleasure. This is the source of the feeling of pleasure regardless of the activity producing it.

Excess of usable dopamine produces behavioral or emotional outbursts and inappropriate affect found in schizophrenia.

Lack of usable dopamine produces anhedonia found in both schizophrenics and recovering cocaine and amphetamine addicts.

Lack or excess of usable dopamine may be due to actual amounts present or improper regulation of dopamine action by way of other substances such as serotonin as well as various drugs.

Amphetamine, cocaine, and related stimulant drugs prevent dopamine reuptake increasing the time that dopamine remains in the synapses activating receptors. This enhances the user's ability to focus attention and concentrate. It also produces strong sensations of pleasure and lack of impulse control.

Prolonged abuse of these stimulant drugs results in effects that resemble schizophrenia. Prolonged use also affects the number of dopamine receptors, and by way of this the amount of dopamine or drug needed to activate these functions/systems is elevated (tolerance). Discontinuing use of these stimulant drugs results in anhedonia as the body cannot supply enough dopamine to activate the receptors in the brain's pleasure centers so relapse is common.

The amino acid tyrosine is oxidized to produce L-Dopa, which is then transformed by an enzyme to produce dopamine.

[Serotonin](#)

Regulates and Modulates the Action of
Other Neurotransmitters and Neuropeptides
Modifies Motivational Levels and Emotional Responses

Found in the reticular formation where it controls and regulates the sleep/wake cycle.

Responsible for sleep disorders such as insomnia or excessive sleep.

Found in the frontal and temporal lobes where it controls and regulates overall mood.

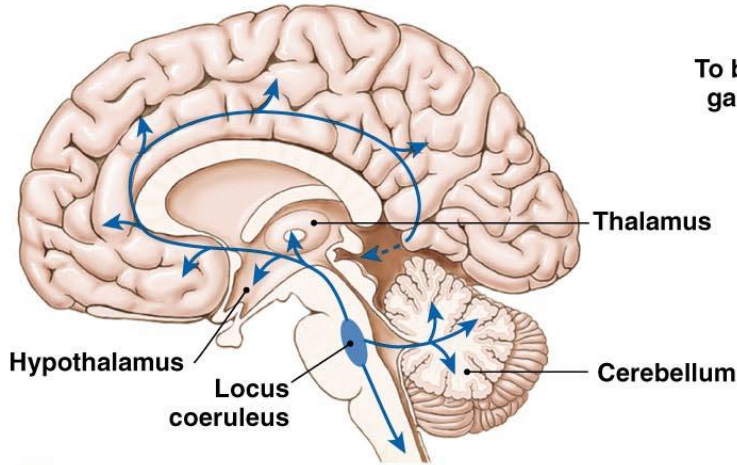
Implicated in mood disorders such as chronic depression and bipolar disorder, as well as a number of other conditions.

Chemically related to the amino acid tryptophan, as well as the neurotransmitters norepinephrine and dopamine.

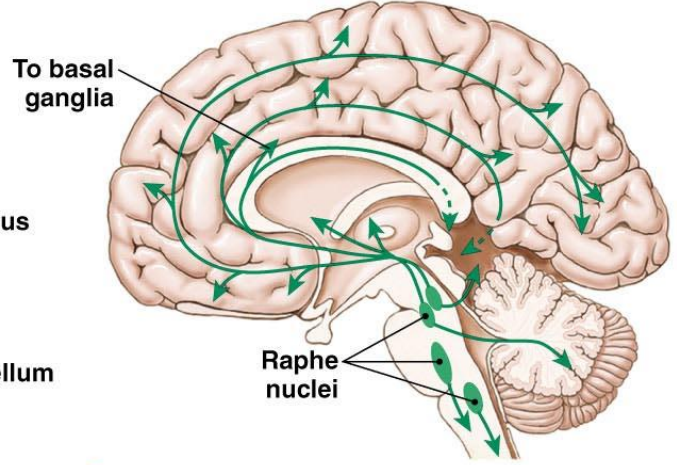
All known hallucinogens believed to simulate the structural characteristics of serotonin, norepinephrine, and/or dopamine.

(Overall function designed to modulate the effects of the other neuro-chemicals across a wide range of locations and systems.)

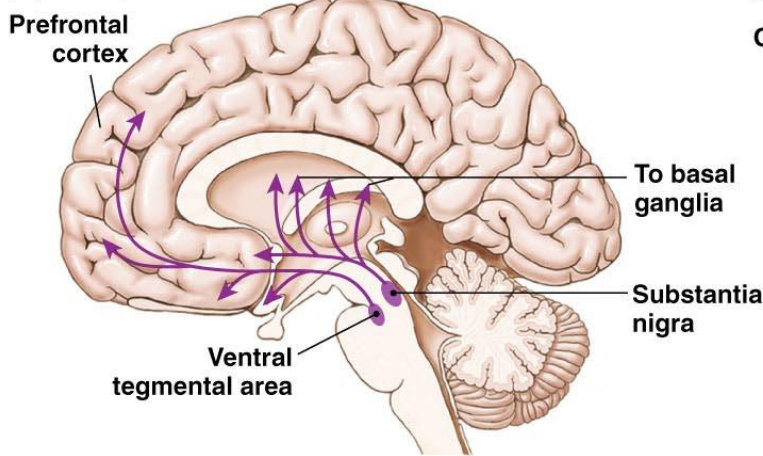
(a) ● Norepinephrine



(b) ● Serotonin



(c) ● Dopamine



(d) ● Acetylcholine

