What Are Neurotransmitters and Neurochemistry?

People often compare the brain to a computer that's filled with busy circuits humming along, doing our thinking and feeling, planning and perceiving, as well as everything else that makes us who we are. In some ways, that's not a bad analogy. The brain relies on circuits made of living tissue, long tracts of nerves sending signals to each other in the form of electrical current.

But there the likeness stops. Unlike mechanical or electric circuitry, the nerves of the brain do not touch each other. In fact, for them to work well, it's crucial they don't make direct contact. This raises the question of how these biological circuits can possibly work if the nerves that make them up don't connect to each other.

The answer lies in the complex neurochemistry of the brain and a special class of chemicals called neurotransmitters. Neurotransmitters are the nervous system's messengers, allowing a nerve impulse that originates deep within the brain to travel throughout the body. There are many different neurotransmitters, each of which has a primary function, although there's a lot of overlap, particularly in primary functions, like memory and learning, or movement and balance.

Let's examine how that works.

How the Brain Works: Neurotransmitters

To understand the need for neurotransmitters we need to understand how the brain's living circuits work. There are two kinds of brain cells: neurons and glia. Neurons do our thinking and feeling, while glial cells support the neurons. Neurons are the main location where neurotransmitters work, although some glial cells rely on neurotransmitters, as well.

Neurons are separated from each other by a tiny gap. The area where two nerve cells communicate with each other is called the synapse; the gap is called the synaptic cleft. When one neuron signals another, specialized chemicals called neurotransmitters pass from the signaling nerve to the receiving nerve. The neurotransmitters pass across the synaptic cleft and are absorbed by the receiving nerve.

At the site of contact on the receiving nerve are chemical receptors that work like locks. Each type of neurotransmitter has a unique shape, like a key, that's matched by a matching receptor site. When enough of these receptor sites are filled, the "message" is passed on.

Most neurons send only one kind of neurotransmitter, but some can release several different kinds, in a process called transmitter switching. Neurotransmitters either increase signaling activity in nerve cells (excitatory neurotransmitters) or reduce it (inhibitory neurotransmitters).

Common Neurotransmitters

Acetylcholine. The first neurotransmitter to be discovered, acetylcholine (Ach) works in the muscles, passing on instructions from the brain to move into action. In fact, our ability to use the

smooth muscles of the body relies entirely on acetylcholine. In the brain, Ach assists with learning and memory.

Serotonin. Serotonin helps regulate our mood. Disturbances in serotonin levels in the brain have been associated with depression and anxiety, as well as other psychological disorders. Serotonin also helps regulate appetite and our sleep cycle. In the digestive tract, serotonin helps the intestines contract and relax.

Many antidepressant medications belong to the selective serotonin reuptake inhibitor (SSRI) family. They help serotonin stay available in the brain longer than it otherwise would, making sure neurons that need it have a plentiful supply.

Glutamate. Glutamate is the neurotransmitter that most strongly stimulates nerves to send signals to each other. It's vital to the processes that allow us to form memories and learn. Glutamate is utilized to differing degrees by over 90 percent of the brain's neurons. Glutamate is so powerful that an overabundance can cause cells to die from exhaustion. Consequently, glutamate is highly regulated in the brain.

Dopamine. Dopamine is often called the "feel good" chemical and for good reason, as it controls our sense of pleasure and well-being. It also governs our learning, reinforcement, and reward systems. Dopamine is a part of the arousal system and allows us to carry out goal-directed behavior and focus our attention. It's also used by the brain to help us make smooth, coordinated movements.

Too much dopamine has been implicated in symptoms like hallucinations in some disorders like schizophrenia, while too little dopamine is implicated as a cause of Parkinson's disease.

Norepinephrine. Also called noradrenaline, norepinephrine is a hormone and neurotransmitter. It's a major component of the fight-or-flight system and can elevate blood pressure and heart rate. It also promotes alertness and mental focus. Low levels of norepinephrine have been associated with disorders like attention deficit hyperactivity disorder (ADHD) and for some people, major depression. Depression related to norepinephrine is treated with serotonin-norepinephrine reuptake inhibitors (SNRIs).

Gamma-Aminobutyric acid (GABA). GABA is the most inhibitory of all neurotransmitters. It prevents over-excitability of neurons and helps fine-tune nerve activity. It's an important part of the neurochemistry of learning. Low levels of GABA are associated with anxiety disorders.

The takeaway

Neurotransmitters are chemical messengers that allow nerve cells to communicate with each other and cells throughout the body. Most neurotransmitters have unique functions, as well as roles they share with other chemical messengers. Imbalances in the amount or availability of neurotransmitters are associated with psychological disorders like depression, anxiety, bipolar disorder, and schizophrenia.

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