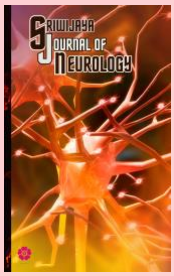

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The Mechanism of Nerve Impulses: A Narrative Literature Review

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A B S T R A C T

Neurons are not physically continuous with each other but form points of contact with adjacent neurons by special structures called synapses. The synapse consists of a small rounded end of the presynaptic neuron (synaptic knob) that is separated from the postsynaptic neuron by the synaptic cleft. This literature review aimed to describe the mechanism of nerve impulses in the human body. Neurons generate and conduct electrical impulses by selectively changing the conductance across their plasma membranes and influencing other nearby neurons by releasing chemical signals (neurotransmitters). Neurotransmitters are synthesized in neurons and in localization at the presynaptic terminal (synaptic boutons). The neurotransmitter is released into the synaptic cleft in response to the arrival of an electrical impulse and binds to receptor sites (binding sites) on the postsynaptic membrane of adjacent neurons or other effectors. In conclusion, an understanding of the impulse mechanism of nerves will assist in determining the treatment of neurological disorders.

1. Introduction

Neurons generate and conduct electrical impulses by selectively changing the conductance across their plasma membranes and influencing other nearby neurons by releasing chemical signals (neurotransmitters). Unexcited neurons maintain resting membrane potential. When the membrane potential is raised sufficiently, an action potential is generated and propagated to other parts of the neuron. Action potentials only occur when the stimulus is strong enough; if it is too weak, the membrane remains unexcited. This condition is often called all-or-none response.[1-3] This literature review aimed to describe the mechanism of nerve impulses in the human body.

Synapse

Neurons are not physically continuous with each other but form points of contact with adjacent neurons by special structures called synapses. The synapse consists of a small rounded end of the presynaptic neuron (synaptic knob) that is separated from the postsynaptic neuron by the synaptic cleft. Impulses are transmitted across the synapse by chemical and electrical conduction; only chemical conduction is discussed here. Neurons that conduct nerve impulses are named according to whether they convey impulses *going to*(presynaptic neuron) or *avoid* from the synapse (postsynaptic neuron). Four basic types of connections occur at the contact area between the presynaptic and postsynaptic neurons. These are between axons (axo-axonic), from axons to cell bodies (axo-somatic), from axons to dendrites (axo-dendritic), and from dendrites to dendrites (dendro-dendritic). In response to the arrival of an action potential at the synaptic knob, the

containing vesicle neurotransmitter releases its contents into the synaptic cleft. The neurotransmitter diffuses across the synaptic cleft (space between neurons) and binds to specific receptors on the neuron-post synaptic, Where they trigger action potentials in the postsynaptic neuron. Brain synapses can change in strength and number throughout life; this is known as synaptic plasticity or neuroplasticity.[4-8]

Neurotransmitter

Neurotransmitters are synthesized in neurons and in localization at the presynaptic terminal (synaptic bouton). The neurotransmitter is released into the synaptic cleft in response to the arrival of an electrical impulse and binds to receptor sites (binding sites) on the postsynaptic membrane of adjacent neurons or other effectors. Here, the binding of the neurotransmitter to its receptor causes a change in the conductance of the postsynaptic membrane, which allows the propagation of the impulse. Efficient signal termination requires rapid degeneration of neurotransmitters in the cleft or on the postsynaptic cell surface. Neurons can synthesize more than one neurotransmitter, and the postsynaptic membrane can contain more than one type of transmitter-specific receptor. Common neurotransmitters include norepinephrine, acetylcholine, dopamine, histamine, and serotonin (Table 1).

Table 1. Substances that are neurotransmitters or neuromodulators.

Substance	Location	Effect	Clinical example
Acetylcholine	Many parts of the brain, spinal cord, neuromuscular connections of the skeletal muscles, and many ANS synapses	Excitatory or inhibitor	Alzheimer's (a type of dementia) is associated with a decrease in the amount of acetylcholine secreted by neurons. Muscle weakness caused by myasthenia gravis results from an autoimmune response to acetylcholine receptors at the postsynaptic terminal
Monoamines			
Norepinephrine	Many areas of the brain and spinal cord back; also, in multiple ANS synapses	Stimulate or Inhibitor	CNS: sleep-wake cycles and moods. Cocaine and amphetamines* produce postsynaptic overstimulation neuron. PNS: Sympathetic nerve transmission.
Serotonin	Many areas of the brain and spinal cord back	Generally inhibition	Involved with mood, anxiety, and sleep induction. Serotonin levels are increased in schizophrenia (delusions, hallucinations, withdrawal).
Dopamine	Multiple brain areas and ANS synapses	Generally stimulate	Parkinson's (voluntary motor control depression) results from the destruction of the dopamine-secreting neurons. Drugs used to increase dopamine can cause vomiting and hallucinations.
Histamine	Posterior hypothalamus	Excitation (H1 and H2 receptors) and inhibition (H3 receptors)	There is no clear indication of a histamine-associated pathological condition. Histamine is involved with arousal and attention and links to other brain transmitter systems.
Amino acids			
Gamma acid aminobutyrate (GABA)	Most CNS neurons have GABA receptors	Most of the postsynaptic inhibition in the brain	Drugs that enhance GABA function have been used to treat epilepsy by inhibiting its excessive neuronal discharge.
Glycine	spinal cord	Most of them postsynaptic inhibition in the spinal cord	Glycine receptors are blocked by strychnine.
Glutamate and aspartate	Widespread in brain and spinal cord	Exciter	Drugs that block glutamate or aspartate, such as riluzole, are used to treat amyotrophic lateral sclerosis. These drugs can prevent overexcitation from seizures and nerve degeneration.
Neuropeptides			
Endorphins and enkephalins	Widely distributed in CNS and	Generally inhibition	Morphine and heroin bind to endorphins and enkephalin receptors on presynaptic neurons and reduce pain by blocking neurotransmitter release.
Substance P	The spinal cord, brain, and sensory neurons that are associated with pain, GI tract	Generally of the exciter	Substance P is a neurotransmitter involved in pain transmission pathways. Blocking the release of substance P by morphine reduces pain.
Vasoactive intestinal peptides	Gastrointestinal tract	Generally stimulate	Stimulates secretion, vasodilation, and smooth muscle relaxation (vasodilation, sphincter relaxation).

*Increases release and blocks norepinephrine reuptake.

ANS; Autonomic nervous system; CNS, central nerve system; GI, digestive; PNS, peripheral nervous system.

Because neurotransmitters are usually stored on the presynaptic side of the synaptic cleft, and the receptor sites are on the postsynaptic side, chemical synapses operate in one direction. Hence the action

potential is transmitted along the multi-neuronal pathway multi neuronal in one direction. Bonding neurotransmitter at the receptor site changes the permeability of the postsynaptic membrane and, consequently, its membrane potential. Two possible scenarios could follow: (1) the postsynaptic neuron might be excited (depolarized; excitatory postsynaptic potentials [EPSPs]), or (2) the postsynaptic membrane might be inhibited (hyperpolarization; inhibition of postsynaptic potentials [IPSPs]).

Normally, a single postsynaptic potential is unable to induce a neuronal action potential and nerve impulse propagation. The occurrence of action potentials depends on the number and frequency of excitatory and inhibitory potentials received by the postsynaptic neuron, a concept known as summation. Temporal summation refers to the effects of fast, sequential impulses received from a single neuron at the same synapse. Spatial summation is the combined effect of impulses from a number of neurons at a single synapse at the same time. Facilitation refers to the effect of some EPSPs on the plasma membrane potential. The plasma membrane is facilitated when summation brings the membrane closer to the threshold potential and reduces the stimulus required to induce the action potential. The effect of the neurotransmitter on the membrane potential depends on the balance of these effects. The mechanisms of convergence (many neurons fire and converge on one neuron), divergence (one neuron fires and diverges on many neurons), summation, and facilitation allow the integrative processes of the nervous system.[9-15]

2. Conclusion

Neurons generate and conduct electrical impulses by selectively changing the conductance across their plasma membranes and influencing other nearby neurons by releasing chemical signals (neurotransmitters).

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