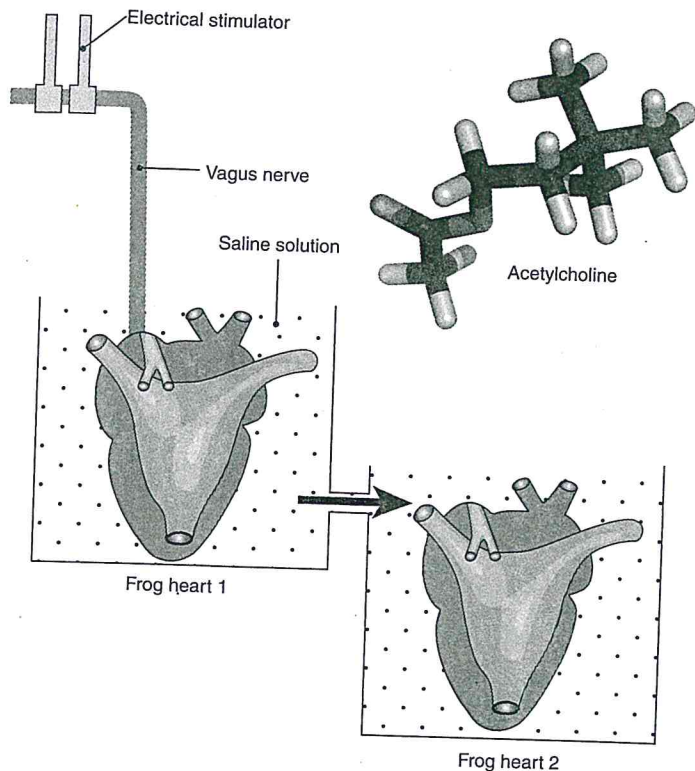


# Neurotransmitters

Neurotransmitters are chemicals that allow the transmission of signals between neurons. They are found in the axon endings of neurons and are released into the space between one neuron and the next (the **synaptic cleft**) after a depolarization or hyperpolarization of the nerve ending. Neurotransmitters can be

classified into amino acids, peptides, or monoamines. The many neurotransmitters produce various responses depending on their location in the body. They can be excitatory (likely to cause an action potential in the receiving neuron) or inhibitory (causing hyperpolarization) depending on the receptor they activate.

## Neurotransmitters Carry Signals Between Neurons



Chemical signaling between neurons was first demonstrated in 1921 by Otto Loewi. In his experiment, the still beating hearts of two frogs were placed in connected flasks filled with saline solution. The vagus nerve (parasympathetic) of the first heart was still attached and was stimulated by electricity to reduce its rate of beating. After a delay, the rate of beating in the second heart also slowed. Increasing the beating rate in the first heart caused an increase in the beating rate in the second heart, showing electrical stimulus of the first heart caused it to release a chemical into the saline solution that then affected the heartbeat of the second heart. The chemical was found to be **acetylcholine**.

## Neurotransmitters

Name	Postsynaptic effect	
Acetylcholine	Excitatory/ inhibitory	Responsible for the stimulation of muscles. Found in sensory neurons and the autonomic nervous system.
Norepinephrine	Excitatory	Brings the nervous system into high alert. Increases heart rate and blood pressure.
Dopamine	Excitatory/ inhibitory	Associated with reward mechanisms in the brain. Produces the "feel good" feeling.
Gamma amino butyric acid (GABA)	Inhibitory	Inhibits excitatory neurotransmitters that can cause anxiety.
Glutamate	Excitatory	Found in the central nervous system and concentrated in the brain.
Serotonin	Inhibitory	Serotonin is strongly involved in regulation of mood and perception.
Endorphin	Excitatory	Involved in pain reduction and pleasure.

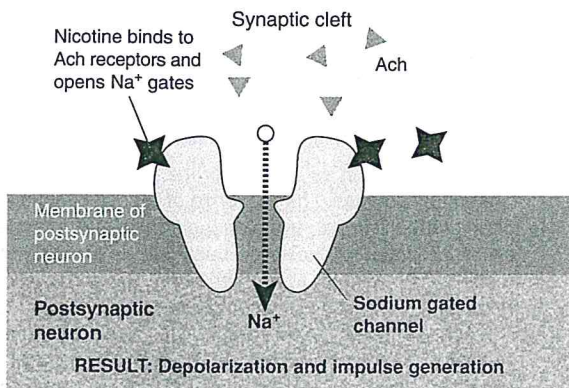
- Describe the purpose of a neurotransmitter: \_\_\_\_\_  
\_\_\_\_\_
- (a) Explain why stimulating the first frog heart with electricity caused it to change its beating rate:  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- (b) Explain why the second heart in the experiment reduced its beating rate after a delay:  
\_\_\_\_\_  
\_\_\_\_\_
- Why can some neurotransmitters be both excitatory and inhibitory? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

# Drugs at Synapses

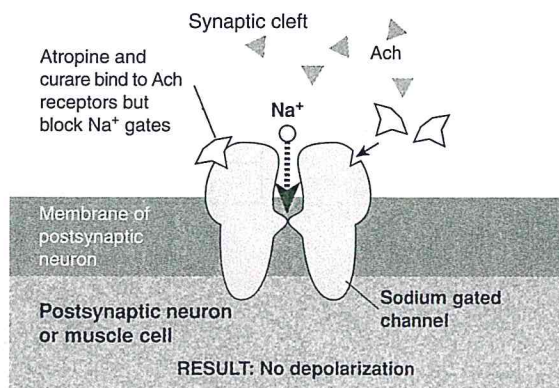
Synapses in the peripheral nervous system are classified by the type of neurotransmitter they release. **Cholinergic** synapses release **acetylcholine (ACh)**, while adrenergic synapses release **epinephrine** (adrenaline) or norepinephrine (noradrenaline). Postsynaptic receptors are also classified by the type of neurotransmitters they bind. Cholinergic receptors

all bind acetylcholine, but they can also bind **drugs** that mimic ACh. Drugs act on the nervous system by mimicking (**agonists**) or blocking (**antagonists**) the activity of neurotransmitters. Because of the small amounts of chemicals involved in synaptic transmission, drugs that affect the activity of neurotransmitters, or their binding sites, can have powerful effects in small doses.

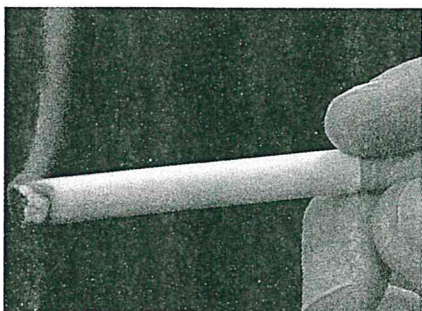
## Drugs at Cholinergic Synapses



**Nicotine** acts as a **direct agonist** at nicotinic synapses. Nicotine binds to and activates acetylcholine (ACh) receptors on the postsynaptic membrane. This opens sodium gates, leading to a sodium influx and membrane depolarization. Some agonists work indirectly by preventing ACh breakdown. Such drugs are used to treat elderly patients with Alzheimer's.



**Atropine** and **curare** act as **antagonists** at some cholinergic synapses. These molecules compete with ACh for binding sites on the postsynaptic membrane, and block sodium influx so that impulses are not generated. If the postsynaptic cell is a muscle cell, muscle contraction is prevented. In the case of curare, this causes death by flaccid paralysis.



**Nicotine** is the highly addictive substance in cigarettes. It acts on the nicotinic acetylcholine receptors, increasing the levels of several neurotransmitters, including dopamine. Dopamine produces feelings of euphoria and relaxation. These feelings reinforce nicotine consumption, and create nicotine addiction.



**Muscarine**, a compound found in several types of mushrooms, binds to muscarinic acetylcholine receptors. Muscarine is used to treat a number of medical conditions (e.g. glaucoma), but consumption of the mushrooms can deliver a fatal overdose of muscarine.



Mamba snake venom contains a number of neurotoxins including **dendrotoxins**. These small peptide molecules act as acetylcholine receptor antagonists (blocking muscarinic receptors). They have many effects including disrupting muscle contraction.

- Providing an example of each, outline two ways in which drugs can act at a cholinergic synapse:
  - \_\_\_\_\_
  - \_\_\_\_\_
- Explain why atropine and curare are described as direct antagonists: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_
- Suggest why curare (carefully administered) is used during abdominal surgery: \_\_\_\_\_  
 \_\_\_\_\_