SNAKE NEUROTOXINS

The neurology behind snake venom and how it affects synapses

What is a Neurotoxin?

The world around us is full of toxic substance that harm our body daily. Whilst there are many types of toxins, one of them is neurotoxins[12]. They are an exogenous chemical-type of toxin that alter the activity of the nervous system, causing the degradation and destruction of nerve tissue[2]. This usually results in many adverse side effects, primarily involving the function and the relay of electrical information through our body as nerves are the important component of our bodies that are responsible for the transmission of information, which is processed by the brain[3].

This type of neurotoxin is prevalent in snake venom. Snakes have a defensive mechanism in which they release venom when provoked by danger. Their venom is dangerous as such, as it works by interfering with nerve impulses to muscles; resulting in their disability[11]. This can be quite severe when considering the different types of muscles we have in our body. Whilst paralysis can occur in parts of the body, such as our limbs, there can also be a blockage of electrical impulses to the muscles responsible for breathing. This results in respiratory failure, and can in certain cases lead to death[11]. Reports have previously shown that snake neurotoxins have had such extreme effects on the body that in some cases, death had occurred within approximately ten minutes of infection.

Some snake neurotoxins target receptors found in the CNS, that affect the functions of the heart, the contraction of smooth muscles, and the release of neurotransmitters; which also can have adverse side effects[10].

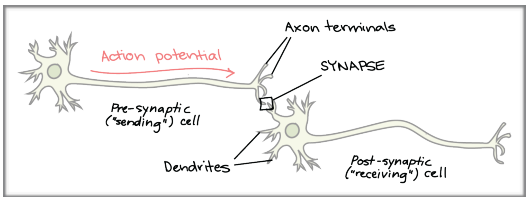
Symptoms of a Severe Neurotoxic Bite:

-Respiratory failure

-Muscle paralysis

-Double vision

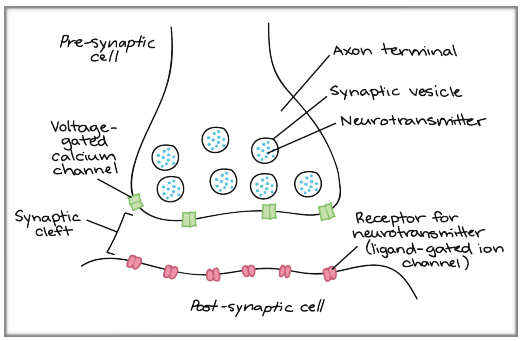
-Inability to speak or swallow



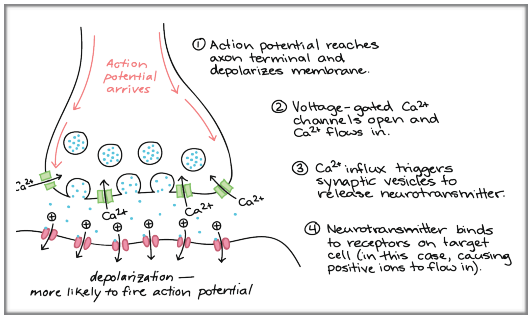
How Do Synapses Work?

Information is relayed throughout the body by 'synapses.' These synapses are present at nerve/axon terminals, and send information across dendrites[8].

The axon terminal of dendrites contain many synaptic vesicles. These are membrane bound spheres that carry neurotransmitters; the molecule which causes depolarisation at the post synaptic terminal[1].



However for these vesicles to be released across the synaptic cleft, an action potential is required. Upon an AP, voltage-gated calcium channels are activated, causing Ca^{2+} to rush into the cell, releasing neurotransmitters; which will then bind to receptor proteins on the postsynaptic cell causing either a depolarisation or hyperpolarisation, and thus the relay of the nerve impulse[13].



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Presynaptic & Postsynaptic Neurotoxins

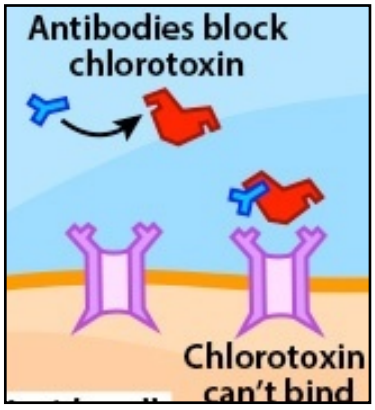
There is a wide array of neurotransmitters that are released from the presynaptic junction of nerve terminals, and neurotoxins are known to target these areas[9]. Most presynaptic neurotoxins work by the inhibition or activation of synaptic transmission to produce abnormal nerve impulse activity[4]. An example of this type of neurotoxin is the snake neurotoxin crotoxin. It is a β-neurotoxin that acts by blocking the release of acetylcholine at the presynaptic junctions in nerve endings[6]. This prevents any acetylcholine reaching the receptors at the post synaptic membrane and thus, dysregulating the generation of action potentials down the nerve[10].

There are also postsynaptic neurotoxins and they work by the blocking/competitive binding to acetylcholine receptors at the postsynaptic membrane[5]. An example of this neurotoxin is α-bungarotoxin, a snake neurotoxin which works by affecting the acetylcholine receptors at the postsynaptic junction. This works by the neurotoxin's peptides competitively binding to the nicotine acetylcholine receptor at the postsynaptic membrane, blocking acetylcholine from binding and depolarising the membrane. Thus inhibiting the transmission of the nerve impulse[7].

Treatment Options and How They Work?

Prevention is always better than cure, and whilst we can only try to keep ourselves protected from the chances of infection, sometimes infection can still occur; such as in the case of snake bites. In cases like this treatment is an option and for successful results, understanding the chemical nature of the specific neurotoxin in action helps.

When infected by snake venom usually an anti-venom is used to counteract the effects of the neurotoxin. The way this process works is by the antibodies of the anti-venom binding to the sites of the neurotoxin[15]. This prevents the neurotoxin from binding to the receptor sites of the postsynaptic membrane, and thus slowly returning back normal synaptic function[14].



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