



# The Synapse

- Describe, with the aid of diagrams, the structure of a cholinergic synapse.
- Outline the role of transmitters in the transmission of action potentials.
- Outline the roles of synapses in the nervous system.

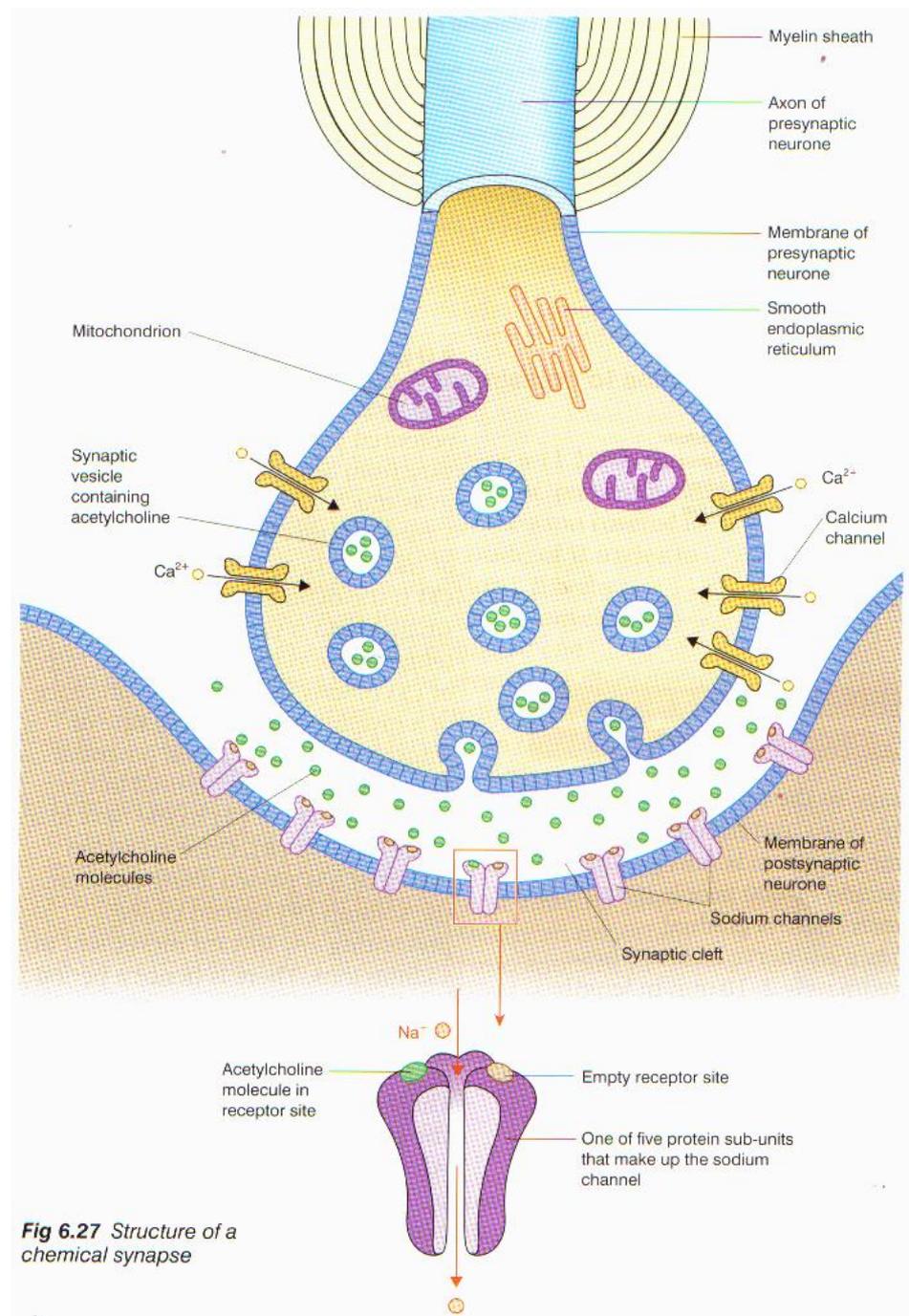


# The Synapse

- The point where the axon of one neurone connects with the dendrite of another or with an effector.
- It links different neurones together.
- The human brain has  $10^{11}$  neurones and  $10^{14}$  synapses.



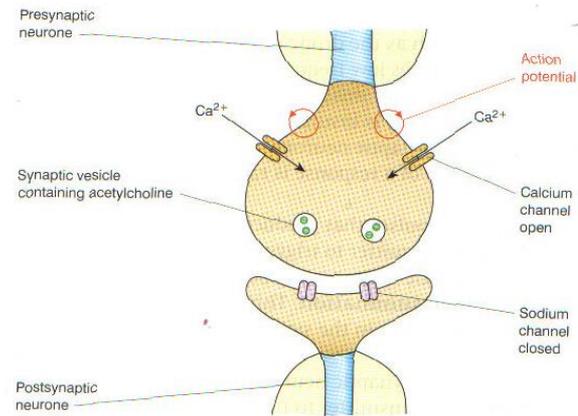
# Structure of a Chemical Synapse



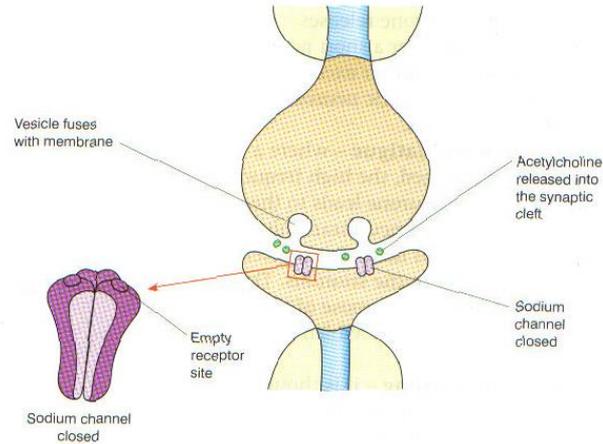
**Fig 6.27** Structure of a chemical synapse



1. The arrival of an action potential at the end of the presynaptic neurone causes calcium channels to open and calcium ions ( $\text{Ca}^{2+}$ ) enter the synaptic knob.



2. The influx of calcium ions into the presynaptic neurone causes synaptic vesicles to fuse with the presynaptic membrane, so releasing acetylcholine by exocytosis into the synaptic cleft.



3. Acetylcholine molecules fuse with receptor sites on two of the five protein sub-units that make up each sodium channel. This causes the sodium channels to open, allowing sodium ions ( $\text{Na}^+$ ) to diffuse in rapidly along a concentration gradient.

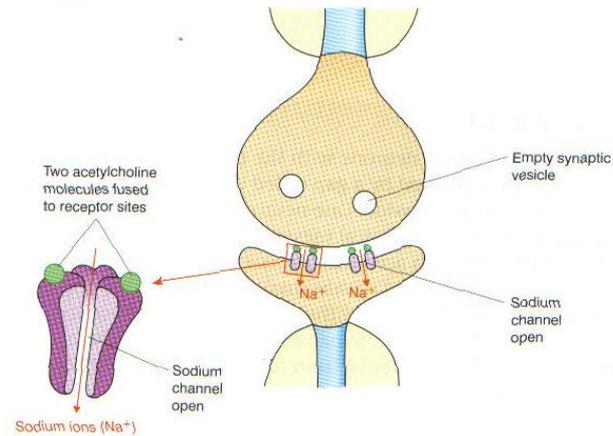
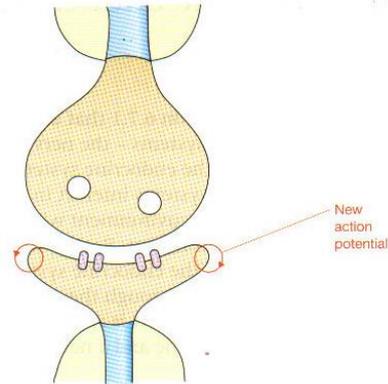
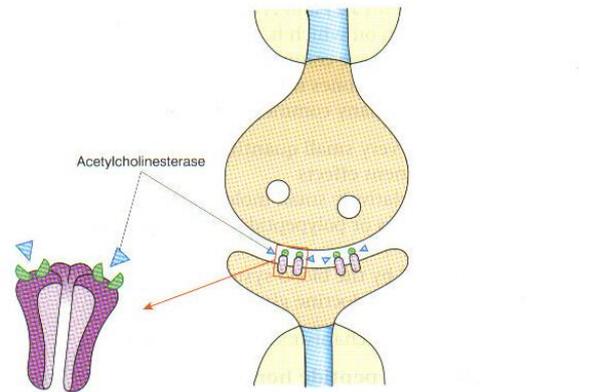


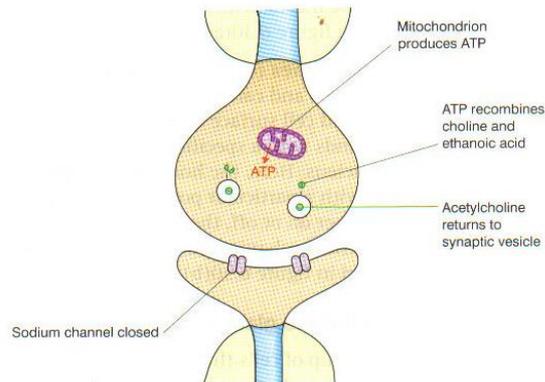
Fig 6.29 Mechanism of transmission across a cholinergic synapse



4. The influx of sodium ions generates a new action potential in the postsynaptic neurone. This is called the **excitatory postsynaptic potential (EPSP)**.



5. Acetylcholinesterase hydrolyses acetylcholine into choline and ethanoic acid (acetyl), which diffuse back across the synaptic cleft into the presynaptic neurone (= **recycling**).



6. ATP released by mitochondria is used to recombine choline and ethanoic acid into acetylcholine. This is stored in synaptic vesicles for future use. Sodium channels close in the absence of acetylcholine in the receptor sites.



# What are the functions of a synapse?

- Transmit information between neurones.
  - This is the basic function.
- Act as unidirectional valves.
  - Only the presynaptic neurone has neurotransmitter vesicles so it acts as a one-way valve.
- Act as junctions
  - Allow nerve impulses to diverge or converge.

- **Divergence.**

- A single impulse can be conveyed to a number of different neurones to create a number of simultaneous responses.

- **Convergence.**

- A number of impulses can be combined into a single impulse.
  - This occurs in the retina of the eye.

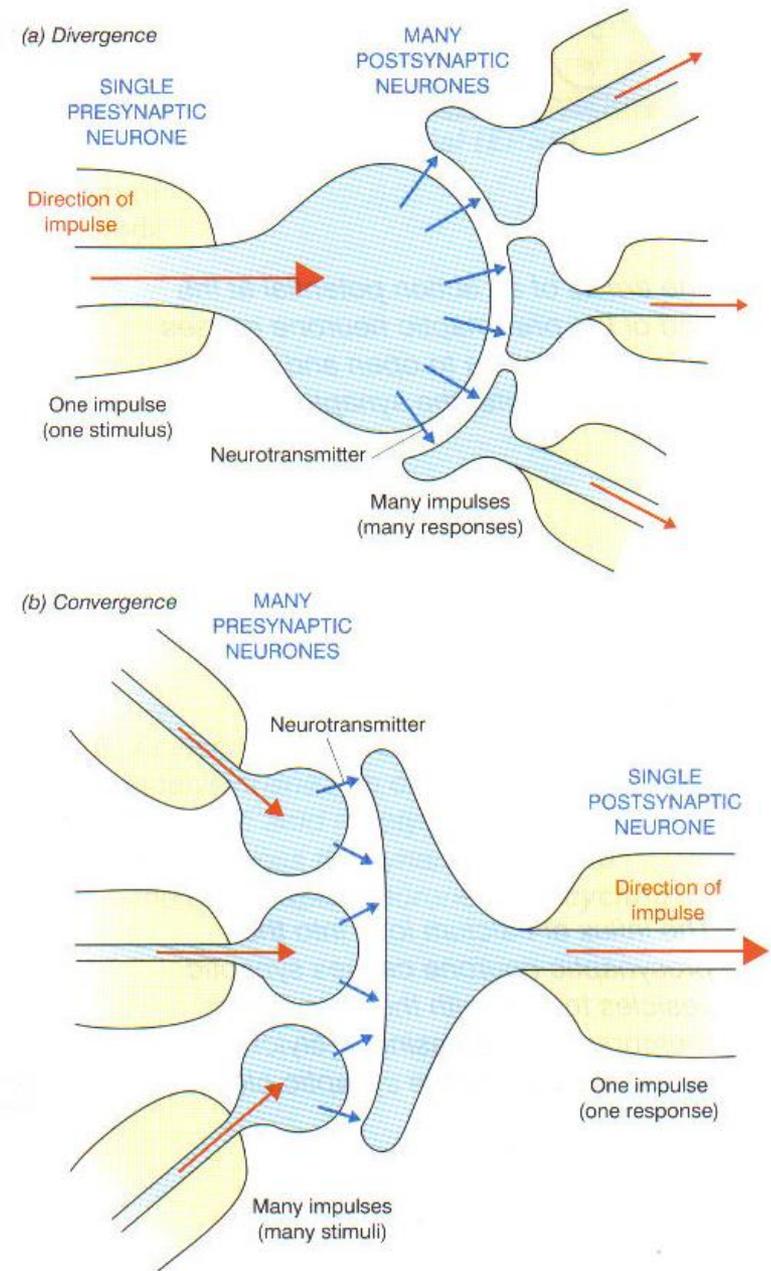


Fig 6.28 Divergence and convergence at synapses





# What are the functions of a synapse?

- Filter out low level stimuli.
  - Eg. Drone of traffic noise.
  - Low frequency impulse produce small amount of neurotransmitter. May not be sufficient to create a new impulse in postsynaptic neurone.



# What are the functions of a synapse?

- Allows impulse **summation**.
  - Low frequency impulses can be made to trigger a new impulse by one of two ways:
    - Where converging presynaptic neurones together produce enough neurotransmitter to trigger a new impulse.
    - Where a single presynaptic neurone produces a small amount of neurotransmitter many times over a short period.



# What are the functions of a synapse?

- Prevents overstimulation of the effector.
  - With a powerful stimulus, a high frequency of presynaptic impulses releases a lot of neurotransmitter.
    - Eventually the neurotransmitter release will stop as supply runs out.
    - The presynaptic neurone is said to be **fatigued**.
    - This prevents overstimulation & damage to an effector.
- Thought to be involved in memory & learning.



# How do drugs affect synapses?

- Nicotine is a drug that interferes with **cholinergic** synapses
  - those with acetylcholine as their neurotransmitter.
- Nicotine has a similar shape to acetylcholine.
- It binds to the acetylcholine receptor molecules.
  - This opens the sodium channels, creating an action potential in the postsynaptic neurone even in the absence of an incoming impulse from the presynaptic neurone.



# The effects of nicotine

- Increases adrenaline production.
  - Leads to raised heart rate & blood pressure.
- Easy to imagine a situation where nicotine stimulates the autonomic motor neurones that promote adrenaline production.
- When the body has got used to working with nicotine present, to withdraw it causes withdrawal symptoms. This makes it difficult to stop smoking.



# Summary Test

Synapses connect the axon of one neuron with the [1] of another. These are separated by a gap called the [2] that is about [3]nm wide. The [4] neurone releases a chemical messenger known as a [5], of which acetylcholine is an example. These messengers are stored inside small [6] and once released, diffuse across to receptor molecules on the [7] neurone. Synapses perform a number of functions, all of which derive from their ability to transmit impulses between one neurone & another. They act as junctions, allowing nerve impulses to [8] or [9]. They can also allow low frequency impulses to build up sufficient messenger substance over time that they trigger a new impulse in the postsynaptic neurone – a process called [10]. In the event of an intense & prolonged stimulus, synapses can also prevent [11] of an effector as the release of the messenger substance decreases over time – in this condition the presynaptic neurone is said to be [12].



# Summary Test Answers

1. Dendron
2. Synaptic cleft
3. 20-30
4. Presynaptic
5. Neurotransmitter
6. (synaptic) vesicles
7. Postsynaptic
8. Converge
9. Diverge
10. Summation
11. Overstimulation
12. Fatigued

**Answers in red may be in any order.**