

COMMONWEALTH OF AUSTRALIA  
Copyright Regulations 1969  
WARNING

This material has been copied and communicated to you by or on behalf of the University of New South Wales pursuant to Part VB of the Copyright Act 1968 (the Act).

The material in this communication may be subject to copyright under the Act. Any further copying or communication of this material by you may be the subject of copyright protection under the Act.

Do not remove this notice.

## Neurotransmission

- electrical signals are transmitted between neurons, from neurons to muscle, or between any excitable tissue, via synapses.

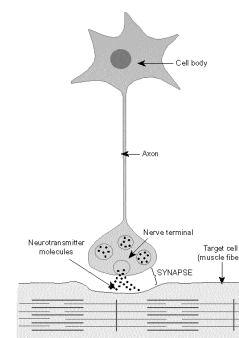
- synapses are either chemical or electrical.

### **Chemical transmission**

- 4 basic properties associated with chemical transmission.

- 1) generally signals transmitted in only one direction
- 2) synaptic delay between pre- and post-synaptic effects
- 3) requires release and binding of chemical neurotransmitter
- 4) signal transmission can be readily modified

### **Neuromuscular junction**



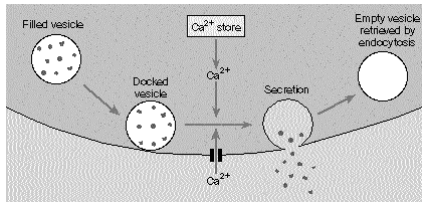
- events in neuromuscular transmission

1. action potential in presynaptic motor nerve terminal, leading to depolarisation of the terminal
2. increase in  $Ca^{2+}$  permeability and influx of  $Ca^{2+}$  into terminal
3. release of ACh from synaptic vesicles into synaptic clefts. (quantal release).
4. diffusion of ACh to postjunctional membrane
5. ACh combines with receptors on post synaptic membrane - opening channels in the post-synaptic membrane.

6. increases permeability to  $Na^+$  and  $K^+$

7. results in inflow of current (end-plate current, epc) which depolarises the post-synaptic membrane and causes a voltage change called an end-plate potential (epp).

8. post-synaptic membrane does not fire action potentials - the depolarisation of the postsynaptic membrane spreads electrotonically to adjacent regions of the membrane and an action potential is generated there that is propagated along the muscle fibre.



- ACh stored in synaptic vesicles in nerve terminal
- terminal contains voltage-gated  $Ca^{2+}$  channels – presence of  $Ca^{2+}$  triggers release of ACh by vesicles fusing to pre-synaptic membrane and emptying contents into synaptic cleft.

- in resting muscle the membrane potential shows small fluctuations with the same time course as epp's but only about 0.5 mV → *miniature end-plate potentials* (mepp's).

- mepp's produced by spontaneous release of the contents of a single vesicle (a quantum of ACh).

- normal epp is the response to hundreds of quanta released at the same time following the arrival of an action potential at the axon terminal.

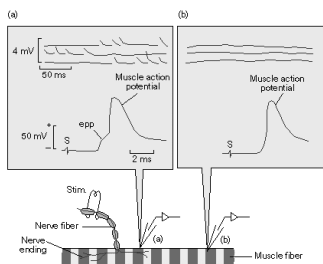
- epp displays a rapid depolarisation followed by a slower return to resting membrane potential.
- epp graded in amplitude – depends on amount of ACh released and degree of binding of ACh to receptors on postsynaptic membrane.
- the epp is transient - the action of ACh is ended by the hydrolysis of ACh to form choline and acetate - taken up by the presynaptic terminal and used to resynthesize ACh.
- hydrolysis is catalysed by the enzyme acetylcholinesterase (AChE)

-receptors for ACh located on postsynaptic membrane (average density  $\sim 10^4 \mu m^{-2}$ ).

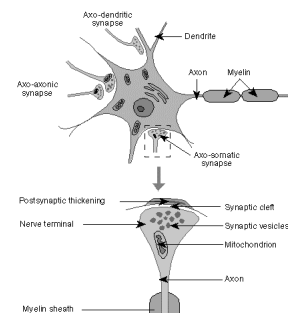
-ACh acts by increasing permeability of postsynaptic membrane to  $Na^+$  and  $K^+$ .

- channels opened by binding of neurotransmitter to receptor – ligand gated

- recording epp and action potentials in muscle



### Synaptic transmission



### Excitatory postsynaptic potential (epsp)

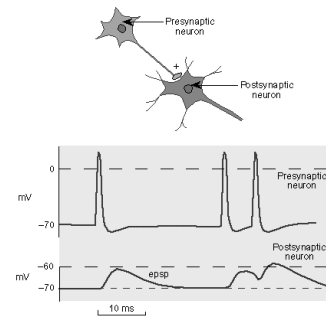
-postsynaptic depolarising response following activity in a synapse - - rapid rising phase followed by a slower return to the resting potential (similar to epp at the neuromuscular junction).

- epsp produced by conductance change ( $\text{Na}^+$ ) – ligand gated

- activity in one synapse does not produce sufficient depolarisation (epsp) to reach threshold.

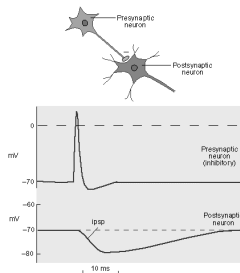
-the size of the epsp is proportional to the number of presynaptic fibres that are active (spatial summation) and/or the timing of activity at the synapse (temporal summation).

- temporal summation



### Inhibitory postsynaptic potential (ipsp)

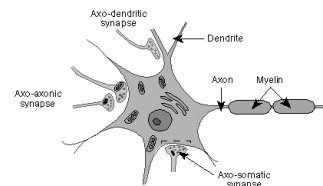
- inhibition of a postsynaptic cell occurs in a similar way to that seen in the epsp, except the effect is normally hyperpolarisation rather than depolarisation as in the epsp.



- most likely due to transmitter substance producing an increase in the permeability of the postsynaptic membrane to  $\text{Cl}^-$  or  $\text{K}^+$ .

- ipsp's show spatial and temporal summation.

- can be direct synaptic connection with neuron, via interneuron or presynaptic inhibition.



### Neurotransmitters and second messengers

-neurotransmitters may activate ion channels directly (ionotropic) or act via G-protein linked receptors (metabotropic).

-G-proteins act to open ion channels or to alter the rate of production of second messengers eg. cyclic AMP or inositol triphosphate ( $\text{IP}_3$ ).

-second messengers act to regulate a variety of intracellular events eg.  $\text{IP}_3$  acts mainly by releasing calcium from intracellular stores.

### G-protein activity

