Homeostasis Worksheet 4

1

The autonomic nervous system can be defined as that part of the motor system that does not innervate skeletal muscle. The nerves are all motor and have one synapse between the central nervous system and their effector organ, therefore having a ganglion along their length. All preganglionic fibres are cholinergic. The fibres conduct more slowly than in the somatic system and there are not usually one to one correspondences between nerve ending and target cell.

2

The two divisions of the autonomic nervous system are the sympathetic – with its thoraco-lumbar outflow, and the parasympathetic – with its cranio-sacral outflow. The fundamental difference is that the preganglionic fibres of the sympathetic nervous system are small and the ganglia exist within a sympathetic chain either side of the vertebrae, whereas the parasympathetic fibres have long preganglionic fibres and do not synapse until very close to or on the effector organ. Also, the sympathetic postganglionic fibres are cholinergic, with muscarinic receptors, whilst the parasympathetic are mainly adrenergic (although there are some cholinergic parasympathetic fibres). The parasympathetic system tends to be involved with helping the body whilst at rest, whilst the sympathetic prepares the body for action.

3

- Acetylcholine interacts with a receptor at the neuromuscular junction and the interaction results in conformational change. The receptor is a ligand gated ion channel. The ACh binding causes the permeability of the membrane to monovalent cations to increase, ie, both potassium and sodium. This results in the depolarisation of the membrane causing an action potential in the muscle surface membrane to be initiated. An agent that will mimic is curare – D-tubocurarine, whilst an agent that will block the effect is eserine or decamethonium.
- Acetylcholine also has an effect at the pacemaker region of the heart – ie, the sinoatrial node. The effect here is to slow the rate of heart beating. It achieves this, by increasing the permeability of the membrane to potassium, causing potassium to leave the cells, which results in a hyperpolarising effect to the membrane potential. An agent that mimics ACh is muscarine and an agent that blocks ACh is pirenzepine.
- At the sympathetic ganglion, the ACh is used to transmit the action potential rapidly across the junction so as to allow its propagation through the postganglionic fibre. The ACh receptor is a nicotinic receptor, as with the neuromuscular junction, but it has a slightly different structure. Like those of the neuromuscular junction, the effect of ACh binding is to increase the permeability to monovalent cations, which results in the membrane becoming depolarised, allowing an action potential to be initiated. An agent that mimics ACh is nicotine and an agent that can block the effect is hexamethonium.

4

ACh acts on the heart, mainly by acting on the sinoatrial node region of the heart. ACh is transmitted to this region by the vagus nerve which is part of the parasympathetic nervous system. The effect of ACh on the heart is to reduce the rate of firing of the SA node, which means a reduction on the pulse rate, and it also reduces the force of contraction. However, an observation not expected is seen. It is noticed that upon stimulation by ACh the absolute refractory period reduces – which would be expected to be associated with an increased rate of action potential firing. This paradox can be resolved by considering the effect of ACh on the heart cells. The ACh causes the potassium permeability to increase across the membrane of such cells. The result is an outflow of positive potassium ions which results in the membrane becoming hyperpolarised. This allows the sodium voltage gated ion channels to become transferred into the closed but openable state, which is ultimately responsible for the absolute refractory period. Thus it is achieved quicker. However the hyperpolarised membrane means that the I_f current takes longer to reach the threshold potential to initiate an action potential. This current is due to the SA node having a permanent sodium conductance that results in the constant inflow of sodium resulting in a small depolarising current. This current takes longer to reach threshold thus the rate of the heart is reduced whilst the absolute refractory period is reduced. Thus the paradox has been resolved.

5

Deadly nightshade contains atropine which is a antagonist of the muscarinic ACh receptors. It is also known as belladonna due to Greek mythology. Belladonna means beautiful woman. It refers to the cosmetic effect of the dilation of the pupils produced by atropine (we tend to feel attracted to those whose pupils dilate when they look at us).

6

When recording evoked potentials non-invasively, using a surface electrode on the skin, all the electrical activity within the body is non-selectively picked up. Sources of such activity include a variety of neural activities, muscle activity (EMG), heart activity (EKG) and eye-movement artifacts (EOG) from the subject, in addition to environmental electric noise such as the mains power supply, instrumental noise such as video monitor raster, stimulus artifacts etc. Thus, surface recorded evoked potentials are embedded in considerable noise, resulting in a low signal to noise ratio. This is ‘single ended recording. Appropriate placement of recording electrodes on either side of the active membranes, using differential recording can enhance the signal while rejecting common mode noise resulting in a better result of the actual electrical potential changes that you are looking for. The electrocardiogram is a single ended recording.

7

See next page

8 – What is the difference between an isotonic contraction and a isometric contraction and how could you experimentally measure the tension created by each method.

9 – What is Darcy's equation and what is its relevance to the linear velocity in the different blood vessels.