Contents

Introduction and Homeostasis

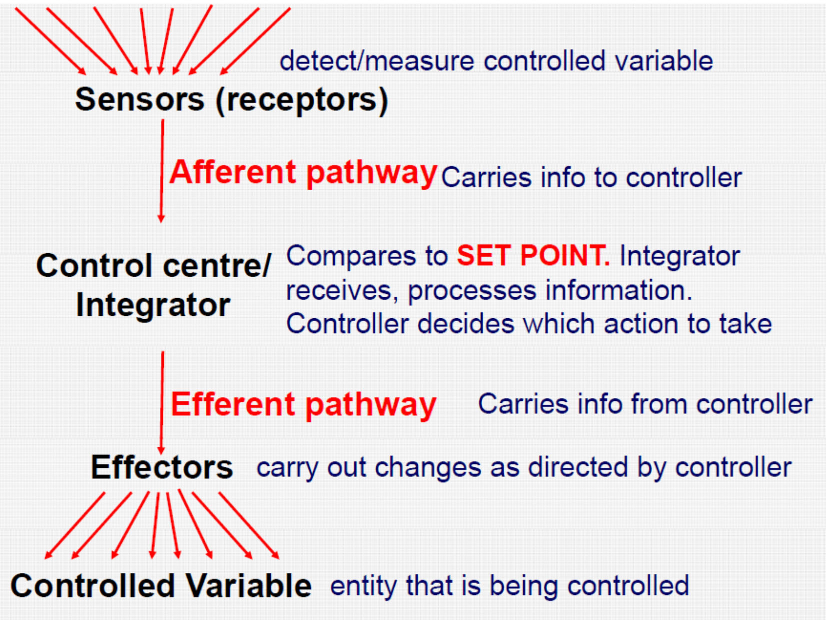
Homeostasis

Homeostasis maintains optimal conditions within the body to maintain cell and enzyme functions and to keep the body functioning properly. It involves expelling toxins, keeping pH and core temperature constant, taking in energy and other processes. If homeostasis is disturbed, a number of changes will be made in order to return systems to homeostasis.

The factor being maintained is the **controlled variable**. This controlled variable is monitored by **sensors** (these are the **receptors** for information) and sent via the **afferent pathway,** generally a system of nerves, to the controller, in many cases the brain or spinal cord. The **control centre** or **integrator** compares the information about the controlled variable to a **set point**, the level which the variable must be in order to maintain homeostasis. After processing this information, the controller decides which action must be taken and sends information to the **effectors** via the **efferent pathway.** These effectors carry out he changes as directed in order to bring the controlled variable back to levels required for homeostasis.

Both the nervous and endocrine systems are required to maintain homeostasis. The nervous system is fast acting, protective and localised and the effect usually only lasts as long as the reaction itself. For example, reflex arcs are a protective response which happens immediately in reaction to stimulus. The endocrine system is both longer acting and more wide acting. Hormones travel in the bloodstream until they meet their receptors, which are specialised to react to a particular stimulus. The endocrine system is usually controlled by a negative feedback of their product hormone.

There is constant feedback being carried to the controller regarding these controlled variables. Whenever information is sent to effectors and a change is made, information is sent back in order to monitor when the variable is back to homeostatic levels.



Negative feedback

Negative feedback is when the response brings the controlled variable closer to normal and is the most common type of feedback. An example of this can be seen in the body's response to dehydration- in this case the controlled variable is osmolarity. Dehydration leads to an increased electrolyte concentration in the blood which triggers the hypothalamus (our controller/integrator) to stimulate thirst and increases the amount of ADH (anti-diuretic hormone: increases the concentration of urine, hence decreasing the amount of water lost). When the animal drinks, the electrolytes in the blood are diluted and the osmolarity drops back to normal.

Positive feedback

This is an unusual form of feedback- it makes the controlled variable further from normal. One example of positive feedback occurs during labour. Contraction of the uterus forces the head of the child into the cervix. The mother's hypothalamus is the integrator in this instance and it stimulates the pituitary gland to release oxytocin (the effector) which increases further contraction of the cervix.

Feedforward

Feed forward is the body's way of averting a potential problem by reacting to a problem before it occurs. For example, when you get out of your air conditioned car on a very hot day, sensors on your skin immediately detect the heat and send a message to your brain which immediately readies the body to lose heat although body temperature has not yet changed. A modified negative feedback system kicks to prevent an increase of body temperature which the body judges as likely to occur as a result of the environment.

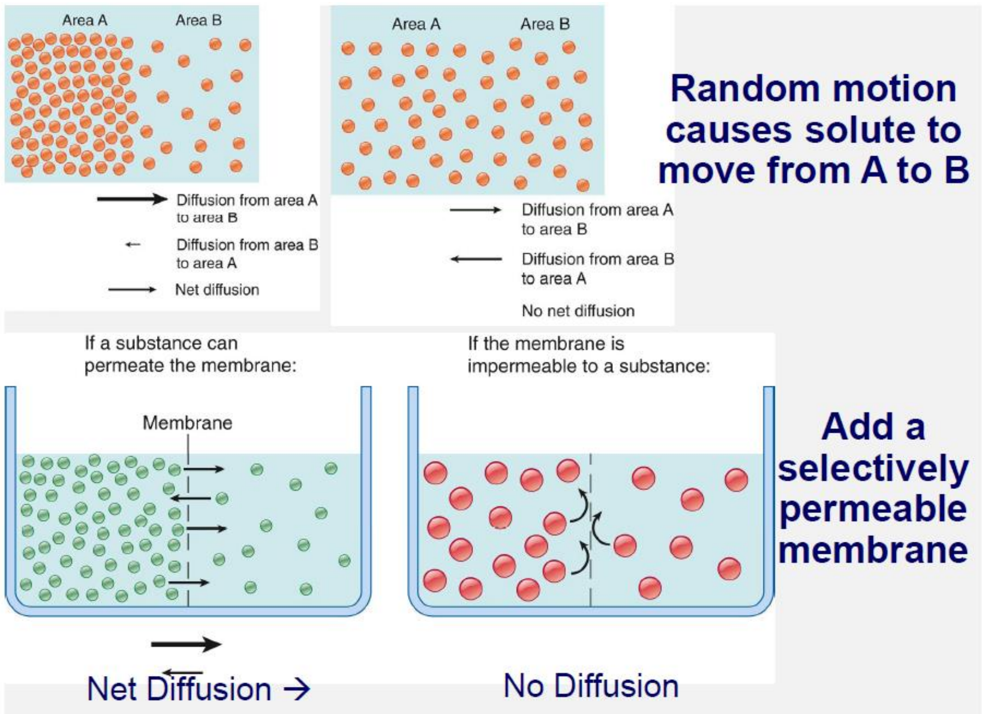
Body fluids

Water is essential for normal functioning of the body and makes up about 60% of adult body weight. 2/3 of this weight consists of intracellular fluid and the rest consists of extracellular fluid. 80% of this ECF is interstitial fluid- fluid found between cells for lubrication and communication. The remaining 20% of extracellular fluid makes up the fluid portion of blood known as plasma. A small amount of water is also found in minor compartments such as the gastrointestinal tract, eyes and as sinosidal fluid (fluid in joints). The osmolarity is the same in each compartment thanks to osmosis! If the osmolarity was higher in one compartment then it would be evened out by osmosis (see below).

The volume of the extra cellular fluid is proportional to the total sodium ions. Hence, if the sodium is increased this leads to increased ECF and ICF volume. This in turn causes increased water intake and retention which increases blood volume and hence blood pressure.

Cell membranes separate intercellular fluid and extracellular fluid which have very different compositions. These membranes are semi-permeable meaning they allow specific substances through. Water and other small, uncharged molecules may pass through the membrane through simple diffusion. Diffusion is a slow process involving the random movement of particles which collide with the membrane and pass through. If the temperature is increased, the particles move faster, increasing the number of collisions with the membrane and hence increasing the number of particles which pass through the barrier. The rate of diffusion is governed by Ficks' law which takes into the following factors. The concentration gradient is the difference in charge between two sides of a membrane. If the difference is large, the rate of diffusion will be higher. Membrane permeability is also a large contributing factor- membranes which are more permeable, that is have more holes or channels in them lead to a faster rate of diffusion as particles are more likely to pass through. Molecular weight; smaller molecules tend to pass through the barrier better than large molecules. The diffusion distance also makes a difference. If particles are required to diffuse over a long distance it will take longer than diffusion across a short distance. Finally the larger the surface area of the membrane, the more collisions will occur and hence the more particles which will pass through, increasing the rate of diffusion.

In summary, Fick's law takes into account the combined factors of concentration gradient, membrane permeability, molecular weight, diffusion distance, temperature and surface area.



Large molecules rely on facilitated diffusion to cross membranes. This may involve the use of a protein channel or a carrier protein. Channel proteins may be permanently open- these are pores which generally allow water and water soluble solutes through. Some of these protein channels may be ion-gated channels which are triggered by a particular chemical or voltage gated channels which open when a particular membrane potential is reached (different numbers of ions on either side of the membrane and ions are allowed through to even out the charge) or by a chemical gradient. Some channels may even be mechanical and are opened by the molecule physically pushing it open.

As well as channels, ions may be transported by proteins which change their configuration to allow solutes through. These forms of transport all move chemicals down their chemical gradients and hence do not require the input of energy. If chemicals are to be transported against their chemical gradients, then chemical energy, known as ATP, must be put in.

Osmosis

Osmosis refers to the specialised diffusion of water across a membrane. The water will move from areas of high “concentration to areas of low “concentration. For example if there is a 10M solution of NaCl on one side of a membrane and a 5M solution on the other, presuming that the Na+ and Cl – ions are unable to move through the membrane, the water will flow across in order to make both solutions 7.5M. The effective osmotic pressure exerted by a solution depends on the number of particles, not the type. Osmosis through water channels is how water constantly moves in and out of cells. All body fluid compartments are in osmotic equilibrium.

Osmolarity refers to the number of osmotically active particles per litre of solvent. **Tonicity** is the effective osmotic pressure of a solution relative to another, generally plasma. **Isotonic solutions** have the same osmolarity as plasma and hence the same osmolarity as the intracellular fluid of most cells. If a cell with intercellular fluid of osmolarity 300mOsm is placed into a solution of 300mOsm, there will be no net movement of water between the compartments and hence no change in cell