

Osmoregulation and excretion:

Basic idea is to keep a balance of salts in your body.

Osmosis review: definition - diffusion of water across a semi-permeable membrane.

diffusion - movement of a substance from a high concentration to a low concentration.

Thus, a simple example:

- a beaker with 5% salt on one side, 0% salt on the other, divided by a semi-permeable membrane (in this case salt can't move across the membrane).

- which way does water move?

- CONVERT to % water. So we have 100% water on one side, 95% water on the other. Water will move from a high concentration to a low concentration.

- lots of confusing terminology - hyperosmotic, hypoosmotic, hypotonic, etc., the only one you need to know is isoosmotic (concentration is the same). Otherwise, keep track of where the concentration of water is higher or lower.

A problem for many animals: sometimes the concentration of salt (and therefore water) in the surrounding environment is totally different from that inside the body.

Aquatic animals:

Types:

- osmoconformer - animal has the same salt concentration as surrounding water.

- osmoregulator - animal needs to regulate salt concentration since salt concentration in body is different than in the surrounding environment.

[Fig. 25.4A & B, p. 508]

Fresh water - problem is water will enter body. Animal must get rid of excess water, or it will "explode". How?

- Fish - will eliminate water through kidneys (very dilute urine)

- absorbs extra salt ions through the kidneys.

Many other animals similarly will excrete large amounts of dilute urine.

Marine water - opposite problem. Water will leave body because salt concentration outside the body is often higher than inside the body (water goes to more concentrated salt area - the animal would shrivel like a raisin).

Fish (most)- will excrete highly concentrated urine, thus keeping water inside the body.

- will also remove excess salt ions by excretion across gills.

Invertebrates - most are osmoconformers

(incidentally, in fresh water, many invertebrates can/must pump out water).

Terrestrial animals:

The problem is water conservation. Water is lost due to respiration, evaporation through surfaces (remember amphibians, for example), urine, etc.

- Water is restored by drinking, or conserved by behavioral adaptations (active at night) or physiological adaptations (below).

- Features that prevent water loss are dead keratinized skin, exoskeleton, and producing very concentrated urine.

- Excretion of metabolic wastes will now be examined in detail.

Excretion:

Substances excreted [**Fig. 25.5, p. 509**]:

- ammonia - this is the basic by-product of metabolism. Ideally, this is excreted directly into the environment. Problem --> highly toxic. But many aquatic organisms do this since they can easily replace water. [In fish, some of this is often excreted across the gills].

- urea - for terrestrial animals ammonia is no good - they can't get rid of it quickly enough. Instead, they convert ammonia into urea (100,000 times less toxic than ammonia) in the liver. This is then transported to the kidney and eliminated. This is also used by some marine organisms that need to conserve water (since high concentrations of urea are readily tolerated (e.g. sharks)).

- uric acid - many terrestrial organisms excrete uric acid (birds, many reptiles, insects, etc.). Uric acid is not very water soluble, so it can be excreted with very little loss of water. This is also good if you're an egg-layer since the waste material can be stored as a precipitate in the egg (the other two compounds would

remain dissolved, and even urea would eventually rise to toxic levels).

Mammalian kidneys:

- fairly complicated - here's an overview:

- [Fig. 25.6, p. 510].**

- materials in blood are excreted through the glomerulus (highly coiled capillaries) into Bowman's capsule (a collecting area).

- important nutrients are then reabsorbed in the proximal tubule. In addition water and salt are reabsorbed. The resulting fluid has about the same salt content as the surrounding tissues, but there's less of it. [Details: sodium is reabsorbed. Chlorine and water then follow].

- in some nephrons there exists the "loop of Henle". The main function of this loop is to establish a concentration gradient that can be maintained. To do this, salt is removed from the loop through passive and active transport. The surrounding tissue is much saltier near the bottom of this loop.

- As the filtrate moves to the top of the loop, it again becomes more and more dilute. This is because actual salt content of urine is controlled in the collecting duct (i.e., you want to start with reasonably dilute material and then reabsorb as necessary).

- at the distal tubule, concentrations of Potassium and Sodium ions are controlled, and pH is buffered (using bicarbonate) - this is similar to what happens in the proximal tubule.

- Finally, at the collecting duct, all that needs to be done is to change the permeability of the membrane and urine can be as concentrated or dilute as needed (within limits).

- This is much quicker than setting up the gradient every time. Note that as one goes down collecting duct, surrounding tissue becomes more and more salty. If membrane stays permeable, then a lot of water is reabsorbed. If membrane is made impermeable then more water is expelled.

- Details: go through **[Fig. similar to 25.8, p. 512]**

- note that water is removed as fluid descends loop. This is because loop is water permeable, but not salt permeable.

- as one moves up ascending loop, salt is removed - loop is now permeable to salt but not water, so salt will move from a high concentration within loop to the outside.

- salt is still removed as fluid moves further up loop, but this time due to active transport of molecules.

- note that all this salt removal establishes a concentration gradient, with lots of salt at the bottom, and less salt at the top.

- after going through the distal tubule, fluid now moves down collecting duct. Here the permeability of the membrane can be changed rapidly depending on the need for water.

So how is all this controlled? Or, in other words, how is the permeability of the collecting duct changed (remember - the gradient is maintained, all that changes is the permeability of the collecting duct)?

Methods of controlling kidneys [**Fig., not in book**]:

- ADH pathway:

- ADH (anti-diuretic-hormone) is produced in the hypothalamus and stored in pituitary. The hypothalamus monitors salt concentration of blood.

- If salt concentration rises, then => more water is needed in the body. So ADH is released. ADH increases the permeability of the collecting duct and so more water is reabsorbed.

- If the salt concentration drops, then the opposite happens. ADH is retained, and collecting duct remains impermeable to water. More water is expelled.

- [Alcohol disrupts this pathway some, causing more water to be expelled than otherwise. Causes dehydration (and also the need to urinate more often than normal)].

- RAAS pathway:

- responds to drops in blood pressure and/or blood volume (e.g., due to bleeding).

- when pathway activates, overall urine volume is reduced. This raises blood pressure and blood volume.

- Note: both pathways increase reabsorption of water. But ADH pathway directly senses salt concentration. RAAS pathway senses changes in blood pressure and volume.

- Why? Because blood loss can decrease blood pressure/volume without changing salt concentration, so a mechanism has evolved that helps retain “body fluids” during blood loss.