Osmoregulation and excretion (kidney function):

Two basic ideas:

1) To keep a balance of salts in your body.

Water and salt must stay in balance (the body needs to have a certain concentration of ions to function correctly).

As an example, think of terrestrial animals; most need to conserve water:

Water is lost due to respiration, evaporation, through urine, etc.

So water needs to be replaced and/or conserved.

Some examples:

Drinking.

Being active at night.

Having a water tight skin.

Producing a very concentrated urine.

(Some animals never have to drink!)

Other adaptations.

2) To remove metabolic wastes.

The main problem is nitrogenous wastes, mostly leftover from proteins.

There are three main ways of getting rid of nitrogenous wastes **[Fig. 25.5, p. 509]**:

i) *Ammonia* - this is the basic by-product of metabolism.

Ammonia is highly toxic and must be removed constantly through urination.

But this works for many aquatic organisms since they can easily replace water lost by urination.

(Ammonia is never allowed to accumulate in their bodies).

ii) *Urea* - for terrestrial animals this is much better:

Ammonia is converted into urea, which is 100,000 times less toxic than ammonia.

This can be allowed to accumulate a bit before it needs to be removed from the body.

This is also used by some marine organisms that need to conserve water.

iii) *Uric acid* - also used by many terrestrial organisms.

Birds, many reptiles, insects, etc., use uric acid.

Uric acid is not very water soluble, so it's also good for water conservation (can be excreted with little water loss).

Incidentally, this is also good if you're an egg-layer since the waste material can be stored in the egg and wont dissolve in the tissues.

Mammalian kidneys**[Fig. 25.6, p. 510]**:

(Just a very quick overview!)

1) Waste removal

This is actually a bit complicated, but here is a summary:

Materials in blood are excreted through the *glomerulus* (gomerulus = highly coiled capillaries) into *Bowman's capsule* (a collecting area).

Important nutrients are then reabsorbed in the *proximal* and *distal tubules*. In addition water and salt can be reabsorbed.

Essentially, everything is excreted, useful stuff is reabsorbed, and wasted are eliminated.

2) Salt balance

In about 10% of nephrons there exists the "*loop of Henle*"

(*nepron* = everything from Bowman's capsule to the end of the distal tubule).

The main function of this loop is to establish a salt concentration gradient.

The inside part of the kidney (*renal medulla*) is much saltier.

Once the leftover fluid that was excreted into Bowman's capsule arrives at the *collecting duct*, water can then be saved or expelled.

The *permeability of the membrane* of the collecting duct can be controlled.

If this membrane is permeable, water flows from a high concentration inside the collecting duct to a low concentration in the kidney (water goes to areas that are saltier).

You save water!

If the membrane is not permeable, water can not be reabsorbed, so it just flows out of the kidney.

You get rid of water!

By regulating the permeability of the collecting duct membrane, urine can be concentrated or dilute as needed.

Controlling the permeability of the membrane in the collecting duct (this also leads us into hormones!) **[Fig., not in book]**

ADH (**a**nti-**d**iuretic-**h**ormone) 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.

ADH is released. ADH increases the permeability of the collecting duct.

More water is reabsorbed (you save water).

If the salt concentration drops, then the opposite happens:

ADH is *not* released, and the collecting duct remains impermeable to water.

More water is expelled (you get rid of water).

[Incidentally alcohol disrupts this pathway:

It interferes with ADH, which causes more water to be expelled than normal.

This causes dehydration (and also the need to urinate more often than normal)].

Hormones / endocrine system:

Definition - a chemical signal that is released into the body fluids and causes a specific reaction elsewhere in the body.

Usually, only specific cells known as *target cells* will respond, but some hormones can affect many different systems:

A simple example:

Adrenal gland → epinephrine → raises blood sugar level, increases heart rate, generally increases metabolic activity.

[target cells include liver, heart, lungs.]

Endocrine glands: these are glands that secrete hormones. The human body has many; we'll only caover a few of them **[Fig. 26.3, p. 520]**.

See table on p. 521 for a list of hormones in humans (not exhaustive).

(There are also, *exocrine* glands, which are essentially hormones that are released outside body and can cause responses in other members of the same species e.g., pheromones).

Hypothalamus/pituitary:

Pituitary - a small gland at base of brain. This is composed of two parts **[Fig., 26.4 A, B & C]**:

Anterior pituitary:

This is directly controlled by the hypothalamus (through a portal vein system).

It synthesizes and secretes hormones depending on whether or not the hypothalamus releases a *releasing hormone* (or sometimes an *inhibiting hormone*)

All this does is tell the pituitary to release the appropriate hormone.

Hormones produced and stored by the anterior pituitary:

GH - growth hormones.

Prolactin - stimulates the mammary glands (starts milk production).

FSH/LH - affects the testes or ovaries (see reproductive system notes).

TSH - Thyroid stimulating hormone (more below).

ACTH - stimulates adrenal cortex.(more below).

MSH - Melanocyte stimulating hormone (affects pigments; can cause your skin, for example, to become darker (e.g., after exposure to sun)). Not in your text for some reason.

Endorphins - regulates pain receptors in brain (they can dull pain; also partly responsible for "runner's high").

Posterior pituitary:

Stores and releases two hormones that are *manufactured by the hypothalamus*:

Oxytocin - induces contractions of uterus (see reproductive system notes).

ADH - Anti Diuretic Hormone - we already discussed this (controls permeability of collecting ducts in kidneys)

Other endocrine glands/ functions:

Pineal gland - secretes melatonin, which regulates sleep cycles.

Sometimes sold as a sleep aid (over the counter).

Note, though, that it doesn't directly cause sleep - it sets your biological clock

In other words, it tells you body when to get tired, etc.

Some success has been reported in using melatonin to aid with jet-lag.

Thymus gland - stimulates development of T-cells. We won't discuss this any further.

Thyroid hormones - The thyroid secretes *thyroxine* that is directly responsible for growth and metabolism (note: thyroxine requires iodine, and "essential nutrient").

Hypothalamus → A. Pituitary → TSH (from above) → stimulates thyroid to release thyroxine.

(Both TSH and thyroxine can slow down further release of TSH from hypothalamus using negative feedback **[Fig. 26.4D, p. 523]**).

Calcium homoestasis in the blood **[Fig. 26.6, p. 525]**

The thyroid also releases calcitonin. Calcitonin lowers blood calcium levels.

Calcitonin → stimulates Calcium deposits in bones, reduces calcium uptake by intestine and kidney.

Parathyroid - small glands embedded in the thyroid. The parathyroid releases PTH (parathyroid hormone). This raises blood calcium levels.

PTH → causes bones to release calcium, increases calcium uptake by large intestine and kidneys.

Pancreas - insulin and glucagon **[Fig. 26.7 p. 526]**.

Excess sugar → causes release of *insulin* → liver absorbs glucose (converts glucose to glycogen), cells absorb glucose.

Insufficient sugar → release of *glucagon* → liver breaks down glycogen, releases this into the blood stream.

Note:

Insulin is released by *beta cells* in the pancreas.

Glucagon is released by *alpha cells* in the pancreas.

Type I diabetes (insulin dependent):

Caused by the immune system attacking beta cells in the pancreas. This destroys ability to produce insulin.

People with type I diabetes need insulin.

Type II diabetes (non-insulin dependent):

Caused by a deficiency in insulin production *and* because cells in the body stop listening to insulin (you need more insulin for cells to absorb glucose).

Often associated with bad diet, obesity, etc. (too much sugar eventually disrupts this system)

The problem with diabetes (there are lots!):

The concentration of sugar in the blood stays high

Sugar is excreted by kidneys, water follows by osmosis.

This louses up the bodies water balance, and the result is frequent urination and thirst.

This is often an initial symptom of diabetes.

As cells don't get enough glucose at the right times, lots of damage can occur:

Nerve damage (sensory nerves deteriorate, possibly leading to limb loss).

High blood pressure / kidney damage / glaucoma.

In extreme cases, can cause shock due to blood pH changes:

If glucose in not available, then fats are metabolized.

Normally this is fine, but if nothing but fats are metabolized, this can cause the buildup of ketones - and acidic byproduct, which can lower blood pH.

Depending on the source, diabetes (and complications) is listed as the fourth to sixth biggest cause of deaths in the U.S.

Adrenal medulla and cortex **[Fig. 26.9, p. 528]**:

The adrenal medulla releases *epinephrine* (= *adrenalin*) and *norepinephrine*. This causes the "flight or fight" response.

The adrenal medulla is directly controlled by the nervous system.

When the nerve stimulates the adrenal medulla, it releases adrenalin (as described above)

This is a very fast, powerful response.

The adrenal cortex responds to endocrine signals, not nervous system signals, so the response here is slower and not as powerful (this responds more to long term stress):

Stress → ACTH released by ant. pituitary → causes adrenal cortex to release corticosteroids.

(Note: if you really want to know, ACTH = Adrenocorticotropic hormone).

The release of corticosteroids results in:

Retention of water and salt.

This increases blood volume and pressure.

Protein and fat being converted to glucose.

This increases blood sugar.

Immune system suppression.

Corticosteroids can inhibit ACTH production, which can serve as a negative feedback system.

(In other words, it can slow the stress response).

Corticosteroids are broken down into several different classes, but we'll skip those details.

See your text if you're really interested.

The fact that the immune system is suppressed can be useful:

Cortisone, prednisone, and other corticosteroids can be useful to fight allergies, inflammations, some auto-immune diseases, and other problems.

However, they do have very nasty side effects, and long term use (particularly at higher dosages) can have serious consequences.

(Short term use is generally not a problem)

Finally, sex hormones are discussed in nauseating detail during reproduction lecture.