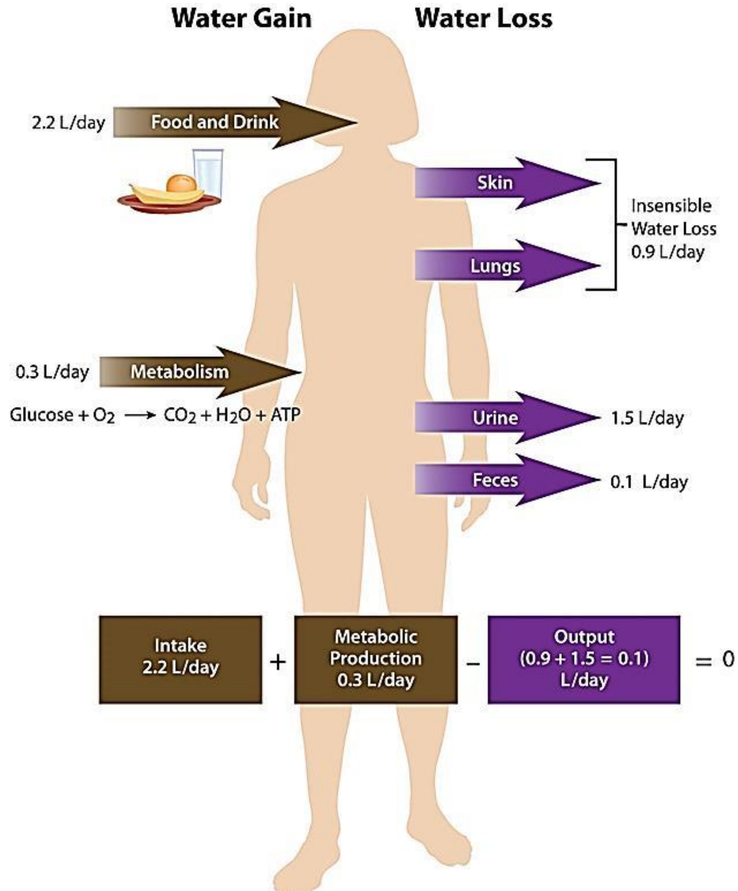
5.4 Control of water content

The maintenance of a relatively constant water potential of body fluids (blood plasma, tissue fluid and lymph) is called **osmoregulation.** The dissolved solute composition of cells and body fluids determines the water potential, and thus affects the water content. An appropriate quantity of water is essential to maintain the volume of cells and organisms within relatively narrow limits.

The water content of a mammal is maintained at a remarkably constant level by balancing water intake with water loss. Most of the water gained by the body on a daily basis (2500 ml) comes from ingestion (eating succulent foods and drinking), with a small proportion from metabolic reactions such as respiration. The body loses about 2500 ml of water per day from the kidneys, skin, lungs and GI tract through urination, sweating, breathing and defecation respectively.

Table: Average daily water gains & losses

Water gain (2500m)	*Water loss (2500ml)*
Metabolic water (200ml)	GI tract (100ml)
Ingested food (700ml)	Lungs (300ml)
Ingested liquid (1600ml)	Skin (600ml)
	Kidney (1500ml)



Control of body water is another important part of homeostasis operating on the principle of negative feedback, involving a hormone called **antidiuretic hormone** (**ADH**) or **vasopressin** produced by the hypothalamus but secreted into posterior pituitary gland and stored.

The water potential of blood is constantly being monitored by **osmoreceptors** in the hypothalamus of the brain.

If the water potential of blood is lower than normal; due to ingestion of little water, much sweating or ingestion of large amounts of salts, osmoreceptors in the hypothalamus are stimulated, setting up nerve impulses; passed to the posterior pituitary gland at the base of the brain; stimulating it to release ADH into the blood stream, carried to the kidney where it increases the permeability of the walls of the distal convoluted tubules and collecting duct to water; more water is thus drawn from the glomerular filtrate into the cortex and medulla by osmosis; carried away in blood; increasing blood water potential to norm. A small volume of a more concentrated (hypertonic) urine is released from the kidney.

Antidiuretic hormone also increases the permeability of the collecting duct to urea; more urea diffuses out of the urine into the tissue fluid of the medulla; lowering water potential here further;

more water moves by osmosis from the descending limb and collecting duct into the medulla; carried away in the capillary network and vasa recta. More water is retained in the body and urine is concentrated further.

A higher water potential of blood than normal owing due to ingestion of large volumes of water, little sweating or extremely low salt intake in the diet, is detected by osmoreceptor cells of the hypothalamus, release of ADH is inhibited; walls of the collecting duct and the distal convoluted become less permeable (impermeable) to water; less water is reabsorbed into the medulla as urine passes down, restoring blood water potential to norm as much water is excreted in urine: a copious dilute (hypotonic) urine is excreted.

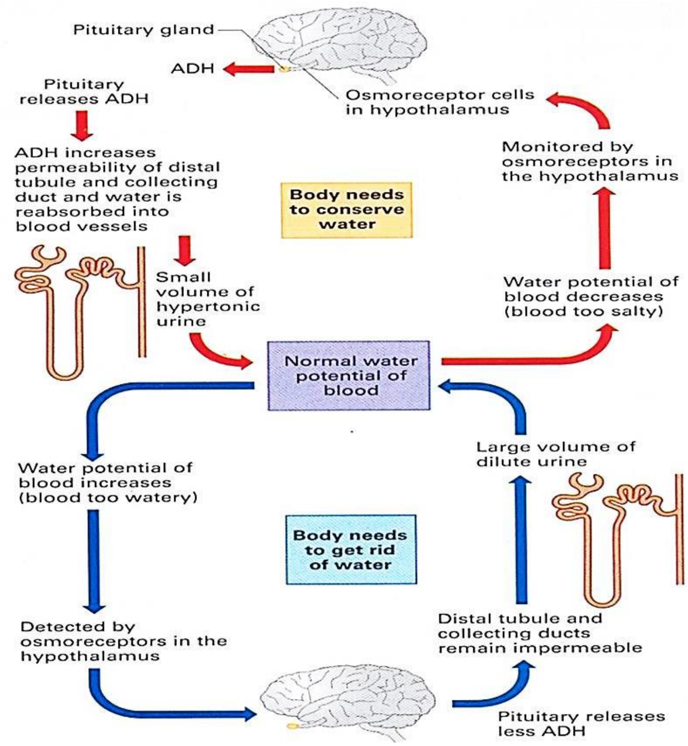


Fig 5.14 Control of blood water potential by negative feedback system

When the blood is too concentrated, the osmoreceptors in the hypothalamus stimulate **thirst centres** in the brain producing a sensation of thirst, causing the person to drink liquids.

The disease **diabetes insipidus** arises from failure to release sufficient levels of ADH, usually due to damaged hypothalamus. In this condition, large quantities of very dilute urine are produced (**diuresis**) and the body's water and salt balance must be artificially maintained regulating input, rather than output.

5.41 Adaptations of animals to different water availability in their habitats

Animals inhabit environments that differ markedly in the amount of water available, ranging from extremely dry deserts to permanently aquatic environments. To survive and function effectively under these contrasting conditions, animals have evolved a range of adaptations that enable them conserve water, regulate its internal balance, or cope with excess water in their surrounding.

Animals of dry (arid) habitats e.g. camel, kangaroo rat, desert frog

These are adapted to survive with little or no liquid water, thus minimize water loss while maximizing water conservation.

The **Kangaroo rat**, *Dipodomys sp. Fig 5.15*

- Exhales air at a temperature below body temperature reducing evaporative loss of water from the lungs
- Lacks sweat glands; minimize water loss through sweating
- Pass out urine concentrated by counter current exchange in extra-long loop of Henle
- Metabolize dry seeds to obtain metabolic water

- Remains in cool burrows during the heat of the day, thereby reducing on evaporation from the lungs
- Respiratory moisture in warm exhaled air condenses on the nasal passages and is conserved
- Passes very dry faeces to reduce water loss during defecation

Table: Water metabolism for a kangaroo rat

Water gains	cm^3	*Water losses*	cm^3
Metabolic water	54.0	Urine	13.5
Water absorbed in dried food	6.0	Faeces	2.6
Total water gain	60.0	Evaporation	43.9
		Total water loss	60.0

The **camel**

- Longer loop of Henle to ensure maximum reabsorption of water from the glomerular filtrate; conserving water by producing concentrated urine
- Possess tissues which tolerate dehydration i.e. can take long periods without drinking water
- Metabolic water; produced from oxidative breakdown of fats stored in the hump
- Able to drink large volumes of water rapidly to replenish losses

Fig 5.16 Dromedary camel

- Urea as excretory product requiring less water for excretion
- Dry faeces (rectal absorption) to reduce loss of water through defecation
- Dry mucus lining the nostrils; to absorb moisture from exhaled air; minimizing moisture loss
- Keratinized epithelium; reduce water loss

The **desert frog**, *Chiroleptes*

- Have small and few glomeruli in their kidneys; thus very low glomerular filtration rates, producing small quantities of urine, conserving water
- Ability to retain urine in their bladder for use during dry season
- Waterproof skin to reduce water loss
- Excrete a non-toxic, insoluble nitrogenous waste, uric acid requiring very small amount water for its elimination, thus much water is conserved

Fig 5.17 Australian desert frog