20 Water

Summary

Water is an essential nutrient. The human body obtains the water it needs from food and beverages and from metabolism of protein, fat and carbohydrate. Water is the most abundant of the body's chemical compounds, comprising about 60 per cent of body weight. The precise regulation of the body water content and its distribution requires control of intake and output by several body mechanisms, of which thirst is one. It is rare for problems of excessive water intake to occur, but Australians, for several reasons, may have an inadequate water intake.

Functions of water

Water acts as a solvent in which the chief chemical reactions of life occur. It is, itself, a by-product of many of these reactions. No doubt the abundant presence of water on the earth (approximately 75 per cent of the earth's surface is covered by water) was a critical factor in the development and evolution of cellular life. The presence of water has often determined the place of settlement of groups of human beings. Most of the major cities of the world, as well as most of the small settlements, require a fresh water source, such as a river or stream, not only for the needs of human consumption and washing, but also for the development of crop and herd growth, and long distance transport. Adequate rainfall is a powerful determinant of the economic success of a region or country.

Water acts as a diluent, by which food can be prepared, and cooked. Its presence in food aids in digestion by emulsifying food, thus enabling enzymes to gain easier access to food constituents. Within the body, the free movement of water across cell membranes enables a critical maintenance of intracellular and extracellular solute concentrations, a factor essential to cell viability. It also acts as a medium by which poisons and tissues are diluted, and, if water soluble, by which they may be excreted.

Water in food

Water, as a food, may be found free, in liquids, or as part of the cellular content of solid foods.

Free water, as a drink, is often found together with other food constituents, for example milk and fruit juices, and acts, therefore, as a vehicle for entry of energy-containing substances such as fats, sugars, and protein, as well as the water-soluble vitamins and many minerals. Naturally, substances derived from these fluids, such as ice cream, also have a water content. The various common alcohol fluids, such as beer and wine, also have a water content, but alcohol itself affects water control mechanisms to promote water excretion (see chapter 24, Alcohol).

Solid foods, of animal or vegetable origin, have a variable water content, which depends, in part, on their structure, and, in part, on their method of treatment before consumption. Nevertheless, a major proportion of water consumed daily is derived from solid food. Any decrease in solid food intake, results in a decrease in water intake. Table 20.1 shows the water content of some common foods.

Table 20.1 Water content of some common foods

Foods	*g/110 g*
HIGH CONTENT	
Marrow	98
Lettuce	95
Milk	93
Tomatoes	94
Melon	92
Fruit juices	92
Strawberries (fresh)	90
Pawpaws	88
Pineapple (fresh)	85
Oranges	85
Peas (raw)	78
MEDIUM CONTENT	
Potato (raw)	77
Passion fruit	74
Lamb (lean, raw)	72
Beef (lean, raw)	71
Chicken (boiled)	63
Lamb chops (average grilled)	50
Potato (fried)	47
Steak fillet (grilled, medium)	44
Pork, leg (roast)	34
LOW CONTENT	
Almonds (shelled)	5
Potato crisps	2

Distribution in the body

Water constitutes a little more than 60 per cent of total body weight in the average human being. This level is increased slightly in infancy, and decreased slightly in obesity.

Within the body, the cells are bathed in an internal sea of 'extracellular' water, from which they take up oxygen and nutrients, and into which they discharge metabolic waste products. The extracellular water, containing solutes (the most important of which is sodium cation*), bathes all cells; it constitutes about 15 per cent of body weight. An additional component of the extracellular water exists within the blood plasma, containing not only solutes, such as sodium, but also proteins. This constitutes a further 5 per cent of the body weight, and it is in constant close contact with the lungs, kidneys, skin, and the gastrointestinal tract, where exchanges of extracellular fluid may be made. The extracellular water thus constitutes about 20 per cent of body weight. The remainder of the body water, constituting some 40 per cent of body weight, is found intracellularly. Water is able to freely travel between the extracellular and the intracellular compartments.

Cation: positively charged atom in body fluids.

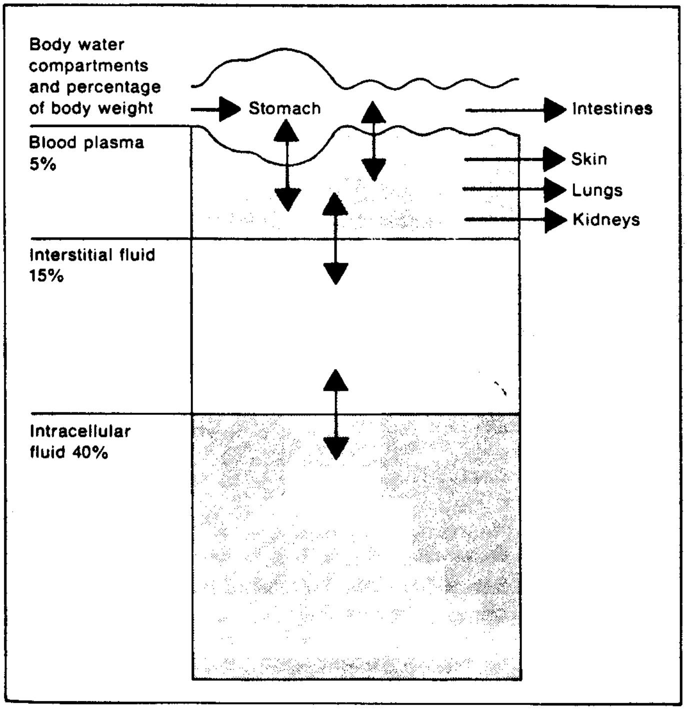

Figure 20.1 Water in the body is distributed widely; there is free diffusion of water from one compartment to another.

Control of intake and output

Thirst is the subjective sensation requiring the desire to drink water. It is, therefore, a phenomenon largely governed by the central nervous system*. Within the central nervous system (a central collection of nerve cells) the hypothalamus* has a prime role in the regulation of water intake and output. (It is also the area of the central nervous system which controls food intake by means of hunger and satiety.)

The hypothalamus has a capacity to sense the osmotic activity, that is, the solute balance, in the blood with which it is bathed. A rise in osmotic activity indicates increased blood concentration of solutes, and, therefore, decreased amounts of water in the blood, and vice versa. The hypothalamus is controlled by the nervous system which relays information from the heart.

If the pressure in the heart falls, the hypothalamus responds by arranging an increase in the blood volume.

The sight, smell and taste of fluids, are directed to the hypothalamus to influence water balance.

In response to all of these influences, the hypothalamus adjusts the secretion of a small protein or peptide hormone called anti-diuretic hormone (ADH) into the posterior part of the pituitary gland* which is in close contact with the hypothalamus. From here it is released into the blood stream. ADH acts within the kidneys; by making the walls of the collecting ducts more permeable to water, allowing water to be re-absorbed back into the capillaries of the vascular system. At the same time, the hypothalamus, through its central nervous system connectors, initiates sensations interpreted as thirst, and behaviour designed to seek fluid replacement. The kidney, by detecting changes in blood pressure caused by changes in blood volume, initiates a cycle of events commencing with the release of renin from the kidney. The net result of these constantly modulated reactions is the production of an appropriately concentrated urine.

Central nervous system: the brain and spinal cord, not including the nerves that run from the spinal cord to supply the body tissues.

Autonomic nervous system (ANS): that part of the nervous system that regulates basic bodily functions. It has connections with the hypothalamus. It receives and delivers nervous impulses to most parts of the body, especially to heart and blood vessels, lungs, gut, and secretory glands.

Hypothalamus: that part of the brain that regulates much of the basic bodily function such as temperature, osmotic activity and thirst, hormone secretion, appetite, sexual behaviour, and defensive reaction, such as fear and rage.

Hormones: hormones are messengers related by an endocrine gland in one part of the body into the blood stream to act on another part of the body. Renin is, in this sense, a hormone released from the kidney which, therefore, has endocrine functions. Aldosterone is also a hormone and the adrenal gland an endocrine gland.

Pituitary gland: an endocrine gland at the base of the brain below, and connected with, the hypothalamus. It is divided into an anterior and posterior part. Each part secretes different hormones.

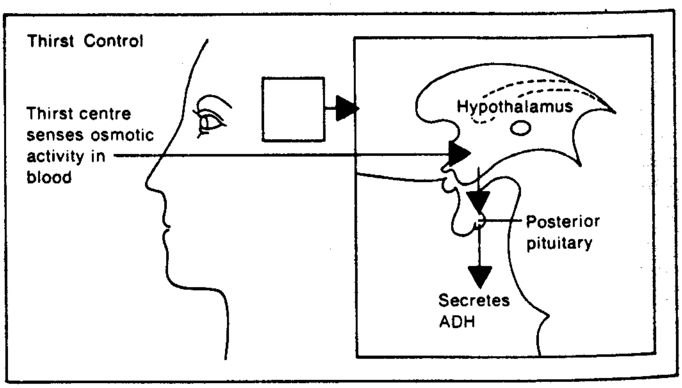

Figure 20.2 The hypothalamus, at the base of the brain, regulates water reabsorption by the release of anti-diuretic hormone (ADH). It also initiates the sensation of thirst. These activities are modulated by a large number of inputs from the brain, blood and heart.

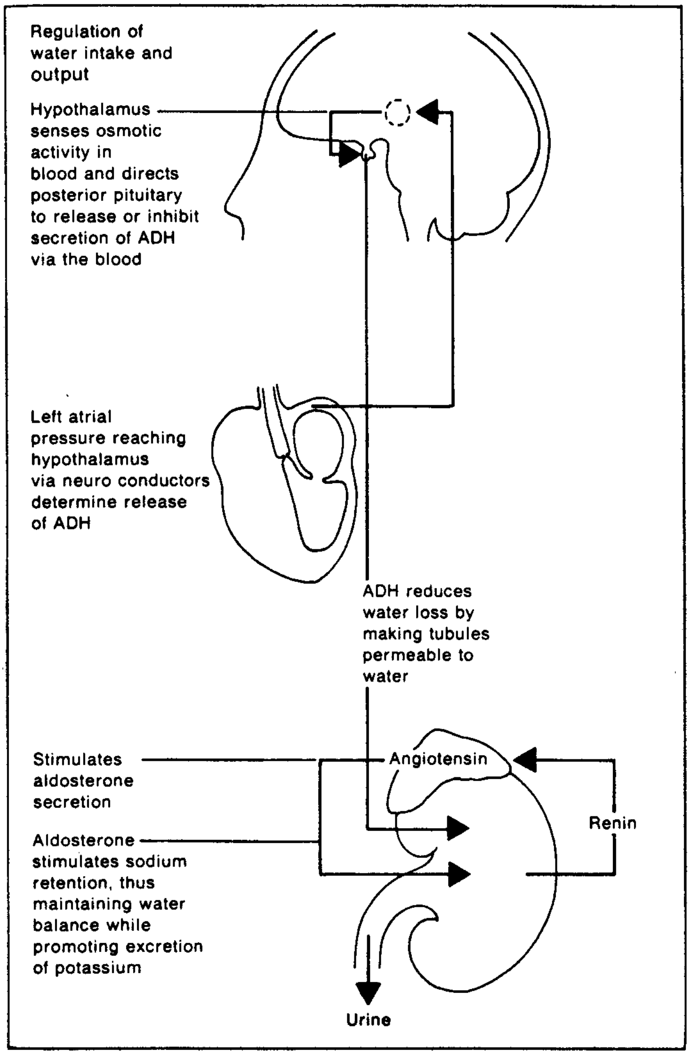

Figure 20.3 Inputs to the hypothalamus include blood pressure, as well as higher brain functions such as thought. This involves the heart, adrenal cortex and kidney.

Water is also lost from the body in a number of other ways from other organs. The largest organ of the body, the skin, loses water through sweat, at a rate determined by the surrounding temperature and humidity. At the same time, by the process of evaporation and convection, sweat helps control body temperature. Expired air from the lungs is also saturated with water vapour (in some species, for example dogs, panting is a significant cause of water excretion). The large intestine is able to transport water in both directions across its membrane. A volume of water is lost with faecal production. A small amount of water is produced intracellularly daily as a by-product of the circulation of food.

Table 20.2 Balance of daily water intake and output

Intake	*ml*	*Output*	*ml*
Solid and semi-solid food	1200	Skin (at average temperature and humidity)	500
Drinks	1000	Expired air (at average temperature and humidity)	350
Oxidation of food	300	Urine	1500
		Faeces	150
Total	2500		2500

Can water control in the body go wrong?

Body-water overload results in an expansion of the volume of the intracellular water compartment. As the body cells swell, they compress each other and their functional efficiency decreases. This applies particularly to brain cells, where expansion in size is limited by the fixed walls of the skull. The result is altered nervous system functioning, leading to confusion and coma.

Whilst this disorder is rare, a number of causes are known. These include a psychological disorder known as 'psychogenic polydipsia', in which there is an increased desire to drink water at the expense of all other nutrients. In addition, there are rare causes of abnormally increased amounts of ADH secretion, leading to an abnormal continual retention of water from the kidney.

However, much more commonly, water intake is reduced or displaced within the needs of the body. Reduction of water intake can lead to dehydration, and subsequent serious disruption of body functions. This is most likely to occur in the setting of increased 'insensible' losses of water through the skin and lungs, especially in high temperature zones, where there is increased water demand. Apart from dehydration affecting conscious functioning, other effects may become noticeable.

Urinary concentration of excreted solutes rises as available water decreases. This may result in increased opportunity for kidney stone formation. The incidence of kidney stones in Australia is the third highest in the world, a fact thought to be related to the generally arid conditions.

Water provides a continual rinse of the mouth, and reduction of intake may result in poor oral hygiene, including the development of dental caries, as bacteria are no longer rinsed away. Displacement of water by other fluids may be associated with an excess intake of other nutrients. The drinking of lemonade or alcohol, for example, will provide additional calories whilst satisfying thirst sensation.

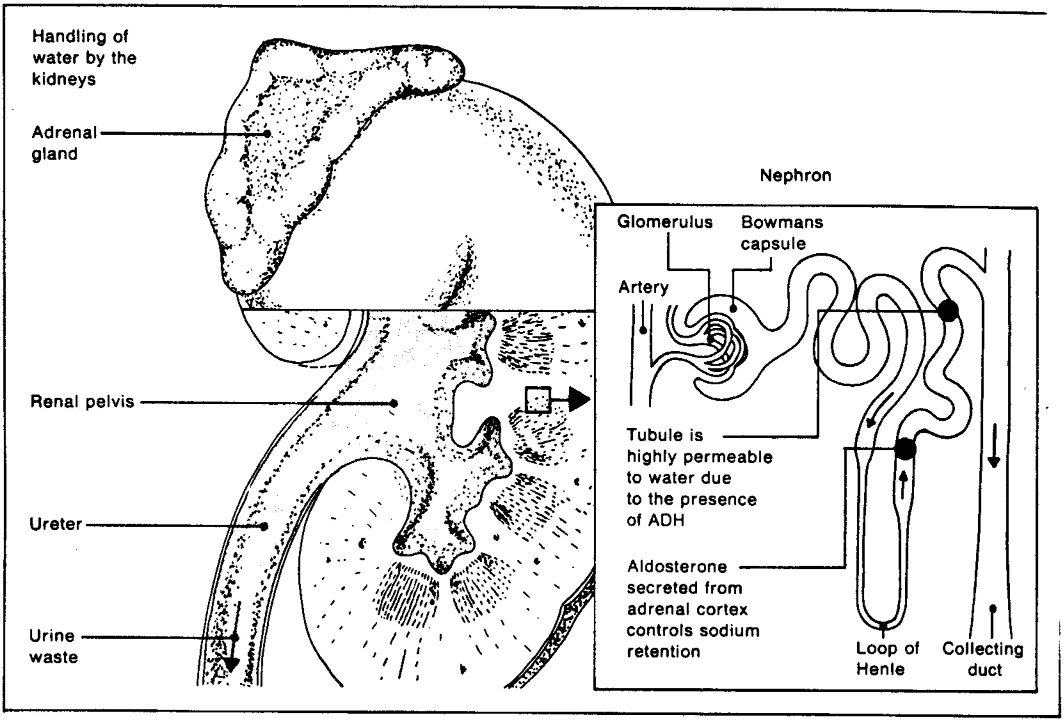

Figure 20.4 The adrenal cortex secretes aldosterone under the influence of the renin-angiotensin system. This hormone regulates the amount of sodium retained by the body. Antidiuretic hormone (ADH) from the hypothalamus regulates the amount of water excreted from the kidney.

The safeguarding of a secure, healthy water supply is important for community health needs. Bacterial contamination of water supplies may lead to widespread epidemics; the eating of foods with a very high water content may help alleviate water depletion in this situation. The content of local water supplies may also determine a number of factors in community health. The supply of fluoride in water is known to affect the rate and incidence of development of dental caries. The natural salinity of water may contribute to the sodium intake of the community.

Certain conditions can lead to decreased secretion of ADH, resulting in production of a copious dilute urine, called diabetes insipidus, and water depletion from the body. The most important cause is head injury with damage to the hypothalamus.

Further reading

McKintyre, A. K. (ed.) *Water, planets, plants and the soil.* Australian Academy of Science, Canberra.

Questions

1. If thirst is a signal that more water is required by the body, how appropriate would a range of drinks used by

Australians be, say, tap water, mineral water, milk, soft drinks (sweetened, carbonated beverages), 'low-calorie' cordials, beer, tea, and coffee? Why in western societies are most of these drinks preferred to water? In what situations would it be better to prefer them to water?

2. Assess your urine output for different periods of the day and night. Consider the factors that might alter urine flow from time to time.

3. Urine flow characteristically increases after drinking beer, but for what reasons?

4. What would you expect the range of daily water requirements to be between the different principal Australian cities and towns and for what reasons?

5. Australians have been encouraged to drink more water by nutritionists (see chapter 40, National nutrition policy). How valid do you think this advice is?

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