Hydration, water and health

Adequate hydration is an absolute requirement for our health [1637] and all active life. Liquid water is the most important nutrient throughout the living world [1628, 2011]. In particular, we cannot live without it for more than about 100 hours, whereas other nutrients may be neglected for weeks or months. Although commonly it is treated rather trivially, no other nutrient is more essential or needed in as great amounts.

Water content

The water content of our bodies (methodology reviewed [961]) varies and is variable between individuals, generally dropping, throughout our lives from above about 90% of total weight as a fetus to 74% as an infant, 60% as a child, 59% as a teenager (male; female 56%) 59% as an adult (male; female 50%) to 56% (male; female 47%) in the over-50's. The gender differences, from the teenager years onwards, are due to their differing fat levels, as is the drop in the elderly who replace muscle mass with fat. There is little difference with gender or age from childhood onwards, if allowance is made for this fat content. Body water is distributed between the cells (intracellular fluid, ICF, ~59%; ~26 L in a 75 kg man, ICF, ~61%; ~19 L in a 60 kg woman [1499]) and the extracellular fluid (ECF, ~41%; ~18 L in a 75 kg man including the ~3 L of plasma, ~12 L in a 60 kg woman [1499]) (for reference values for extracellular water see [1204]). Water is free to move between the ICF and the ECF with any net movement controlled by the effective osmotic and hydrostatic pressures. The molecules of water have a biological half-life in our bodies of about 9-10 days with an average residence time of about 2 weeks (these estimates depend on the person's age, gender, build and water consumption with higher intakes giving shorter half life). The majority of the ions in the ICF are K^+ and protein anions whereas in the ECF they are Na^+, Cl^- and bicarbonate.

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Water balance

Water intake and output are highly variable but closely matched to less than 0.1% over an extended period. Water balance in humans has been modeled [583]. Electrolyte intake and output are also closely linked, both to each other and the hydration status. Typical values for an adult in a temperate climate are given below:

Human water balance

Water input, mL/day		Water output, mL/day	
Drinks[a]	1500	Urine[d]	1500
Food[b]	700	From skin, sweat[e]	500
Metabolic water[c]	300	Respiration[f]	400
		Feces[g]	100

[a] Water, fizzy drinks, tea, coffee, alcoholic beverages, and so on. All water intake counts equally including coffee and alcoholic drinks as any diuretic effect is minimal or non-existent; once accustomed to caffeinated drinks, these count and act as any other water intake [615].

[b] Water contained in foodstuffs, varying from ~6% in peanuts, ~35% in bread to ~85% in fruits and vegetables.

[c] Water produced on metabolizing the foodstuffs and drinks (for example, 1 g fat gives ~1.1 g H_2O).
[d] A significant fraction of this is required for the removal of urea and other solutes. The rest is variable to equalize water input and output
[e] Used for temperature control, varying with energy intake and expenditure, ambient temperature and humidity
[f] Varies with energy intake and expenditure, ambient temperature and humidity. Together with losses from skin this typically amounts to about 50 mL/100 kcal food energy intake.
[g] Varies with diet, particularly increasing with increased dietary fiber

All values will vary with diet, activity and climate. The water ingested is determined by social, practical and psychological factors with need indicated by thirst, when the body is becoming dehydrated. Water output is regulated by hormonal action and the production of urine by the kidneys, which usually can adapt to the body's hydration status.

Water balance during sporting and similar activity can be derived from weight loss less liquid intake, so long as metabolic activity (metabolic water gain and substrate oxidation mass loss) is also accounted for [1523].

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Water requirements

The actual amount of liquid water (from drinks) that an individual needs depends on their age, gender, physical activity, physiological condition or illness and the temperature and humidity of their physical environment. A healthy individual may have slightly lower or somewhat higher water intakes without harm by varying their urine output. The recommended amounts are somewhat higher (1.0-1.5 mL/kcal) than the average intakes, being about 3.0 L for men and 2.2 L for women (rising to 2.3 L if pregnant or 3.1 L if lactating) [962]l. These higher levels of water intake seem to reduce the occurrences of kidney stones, gall stones and some cancers and may be otherwise beneficial [963]. However, there seems to be no scientific source for the argument in favor of much increased water intake (for example, for the statement "Drink at least eight glasses of water a day" or similar) [474] with both benefits and potential hazards of extra water intake being documented [474]. Perhaps surprisingly for such an important nutrient, there is insufficient evidence for either the benefit, or the lack of any benefit, from drinking increased amounts of water [1446]. However, low levels of water intake do not seem to show any health benefits and may be harmful.

Men require more water than women due to their higher (on average) fat-free mass and energy expenditure. Infants[a] and young children have need for more water in proportion to their body weight as they cannot concentrate their urine as efficiently as adults and their surface area relative to their weight is more extensive, giving rise to greater water loss from the skin. Often children are under-hydrated [1907]. The elderly should take care to ensure adequate hydration, as ageing diminishes the sensation of thirst as well as the ability to concentrate the urine.

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Water roles

Water plays many roles within the body; as a media for, and contributor to, molecular interactions; as a solvent and separating medium, to carry and distribute nutrients, metabolites, hormones and other materials around the body and within cells; to remove waste products, mainly via the urine and feces; as a reactant in many metabolic reactions; as a thermoregulator due to its high specific heat and heat of evaporation; as a lubricant between bodily structures and in forming mucous as well as facilitating necessary structural shifts in macromolecules such as proteins and nucleic acids; as a structure-former , maintaining cellular shape; and as a protective shock absorber, for example, for the brain.

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Hydration

Hydration status is difficult to define or determine precisely or accurately. An indicator of hydration status is the osmolality of the blood. However, it is normally closely controlled around about 284

mOsmol/kg (increasing slightly (1-2 %) in the elderly and decreasing ~3% during pregnancy) and is, therefore, a relatively poor indicator of hydration status. Short term hydration status may be determined simply and accurately by weight as only water content affects weight over short periods when food intake, fecal output and other possibly confounding factors (such as sweaty or changed clothing) are controlled.

Although the problem of dehydration in elite athletes appears to be an exagerated problem [1910], dehydration (starting at about 2-3% loss of body weight) otherwise causes a range of symptoms from tiredness, headaches and decreased alertness to collapse and death (at more than 10% loss of body weight). Mild symptoms may be seen in the lack of concentration of schoolchildren towards the end of their school day, with improved concentration in those less thirsty [1558]. Severe symptoms of dehydration are sometimes evident in the elderly, due to restricted water intake for medical, psychological or social reasons. Increased water intake is normally easily controlled due to the effective functioning of the kidneys to produce more urine. If this does not occur, due to greatly excessive water intake (for example, > 1.0 L/hr) or kidney disorder then the extra water (hyperhydration) may produce low blood sodium levels and cause the brain to swell, resulting in death.

Water should be drunk little but often throughout the day such that we are never thirsty, but with care certainly that we are not over-hydrated as a 2% over-hydration producing a generalised oedema that can impair athletic and mental performance [1910]. It is particularly important to hydrate last thing at night to prepare for the significant loss of water during sleeping and rehydrate first thing in the morning as this is a time when the blood is most viscous and strokes particularly prevalent. We should also drink before, during and after exercise to maintain our level of hydration. The thirst-quenching ability of soft drinks has been assessed [964]. Acidity was found to be the taste attribute most closely related with thirst-quenching with sweetness and 'thickness' (viscosity) being the most contra-indicated.

The rate of hydration is best measured by the use of D_2O uptake into saliva [1231]. For rapid uptake water has to be rapidly emptied from the stomach and absorbed by the small intestine. Typically this takes as little as 20-30 minutes, with half of a 300 mL drink being absorbed within about 15 (at rest) to 20 (after exercise) minutes. The rate of uptake is faster when at rest than when exercising with 'sports drinks', containing sugar and salt, showing a marginally faster rate, at rest, but similar time for complete absorption. In this study [1231], there was no difference in the absorption rate, or time for complete absorption, between 'sports drinks' and water when taken after exercise.

In the light of the increased promotion of 'special' water preparations, it is important to take notice that there are definite and proven health benefits from simply drinking more water and from changing fluid intakes from coffee, tea, alcohol, and hypertonic soft drinks to mineral or tap water [413]. That cup of coffee first thing in the morning is best, perhaps, replaced by a glass of water in order to reduce the higher risk of heart attacks at this time of day.

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Water for drinking

There is no such thing as naturally pure water; all waters we drink contain dissolved solutes and many contain some microorganisms [965]. Indeed, drinking 'pure' water even if obtainable, when it would be very expensive and prone to unwanted materials being introduced during its production and storage, is not a healthy option as important minerals are absent [1145]. There are several forms that the water we drink may take, which vary subtly from each other; drinking water, spring water, tap water, natural mineral water and water preparations promoted with various health claims. Our perception of the water is's drinkability is governed by its 'descriptors' rather than its contents [2092].. Bottled waters are subject to international regulations but are not necessarily safer than tap

water. Clearly, all such water must be drinkable, contain solutes (including those classed as contaminants) below the legally-allowed limits, to be bacteriologically safe and be subject to continued monitoring.

Types of water for drinking	
Tap water	Water, from any source, treated to meet legal and quality standards. It may contain low or moderate amounts of minerals depending on the source of the water (for example, hard or soft water areas). This is the major water product with over a billion glasses a day being consumed in the US alone, although most domestic tap water is used for washing, flushing the toilet and through wastage. Often it is chlorinated, which ensures microbiological safety for long periods of storage and eliminates all risks from otherwise devastating diseases such as cholera and dysentery. Although chlorination has been shown to possibly produce potentially hazardous byproducts, the association between exposure and demonstrable adverse health effects is still unproven and the protection chlorination offers far outweighs this risk. Fluoridation of water (for example, by adding SiF_6^{2-}) for the purpose of reducing dental caries, is generally regarded as safe [966a], succeeds in its purpose and is certainly economically beneficial in saving dental treatment [1580]. The health claims for fluoridation remain controversial [1048] but its use is expanding [1580]. Groundwaters containing excessive amounts of fluoride (> 1 mg/liter) are widespread [966b].
Drinking water	 Water intended for human consumption and may contain disinfectants and/or other solutes within legal quality standards. Such bottled water is not necessarily better for health than tap water, as shown in 2004 when Coca Cola was awarded an Ig® Nobel prize for producing Dasani in the UK. Dasani was a bottled 'pure' water prepared from London tap water. It was found that it contained high levels of the carcinogen bromate, which is (and was) not present in the tap water. The bromate was introduced by reaction between the added ozone and calcium chloride containing calcium bromide during production (for background science see [1000]).
Natural mineral water	Water from a spring, artesian well or well that naturally contains dissolved salts [967] (above 250 ppm in the US). It may be carbonated. It is characterized by its mineral content, which may vary between far lower to much higher than tap water, according to source. Mineral waters must be naturally safe with no parasitic or pathogenic organisms as they are not subject to disinfection. The

	presence of safe microorganisms is used as proof that no disinfection has taken place, but the water must be regularly tested [1386] as bottled mineral water is recognised as a potential source of antibiotic resistant bacteria to humans [1799]. Higher silica content distinguishes mineral water from surface (for example, reservoir) water. The price of mineral water is over a thousand times that of quality tap water.
Spring water	Water from an underground naturally flowing aquifer, collected as it flows and bottled at source.
Artesian water	Water from a well tapping an underground aquifer, with a water level above that of the top of the aquifer.
Well water	Water from a hole tapping an underground aquifer.
Purified water	Water produced by distillation, deionization, reverse osmosis or similar process. Such water contains little or no mineral content. many of these are micronutrients necessary for good health (Ca, P, Mg, F for bones and teeth; Zn, Cu, Se, Mg, Mn, Mo for enzymes; Fe, I, Cr for blood and hormones). Generally the amounts involved are far less than obtained by the rest of the diet. However, where the pure water is used for extended periods (e.g. where the sole source of water is obtained by reverse osmosis) and this water is used to cook (and hence leach ions from) vegetables, there may be shortages in the diet and thought must be given to the provision of additives [2082]. Also 'pure' water is not protected (e.g. by chlorination) and will be prone to microbial spoilage [2082].
Processed water with health claims	 There is an increasing market in bottled water and domestic water processing equipment claiming that the water has considerable health benefits varying from more rapid hydration to cures for AIDS and cancer. Generally there are no proper scientific trials to prove these claims, only isolated testimonial evidence. Oxygenated drinks have been proposed to improve the immune status. However, a randomized blinded clinical study [968], although showing a transient moderate increase in oxygen radicals (using 6 mM O_2) and signs of activation of the immune response, was not conclusive. One factor often used to promote these 'health' waters is supposed greater cellular hydration or ease of hydration. It is unclear whether increased cell hydration is actually health-promoting. A recent paper has argued that this may be a determining factor in the initiation of cancer [969]. It has been found that cancer cells and older cells [1745] do have greater water with increased fluidity

	[1998] but the cause and effect relationship (that is, whether increased cellular hydration initiates cancer or cell aging or cancer or cell aging initiates high cellular hydration) has not yet been established. In both cases, the increased fluidity (greater high density water) leads to the generation of reactive oxygen species and the cell becomes less able to repair damage.
'Sports' drinks	Sports drinks [973] are intended to reduce fluid, mineral (*e.g.* particularly Na^+) and energy imbalance due to exercise. The carbohydrate content and osmolality must both be low to encourage efficient hydration (that is, the drink must be hypotonic (<280 mOsmol/L) or isotonic (~280 mOsmol/L)). Na^+ ions (usually as NaCl) are a necessary ingredient as they stimulate both sugar and water uptake in the small intestine as well as replacing material lost by sweat. Hypotonic drinks give more rapid hydration but clearly contain less sugar and minerals. Chilling improves palatability so encouraging consumption. Some sports drinks contain 'power' ingredients such as caffeine or taurine, where there is patchy evidence of some sports benefit. These products are usually promoted with testimonials from athletes or sports teams, but without double-blinded trial evidence.

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Footnotes

[a] Fully breastfed babies do not require extra water [1111]; breast milk having a higher water content for its energy content than the adult diet. Compared with adults (and in spite of appearances to the contrary), they do not produce relatively more urine than adults as they tend to retain more water for growth and have a high loss through their relatively larger surface area [1346]. [Back]

Source:http://www1.lsbu.ac.uk/water/health.html