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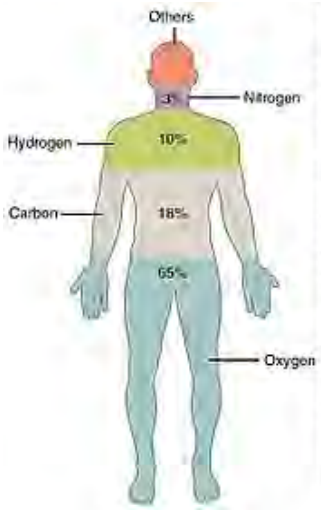
Composition of the human body

Body composition may be analyzed in terms of molecular type e.g., water, protein, connective tissue, fats (or lipids), hydroxylapatite (in bones), carbohydrates (such as glycogen and glucose) and DNA. In terms of tissue type, the body may be analyzed into water, fat, muscle, bone, etc. In terms of cell type, the body contains hundreds of different types of cells, but notably, the largest *number* of cells contained in a human body (though not the largest mass of cells) are not human cells, but bacteria residing in the normal human gastrointestinal tract.



Element	Symbol	Percentage in Body
Oxygen	O	65.0
Carbon	C	18.5
Hydrogen	H	9.5
Nitrogen	N	3.2
Calcium	Ca	1.5
Phosphorus	P	1.0
Potassium	K	0.4
Sulfur	S	0.3
Sodium	Na	0.2
Chlorine	Cl	0.2
Magnesium	Mg	0.1
Trace elements include boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).		less than 1.0

The main elements that compose the human body are shown from most abundant (by mass, not by fraction of atoms) to least abundant.

Contents

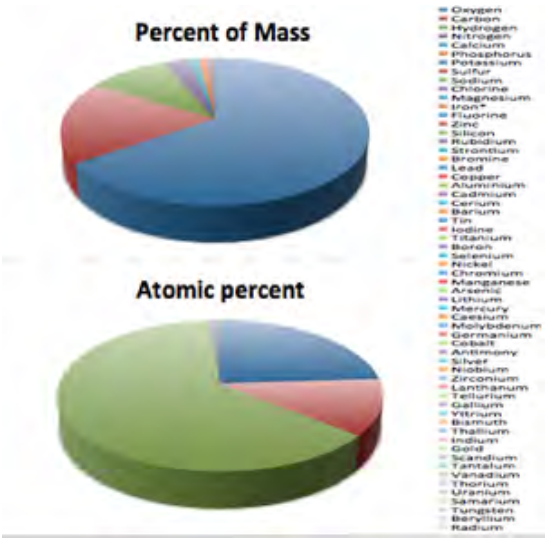
Elements

Almost 99% of the mass of the human body is made up of six elements: oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus. Only about 0.85% is composed of another five elements: potassium, sulfur, sodium, chlorine, and magnesium. All 11 are necessary for life. The remaining elements are trace elements, of which more than a dozen are thought on the basis of good evidence to be necessary for life. All of the mass of the trace elements put together (less than 10 grams for a human body) do not add up to the body mass of magnesium, the least common of the 11 non-trace elements.

Other elements

Not all elements which are found in the human body in trace quantities play a role in life. Some of these elements are thought to be simple bystander contaminants without function (examples: caesium, titanium), while many others are thought to be active toxics, depending on amount (cadmium, mercury, radioactives). The possible utility and toxicity of a few elements at levels normally found in the body (aluminium) is debated. Functions have been proposed for trace amounts of cadmium and lead, although these are almost certainly toxic in amounts very much larger than normally found in the body. There is evidence that arsenic, an element normally considered a toxin in higher amounts, is essential in ultratrace quantities, in mammals such as rats, hamsters, and goats.[1]

Some elements (silicon, boron, nickel, vanadium) are probably needed by mammals also, but in far smaller doses. Bromine is used abundantly by some (though not all) lower organisms, and opportunistically in eosinophils in humans. One study has found bromine to be necessary to collagen IV synthesis in humans.[2] Fluorine is used by a number of plants to manufacture toxins (see that element) but in humans only functions as a local (topical) hardening agent in tooth enamel, and not in an essential biological role.



Pie charts of typical human body composition by percent of mass, and by percent of atomic composition (atomic percent).

Elemental composition list

The average 70 kg (150 lb) adult human body contains approximately 7×10^{27} atoms and contains at least detectable traces of 60 chemical elements.[3] About 29 of these elements are thought to play an active positive role in life and health in humans.[4]

The relative amounts of each element vary by individual, mainly due to differences in the proportion of fat, muscle and bone in their body. Persons with more fat will have a higher proportion of carbon and a lower proportion of most other elements (the proportion of hydrogen will be about the same). The numbers in the table are averages of different numbers reported by different references.

The adult human body averages ~53% water. This varies substantially by age, sex, and adiposity. In a large sample of adults of all ages and both sexes, the figure for water fraction by weight was found to be 48 ±6% for females and 58 ±8% water for males.[5] Water is ~11% hydrogen by mass but ~67% hydrogen by atomic percent, and these numbers along with the complementary % numbers for oxygen in water, are the largest contributors to overall mass and atomic composition figures. Because of water content, the human body contains more oxygen by mass than any other element, but more hydrogen by atom-fraction than any element.

The elements listed below as "Essential in humans" are those listed by the (US) Food and Drug Administration as essential nutrients,[6] as well as six additional elements: oxygen, carbon, hydrogen, and nitrogen (the fundamental building blocks of life on Earth), sulfur (essential to all cells) and cobalt (a necessary component of vitamin B_{12}). Elements listed as "Possibly" or "Probably" essential are those cited by the National Research Council (United States) as beneficial to human health and possibly or probably essential.[7]

Atomic number	Element	Fraction of mass[8][9][10][11][12][13]	Mass (kg)[14]	Atomic percent	Essential in humans[15]	Negative effects of excess	Group
8	Oxygen	0.65 1	43 = 95 lb	24 2	Yes (e.g. water, electron acceptor)[16]	Reactive oxygen species	16
6	Carbon	0.18 2	16 = 36 lb	12 3	Yes[16] (organic compounds)		14
1	Hydrogen	0.10 3	7	62 1	Yes[16] (e.g. water)		1
7	Nitrogen	0.03 4	1.8	1.1 4	Yes[16] (e.g. DNA and amino acids)		15
20	Calcium	0.014 5	1.0 = 2.2 lb	0.22 5	Yes[16][17][18] (e.g. Calmodulin and Hydroxylapatite in bones)		2
15	Phosphorus	0.011 6	0.78	0.22 6	Yes[16][17][18] (e.g. DNA and phosphorylation)	white allotrope highly toxic	15
19	Potassium	2.0×10^{-3} 7	0.14 = 5 oz	0.033 9	Yes[16][17] (e.g. Na^+/K^+-ATPase)		1
16	Sulfur	2.5×10^{-3} 8	0.14 = 5 oz	0.038 7	Yes[16] (e.g. Cysteine, Methionine, Biotin, Thiamine)		16
11	Sodium	1.5×10^{-3}	0.10 = 3.5 oz	0.037 8	Yes[17] (e.g. Na^+/K^+-ATPase)		1
17	Chlorine	1.5×10^{-3}	0.095 = 3.4 oz	0.024	Yes[17][18] (e.g. Cl-transporting ATPase)		17
12	Magnesium	500×10^{-6}	0.019 = 19 gm	0.0070	Yes[17][18] (e.g. binding to ATP and other nucleotides)		2
26	Iron*	60×10^{-6}	0.0042 = 4.2 gm	0.00067	Yes[17][18] (e.g. Hemoglobin, Cytochromes)		8
9	Fluorine	37×10^{-6}	0.0026 = 2.6 gm	0.0012	Yes (AUS, NZ),[19] No (US, EU),[20][21] Maybe (WHO)[22]	toxic in high amounts	17
30	Zinc	32×10^{-6}	0.0023 = 2.3 gm	0.00031	Yes[17][18] (e.g. Zinc finger proteins)		12
14	Silicon	20×10^{-6} 1 gm	0.0010	0.0058	Possibly[7]		14
37	Rubidium	4.6×10^{-6}	0.00068	0.000033	No		1
38	Strontium	4.6×10^{-6} 320 mg	0.00032	0.000033	——		2
35	Bromine	2.9×10^{-6} 260 mg	0.00026	0.000030	——		17
82	Lead	1.7×10^{-6} 120 mg	0.00012	0.0000045	No	toxic	14

Atomic number	Element	Fraction of mass[8][9][10][11][12][13]	Mass (kg)[14]	Atomic percent	Essential in humans[15]	Negative effects of excess	Group
29	Copper	1×10^{-6} 72 mg	0.000072	0.0000104	Yes[17][18] (e.g. copper proteins)		11
13	Aluminium	870×10^{-9}	0.000060	0.000015	No		13
48	Cadmium	720×10^{-9}	0.000050	0.0000045	No	toxic	12
58	Cerium	570×10^{-9}	0.000040		No		
56	Barium	310×10^{-9}	0.000022	0.0000012	No	toxic in higher amounts	2
50	Tin	240×10^{-9}	0.000020	6.0×10^{-7}	No		14
53	Iodine	160×10^{-9} 20 mg	0.000020	7.5×10^{-7}	Yes[17][18] (e.g. thyroxine, triiodothyronine)		17
22	Titanium	130×10^{-9}	0.000020		No		4
5	Boron	690×10^{-9} 18 mg	0.000018	0.0000030	Probably[7][23]		13
34	Selenium	190×10^{-9} 15 mg	0.000015	4.5×10^{-8}	Yes[17][18]	toxic in higher amounts	16
28	Nickel	140×10^{-9}	0.000015	0.0000015	Probably[7][23]	toxic in higher amounts	10
24	Chromium	24×10^{-9}	0.000014	8.9×10^{-8}	Yes[17][18]		6
25	Manganese	170×10^{-9} 12 mg	0.000012	0.0000015	Yes[17][18] (e.g. Mn-SOD)		7
33	Arsenic	260×10^{-9}	0.000007	8.9×10^{-8}	Possibly[1][7]	toxic in higher amounts	15
3	Lithium	31×10^{-9} 7 mg	0.000007	0.0000015	Yes (intercorrelated with the functions of several enzymes, hormones and vitamins)	toxic in higher amounts	1
80	Mercury	190×10^{-9}	0.000006	8.9×10^{-8}	No	toxic	12
55	Caesium	21×10^{-9}	0.000006	1.0×10^{-7}	No		1
42	Molybdenum	130×10^{-9} 5 mg	0.000005	4.5×10^{-8}	Yes[17][18] (e.g. the molybdenum oxotransferases, Xanthine oxidase and Sulfite oxidase)		6
32	Germanium		5×10^{-6}		No		14
27	Cobalt	21×10^{-9} 3 mg	0.000003	3.0×10^{-7}	Yes (cobalamin, B_{12})[24][25]		9
51	Antimony	110×10^{-9}	0.000002		No	toxic	15
47	Silver	10×10^{-9}	0.000002		No		11
41	Niobium	1600×10^{-9}	0.0000015		No		5
40	Zirconium	6×10^{-6}	0.000001	3.0×10^{-7}	No		4
57	Lanthanum	1370×10^{-9}	8×10^{-7}		No		

Atomic number	Element	Fraction of mass[8][9][10][11][12][13]	Mass (kg)[14]	Atomic percent	Essential in humans[15]	Negative effects of excess	Group
52	Tellurium	120×10^{-9}	7×10^{-7}		No		16
31	Gallium		7×10^{-7}		No		13
39	Yttrium		6×10^{-7}		No		3
83	Bismuth		5×10^{-7}		No		15
81	Thallium		5×10^{-7}		No	highly toxic	13
49	Indium		4×10^{-7}		No		13
79	Gold	3×10^{-9}	2×10^{-7}	3.0×10^{-7}	No	uncoated nanoparticles possibly genotoxic[26][27][28]	11
21	Scandium		2×10^{-7}		No		3
73	Tantalum		2×10^{-7}		No		5
23	Vanadium	260×10^{-9}	1.1×10^{-7} 110 mcg	1.2×10^{-8}	Possibly[7] (suggested osteo-metabolism (bone) growth factor)		5
90	Thorium		1×10^{-7}		No	toxic, radioactive	
92	Uranium		1×10^{-7}	3.0×10^{-9}	No	toxic, radioactive	
62	Samarium		5.0×10^{-8}		No		
74	Tungsten		2.0×10^{-8}		No		6
4	Beryllium		3.6×10^{-8}	4.5×10^{-8}	No	toxic in higher amounts	2
88	Radium		3×10^{-14}	1×10^{-17}	No	toxic, radioactive	2

*Iron = ~3 g in men, ~2.3 g in women

Of the 94 naturally occurring chemical elements, 60 are listed in the table above. Of the remaining 34, it is not known how many occur in the human body.

Most of the elements needed for life are relatively common in the Earth's crust. Aluminium, the third most common element in the Earth's crust (after oxygen and silicon), serves no function in living cells, but is harmful in large amounts.[29] Transferrins can bind aluminium.[30]

Periodic table

Periodic table highlighting dietary elements

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

The four organic basic elements	Quantity elements	Essential trace elements	Possible structural or functional role in mammals

Molecules

The composition of the human body is expressed in terms of chemicals:

- Water
- Proteins – including those of hair, connective tissue, etc.
- Fats (or lipids)
- Hydroxylapatite in bones
- Carbohydrates such as glycogen and glucose
- DNA
- Dissolved inorganic ions such as sodium, potassium, chloride, bicarbonate, phosphate
- Gases such as oxygen, carbon dioxide, nitrogen oxide, hydrogen, carbon monoxide, acetaldehyde, formaldehyde, methanethiol. These may be dissolved or present in the gases in the lungs or intestines. Ethane and pentane are produced by oxygen free radicals.[31]
- Many other small molecules, such as amino acids, fatty acids, nucleobases, nucleosides, nucleotides, vitamins, cofactors.
- Free radicals such as superoxide, hydroxyl, and hydroperoxyl.

The **composition of the human body** can be viewed on an atomic and molecular scale as shown in this article.

The estimated gross molecular contents of a typical 20-micrometre human cell is as follows:[32]

Molecule	Percent of Mass	Mol.Weight (daltons)	Molecules	Percent of Molecules
Water	65	18	1.74×10^{14}	98.73
Other Inorganics	1.5	N/A	1.31×10^{12}	0.74
Lipids	12	N/A	8.4×10^{11}	0.475
Other Organics	0.4	N/A	7.7×10^{10}	0.044
Protein	20	N/A	1.9×10^{10}	0.011
RNA	1.0	N/A	5×10^{7}	3×10^{-5}
DNA	0.1	1×10^{11}	46*	3×10^{-11}

Tissues

Body composition can also be expressed in terms of various types of material, such as:

- Muscle
- Fat
- Bone and teeth
- Nervous tissue (Brain and nerves)
- Hormones
- Connective tissue
- Body fluids (blood, lymph, Urine)
- Contents of digestive tract, including intestinal gas
- Air in lungs
- Epithelium

Composition by cell type

There are many species of bacteria and other microorganisms that live on or inside the healthy human body. In fact, 90% of the cells in (or on) a human body are microbes, by number[33][34] (much less by mass or volume). Some of these symbionts are necessary for our health. Those that neither help nor harm humans are called commensal organisms.

See also

- List of organs of the human body
- Hydrostatic weighing
- Dietary element
- Composition of blood
- List of human blood components
- Body composition
- Abundance of elements in Earth's crust
- Abundance of the chemical elements

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