Abundance of elements from Universe to Humans

<table>
<tr><th>Element</th><th>Universe % [1]</th><th>Solar system[4]</th><th>Crust % [1/6|8]</th><th>River ppm[5]</th><th>Ocean ppm [2]</th><th>Marine org %[2/8]</th><th>Micro org %[7]</th><th>Plants % [1/7|8]</th><th>Animals [7]</th><th>Human food [3]</th></tr>
<tr><td>--</td><td>space</td><td>sun+plan</td><td>mantle</td><td>water</td><td>water</td><td>tissue</td><td>tissue</td><td>tissue</td><td>tissue</td><td>food/day</td></tr>
<tr><td>H</td><td>87</td><td>32000</td><td>3/.14</td><td>110000</td><td>110000*</td><td>.</td><td>9.9</td><td>16/8.7</td><td>9.3</td><td>.</td></tr>
<tr><td>He</td><td>12</td><td>2600</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Li</td><td>.</td><td>38ppm</td><td>.</td><td>0.003</td><td>0.17</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>B</td><td>.</td><td>6ppm</td><td>.|0.001</td><td>0.001</td><td>4.45</td><td>./0.002</td><td>.</td><td>.|0.002</td><td>.</td><td>.</td></tr>
<tr><td>C</td><td>0.03</td><td>16.6</td><td>.1/.032</td><td>58.4</td><td>28.0/0.5*</td><td>.</td><td>12.1</td><td>21/11</td><td>19.4</td><td>100g</td></tr>
<tr><td>N</td><td>0.008</td><td>3</td><td>0.0001|0.1</td><td>0.23</td><td>15.5/0.67*</td><td>./5</td><td>3.0</td><td>./0.8|2</td><td>5.1</td><td>.</td></tr>
<tr><td>O</td><td>0.06</td><td>29</td><td>49/45</td><td>*</td><td>883000/6.0*</td><td>.</td><td>73.7</td><td>59/78</td><td>62.8</td><td>.</td></tr>
<tr><td>F</td><td>.</td><td>0.001</td><td>.</td><td>0.1</td><td>1.3</td><td>.</td><td>.</td><td>.</td><td>.</td><td>1-2mg</td></tr>
<tr><td>Ne</td><td>0.02</td><td>2.9</td><td>0</td><td>.</td><td>0.00012</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Na</td><td>0.0001</td><td>0.0418</td><td>0.7/2.3</td><td>6.3</td><td>10800*</td><td>.</td><td>.</td><td>0.01</td><td>.</td><td>3000mg</td></tr>
<tr><td>Mg</td><td>0.0003</td><td>1.046</td><td>8/2.8|0.5</td><td>4.1</td><td>1290</td><td>5.4/0.4</td><td>.</td><td>0.04|0.2</td><td>.</td><td>300mg</td></tr>
<tr><td>Al</td><td>0.0002</td><td>0.0893</td><td>2/8</td><td>0.4</td><td>0.001</td><td>.</td><td>.</td><td>0.001</td><td>.</td><td>.</td></tr>
<tr><td>Si</td><td>0.003</td><td>1.000</td><td>14/27</td><td>1.32</td><td>2.9</td><td>.</td><td>.</td><td>0.1</td><td>.</td><td>.</td></tr>
<tr><td>P</td><td>0.00003</td><td>0.00932</td><td>0.07|0.07</td><td>0.02</td><td>0.088</td><td>./0.6</td><td>0.6</td><td>0.03/0.7|0.2</td><td>0.6</td><td>1000mg</td></tr>
<tr><td>S</td><td>0.002</td><td>0.6</td><td>0.7|0.07</td><td>6-11</td><td>904</td><td>./1</td><td>0.3</td><td>0.02/0.1</td><td>0.6</td><td>.</td></tr>
<tr><td>Cl</td><td>.</td><td>0.001836</td><td>.|1.4|0.01</td><td>7.8</td><td>19400*</td><td>./4</td><td>.</td><td>.|0.01</td><td>.</td><td>3000mg</td></tr>
<tr><td>K</td><td>0.000007</td><td>0.00158</td><td>0.1/1.7</td><td>2.3</td><td>392</td><td>./1</td><td>.</td><td>0.1|1</td><td>.</td><td>3000mg</td></tr>
<tr><td>Ca</td><td>0.0001</td><td>0.045</td><td>2/5|1.4</td><td>15</td><td>411</td><td>18.6/0.5</td><td>.</td><td>0.1|1</td><td>.</td><td>1000mg</td></tr>
<tr><td>Cr</td><td>.</td><td>0.005</td><td>.</td><td>0.001</td><td>0.0002</td><td>20-800ppm/</td><td>.</td><td>.</td><td>.</td><td>0.005mg</td></tr>
<tr><td>Mn</td><td>.</td><td>0.0025</td><td>.|0.09</td><td>0.007</td><td>0.0004</td><td>10-600ppm/</td><td>.</td><td>.|0.005</td><td>.</td><td>5-10mg</td></tr>
<tr><td>Fe</td><td>0.002</td><td>0.117</td><td>18/6|3.8</td><td>0.7</td><td>0.0034</td><td>./0.04</td><td>.</td><td>0.005|0.01</td><td>.</td><td>15mg</td></tr>
<tr><td>Ni</td><td>.</td><td>0.026</td><td>.</td><td>.</td><td>0.0066</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Cu</td><td>.</td><td>0.0035</td><td>.|0.002</td><td>0.007</td><td>0.0009</td><td>./0.005</td><td>.</td><td>.|6ppm</td><td>.</td><td>1-2mg</td></tr>
<tr><td>Zn</td><td>.</td><td>0.0008</td><td>.|0.005</td><td>0.02</td><td>0.005</td><td>./0.02</td><td>.</td><td>.|0.02</td><td>.</td><td>.</td></tr>
<tr><td>Se</td><td>.</td><td>.</td><td>.</td><td>.</td><td>0.00009</td><td>.</td><td>.</td><td>.</td><td>.</td><td>0.1mg</td></tr>
<tr><td>Br</td><td>.</td><td>.</td><td>.</td><td>0.02</td><td>67.3</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Sr</td><td>.</td><td>13.5ppm</td><td>.</td><td>0.06</td><td>8.1</td><td>38ppm</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Mo</td><td>.</td><td>2.5ppm</td><td>.|2ppm</td><td>.</td><td>0.001</td><td>.</td><td>.</td><td>.|0.2ppm</td><td>.</td><td>0.2mg</td></tr>
<tr><td>Ag</td><td>.</td><td>0.26ppm</td><td>.</td><td>.</td><td>0.00028</td><td>0.2-3ppm</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Sn</td><td>.</td><td>1.33ppm</td><td>.</td><td>.</td><td>0.00081</td><td>11pm</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>I</td><td>.</td><td>0.46ppm</td><td>.</td><td>.</td><td>0.064</td><td>.</td><td>.</td><td>.</td><td>.</td><td>0.1mg</td></tr>
<tr><td>Pt</td><td>.</td><td>1.16ppm</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Au</td><td>.</td><td>0.13ppm</td><td>.</td><td>.</td><td>0.000011</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Hg</td><td>.</td><td>0.27ppm</td><td>.</td><td>.</td><td>0.00015</td><td>.</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
<tr><td>Pb</td><td>.</td><td>2.2ppm</td><td>.</td><td>.</td><td>0.00003</td><td>20-500ppm</td><td>.</td><td>.</td><td>.</td><td>.</td></tr>
</table>

Note: 1000 ppm = 0.1%

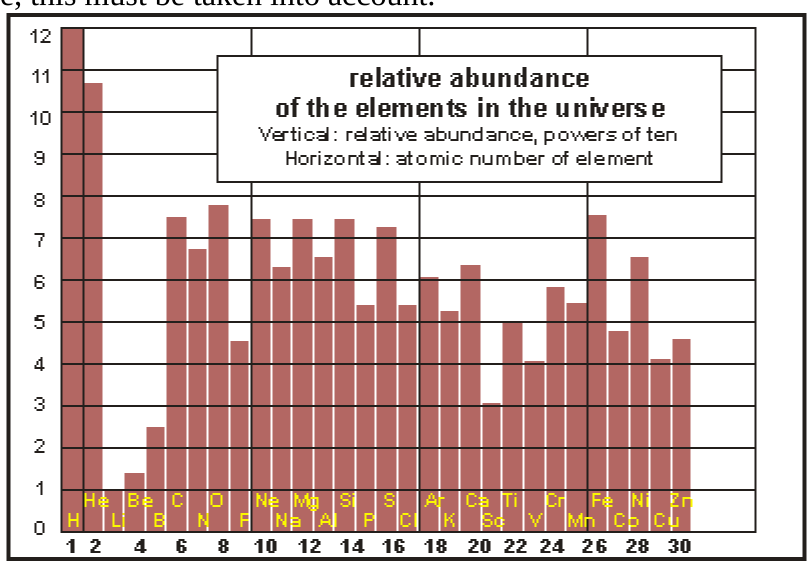
References and notes

[1] **Encyclopedia Britannica**
[2] Turekian, Karl K:**Oceans**.1968. Prentice-Hall
[3] Stewart Truswell: **ABC of nutrition**. 1992. BMJ Publ.
[4] Cameron. Clark, S P(ed): **Handbook of physical constants**. 1966. Geol Soc Am. Abundance

relative to Si.
[5] Turekian, Karl. **Oceans**.1968. C as HCO3; S as SO4; N as NO3, Si as SiO2.
[5] Turekian, Karl. in **Oceanography, the last frontier**. 1974
[6] Skinner, Brian J: **Earth Resources**. The numbers behind the slash (/) are Skinner's.
[7] Curtis & Barnes: **Biology**. 1989. Worth Publ. Plant: alphalpha; animal: human; microorg: bacterium.
[8] Larcher, W: **Physiological plant ecology**. 1980. Springer V. % by weight dried matter. Plants averaged over many groups.
(*) Oxygen and hydrogen as part of water. N2 dissolved versus/Nitrogen in cations. Carbon inorganic (CO2, etc)/ Dissolved Organic Carbon (DOC). Sodium and chlorine as salt.

-- seafriends home -- all about soil -- oceanography --

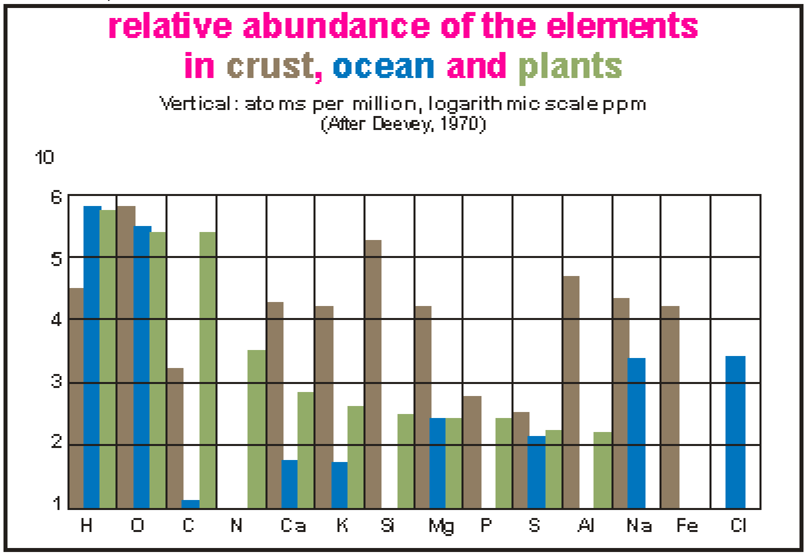
Relative abundance of elements in the universe
The above table of the abundance of the chemical elements in the universe, that are important for life, was composed to give more meaning to elements and nutrients. From left to right it roughly represents the evolution of the universe, the formation of Earth and the emergence and evolution of life. The data has been collected from various sources and as can be seen, there is sometimes considerable difference between these, but the overall picture becomes clear nonetheless.
Note that some concentrations are given in the number of atoms, others in percentage by weight. For some elements such as P, K, Fe, this must be taken into account.



In the physical evolution of the planet, the heavier elements became more abundant as the solar system formed. The accompanying bar chart shows the relative abundances of the most important elements. Note that the vertical scale is logarithmic, each division representing a tenfold increase or decrease.
The bar chart reveals the processes that synthesised heavier elements out of the hydrogen (H) and helium (He) of the Big Bang. Fusion in stars created more helium, skipped over lithium (Li), beryllium (Be) and boron (B) to carbon (C) and generated all the elements up to iron (Fe). Massive stars eventually explode as supernovas and their shockwaves make heavier elements than iron, but in very small amounts.

Abundance of elements in soil, sea and life
The sun and planets formed from the coagulation of cosmic dust and debris. Then the land crust

emerged from mainly the lighter elements, which eroded into rivers to provide the elements in the sea. Early life then formed in the womb of the early oceans or brackish fresh water. Plants established on land, being capable of scavenging precious resources from the soil and to accumulate these in their tissues. Animals on land then evolved, feeding on the plants. Higher animals and carnivores, eventually humans, followed.



This bar chart shows one division for each element horizontally and abundance in a logarithmic scale, vertically. For each element, the concentrations for land (brown), sea (blue) and plants (green) is shown. In fact, the green data is the total of all life, but since the mass of plants far outweighs that of animals, it can be considered plants alone. Note that the concentration is in parts per million, counting atoms, not by weight. The top division is 1E6 or 100%, the bottom line is 1 ppm.

From the barchart, one can see that the elements H, O, Mg, S are plentiful in both soil and sea. Ca, K, Si, P, Al, Fe are plentiful in soil. The element N is in short supply in the soil whereas the elements C, N, Si, P, Al, Fe are in very short supply in the oceans. Note that the concentrations of the elements varies considerably from place to place on the land, whereas they are very equally distributed in the oceans, except close to continents and where upwellings occur. Note that plants produce their own requirement in C (carbon), by photosynthesis, both on land and in the sea. Note also that plants require hardly any salt (NaCl).

Nitrogen compounds are manufactured from air by bacteria in soils and by similar organisms (blue-green algae) in the sea, in quantities 'as the need arises'. Nitrogen-fixing is optimal at 20-30ºC (50-70 kg/ha/yr), drops in temperate regions (2-5 kg/ha/yr) and stops at 0ºC. Tropical reef algae can fix nitrogen at the rate of 30 kg/ha/yr. Symbiotic nitrogen fixing such as in the roots of peas and lupins, can produce much higher yields still (200 kg/ha/season).

The elements of which plants need most, are called **macronutrients**: N, P, S, Ca, Mg, Fe.
The required other elements are called **trace elements** or **micronutrients**: Mn, Zn, Cu, Mo, B, Cl.
In addition there are elements that are essential for only certain plant groups: Na for Chenopodiacea, Co for the Fabales with symbionts, Al for the ferns, Si for the diatoms, and Se for some planktonic algae. The nutrient requirements of agricultural plants have been studied in considerable detail, but much less so for wild plants and

plankton. (Source [8])

One can see how some elements concentrated, others diluted. The most common elements of life are Carbon, Oxygen, Hydrogen and Nitrogen, all plentiful in the atmosphere, as shown in the table below. Other elements precious to life, such as sulfur and iodine also circulate through the atmosphere but in very small amounts.