ADVANCED BIOLOGY
"Atoms in Living Organisms" (Adapted from *Biology, 1st Ed.,* Raven & Johnson)

Of the 92 elements that formed the crust of the cooling earth, only 11 are common in living organisms. The table on the right lists the frequency with which various elements occur in the human body; the frequencies that occur in the bodies of other organisms are similar.

Inspection of this table reveals that the distribution of elements in living systems is by no means accidental. **The "life elements"** – those that make up 0.01% (1 in 10,000) or more of the atoms of organisms – **are not the elements that are the most abundant in the earth's crust.** Unlike the elements that occur most abundantly in this crust, all of the elements common in living organisms are light, each having an atomic number less than 21 and thus a low mass.

Elemental composition of the lithosphere and the human body. Each number represents the percent of the total ***number*** *of atoms present. For example, 47 of every 100 atoms found in a representative sample of the lithosphere are oxygen while there are only 19 atoms of carbon in every 10,000 atoms of lithosphere.*

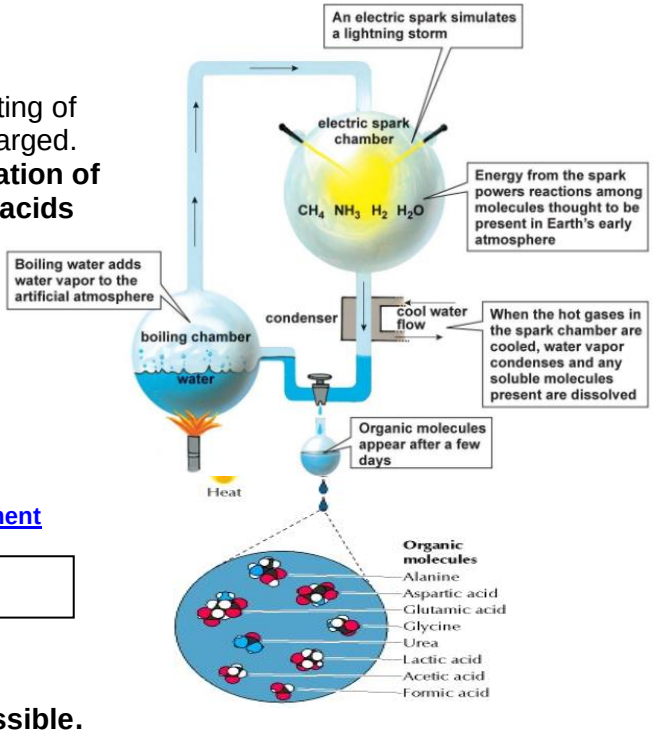
Composition of the Lithosphere		Composition of the Human Body	
Oxygen	47	Hydrogen	63
Silicon	28	Oxygen	25.5
Aluminum	7.9	Carbon	9.5
Iron	4.5	Nitrogen	1.4
Calcium	3.5	Calcium	0.31
Sodium	2.5	Phosphorus	0.22
Potassium	2.5	Chlorine	0.03
Magnesium	2.2	Potassium	0.06
Titanium	0.46	Sulfur	0.05
Hydrogen	0.22	Sodium	0.03
Carbon	0.19	Magnesium	0.01
All others	<0.1	All others	<0.01

http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/E/Elements.html

The great majority of atoms in living organisms – 99.4% of the atoms in the human body, for example – are either nitrogen, oxygen, carbon, or hydrogen. You can conveniently remember these elements by their chemical symbols, NOCH.
Why are these 4 elements the most abundant?

1. First, they all form gases, either alone or in combination with one another. Life is thought to have evolved from complex molecules that were formed from the interaction of these gases in the primitive earth's atmosphere. Many of these molecules are water soluble. As water vapor in the atmosphere cooled and fell as rain, it brought these dissolved molecules to the primitive oceans where life began.

The Miller-Urey Experiment



From: The Origin and Evolution of Cells:

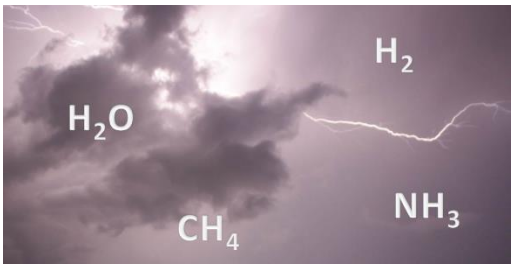
"Water vapor was boiled through an atmosphere consisting of CH_4, NH_3, and H_2, into which electric sparks were discharged. **Analysis of the reaction products revealed the formation of a variety of organic molecules, including the amino acids** alanine, aspartic acid, glutamic acid, and glycine."

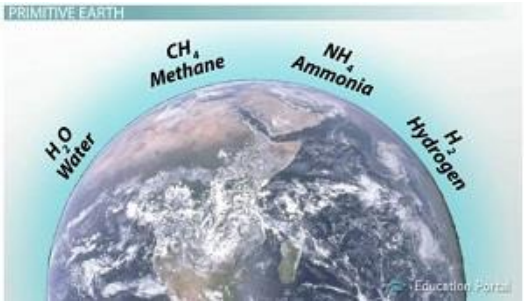
- ***This shows that the substances needed to support life could have formed from natural conditions found in the primitive earth!***

See **Video: Stated Clearly - The Miller Urey Experiment**
& **Video: Quick Lecture (2 minutes) on the Miller Urey Experiment**

See also **Link: Sugars from Outer Space? Are you kiddin' me?**

Conditions on early Earth made the origin of life possible.





The following summary adapted from our text describes the events that probably led to life:

Scientific evidence is accumulating that chemical and physical processes on early Earth, aided by the emerging force of selection, produced very simple cells through a sequence of four main stages:

(1) the synthesis of small organic molecules – such as amino acids and nucleotides – by natural processes, shown as possible in the Miller-Urey experiment;

(2) the joining of these small molecules (monomers) into polymers, including proteins and nucleic acids;

(3) the packaging of these molecules into primitive cells with membranes that maintained an internal chemistry different from that of their surroundings; and

(4) the origin of self–replicating molecules (probably RNA initially before DNA) that eventually made inheritance possible.

This scenario has uncertainties, but it does lead to predictions that can be tested in the laboratory.

The NOCH elements all require the **addition** of from 1 to 4 electrons to satisfy the octet rule.

- As a result, the NOCH elements form molecules with each other by **sharing electrons** and thus forming covalent bonds.
- These covalent bonds are stable enough to form life's needed molecules, but also these molecules contain chemical bonds are not so strong that they cannot be broken.
- Thus, cells can rearrange **the NOCH elements** in these molecules to **form *a great variety of biological molecules*** to suit their immediate needs.

3. Approximately 88.5% of the elements common in living organisms are hydrogen and oxygen, reflecting the predominant role of **water (H_2O)** in living systems.

Here is an enjoyable summary interview:
http://www.pbs.org/wgbh/nova/evolution/how-did-life-begin.html