The origin of life

There is now little doubt that living things owe their origin entirely to certain physical and chemical properties of the ancient earth.

The life-producing chemical and physical properties of the early earth were a result of the way the earth and our solar system as a whole came into being.

The best available evidence indicates that the sun and earth are both about 4½ to 5 billion years old.

According to a new widely accepted hypothesis, the whole solar system formed from a hot, rapidly rotating ball of gas.

This gas was made up of free atoms of hydrogen, probably being the most abundant and other, heavier kinds being present in lesser amounts.

The sun was formed when most of this atomic gas, hence most of the hydrogen, gravitated toward the center of the ball. Even today the sun is composed largely of hydrogen atoms. A swirling belt of gas remained outside the new sun. Eddies formed in this belt, and in time it broke up into a few smaller gas clouds giving rise to the early planets including
The earth. The earth thus probably started out as a glowing mass of free hydrogen and other types of atoms. The heavier atoms such as iron, nickel, sank toward the center of the earth. Lighter atoms such as silicon and aluminum formed a middle shell. The very lightest, such a hydrogen, nitrogen, oxygen and carbon, collected in the outermost layers.

Under the influence of the cold of cosmic space, the earth began to cool gradually. And in time temperatures became low enough to permit relatively stable bonding together of atoms. Molecules were thus formed and free atoms disappeared.

Atoms

Molecules - combinations of atoms

Compound - can be seen (many molecules)

Chemical energy binds atoms together in molecules. This energy can come from an external source. May be of several forms: heat, light, electricity, X-rays and mechanical pressure.
Each kind of atom has a fixed, limited bonding capacity. It can form on a certain number of bonds with other atoms. Every molecule holds energy in storage because of the bond energies between atoms. If a bond between two atoms is broken by appropriate means, the atoms separate and bond energy is released. The amount of this energy equals the amount which had to be supplied originally to link the atoms together.

Chemical events are contact reactions among & between molecules.

Energy Molecular reactions
needs [endoergic] plus energy Synthesis Two or more molecules combine to form a single larger molecule: \( CO_2 + H_2O = H_2CO_3 \)

[exoergic] Decomposition \( H_2CO_3 = CO_2 + H_2O \)

Exchange \( HCl + NaOH = NaCl + H_2O \)

Rearrangement The pattern of atoms changes:

\[
\begin{align*}
  & H - C - C - H - H \\
  & H - C - C - C - H \\
  & H - C - C - H - H \\
  & H - C - C - H - H
\end{align*}
\]
Conditions governing reactions
Temperature
Pressure
Concentration of participating molecules, etc.

Origin of living material
Lightest and most abundant material in the surface gas of early Earth
- Atoms H, O, C, and N
Hydrogen most reactive and combines more readily with O, C, N, than these combine with one another.
The types of compounds must have occurred in the early hot layers
- H with O = H₂O water
- H with N = NH₃ ammonia
- H with C = CH₄ methane
These persisted as gases while the earth was still quite warm (hot)

Also on Jupiter. Evidence These in solid form because of low temperature
Jupiter froze early after formation because of distant from sun.
On earth with lowering of temp
Gaseous liquefied, solidified
These changes started first in center
of earth but weight of overlying material
(countered) tendency to solidify
Middle shall solidified and wrinkled with
cooling and shrinking - solids, mountains
Colder layer (atmosphere) still gases.
With cooling
Gaseous H₂O to liquid form
Rains began increasing; centuries long
Now powers. Rivers, oceans formed
topography shaped.
NH₃ and CH₄ gases dissolved in
H₂O + salts, minerals through
surface land erosion. Also volcanoes
eruptions - lava added their substance
to the mineral content of the waters
of the world. Origin of salt from
of oceans.
Water most essential component of living matter.

\[ \text{H}_2\text{O} \]

Best of all solvents

Ideal medium for chemical reactions

Source of H and O: Principal provider

Only source of usable H. One of the most important sources of O.

Properties of carbon:

\[ \text{H} - \text{C} - \text{H} \]

\[ \text{H} - \text{C} - \text{C} - \text{H} \]

\[ \text{H} - \text{C} - \text{C} - \text{C} \]

Ends of chain tied together to form carbon rings, for example benzene
Carbonto-carbon combinations introduce possibility of tremendously and variety of molecular structure.

A-C linkages occur almost exclusively within living matter.

The first organic compounds probably

1. Sugars
2. Glycorin
3. Fatty acids
4. Amino acids
5. Pyrimidines
6. Purines

Sources of energy for formation-synthesis of compounds

- Sunlight
- Electrical discharge
In laboratory

$\text{CH}_3 + \text{H}_2\text{O} + \text{NH}_3 \to \text{Electrical Discharge}$

produced amino acids, fatty acids
and other simple organic compounds
Evidence that compounds may have formed
in nature.

Then polysaccharides formed - several carbohydrates
fats, fatty acids & glycerol
proteins from amino acids

Protein catalysts = enzymes
Living = enzyme accelerated reactions

Nucleotides - supermolecules formed
formed

1. Purine-sugar-phosphate $\approx 100$ and
   $\approx 1000$ different kinds
2. Pyrimidine-sugar-phosphate

These combined to form nucleic
acids - the basis of formation
of living matter.
Oxygen cycle

Respiration \[ \text{O}_2 \]

Organic compound \[ \text{O}_2 \]

\( \text{O}_2 \) collects \( \text{H}_2\text{O} \) to form \( \text{H}_2\text{O} \)

\( \text{CO}_2 + \text{H}_2\text{O} \)

In photosynthesis

\( \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Organic compound} + \text{O}_2 \)

In some atmospheric \( \text{O}_2 \) enter metabolism

through respiration and leaves plant

metabolism through photosynthesis. In between

\( \text{O}_2 \) is incorporated into \( \text{H}_2\text{O} \)

Oxygen cycle

Into plant in respiration \( \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \)

Out of plant through photosynthesis

\( \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Sugar} + \text{O}_2 \)
Carbon cycle

\[ \text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{Sugar} + \text{O}_2 \]

1. Decay of organic matter (separate) + \( \text{O}_2 \) \rightarrow \( \text{CO}_2 + \text{H}_2\text{O} \)

2. Fuel in respiration \( \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{energy} + \text{H}_2\text{O} + \text{CO}_2 \)

\( \text{CO}_2 \) into atmosphere

1. Biological combustion
2. Physical (non-biological) combustion

- Real fires
- Long decay components of cycle

\( \text{CO}_2 \) acts as heat screen

Prevent heat leaving earth - greenhouse effect.

Volcanic eruption add \( \text{CO}_2 \) to atmosphere
Nitrogen cycle

\[ \text{N}_2 \text{ ultimate source} \]
\[ \text{NO}_3^- \text{ usable by higher plants} \]

Through decay all organic nitrogen converted into \( \text{NH}_3 \)

Nitriﬁying bacteria convert

a) \( \text{NH}_3 \rightarrow \text{NO}_2^- - \text{excreted} \)
b) \( \text{NO}_2^- \rightarrow \text{NO}_3^- - \text{excreted} \)

\[ \text{NO}_3^- \text{ + denitriﬁying bacteria} \]
\[ \text{NO}_3^- \rightarrow \text{N}_2 \]

\[ \text{N}_2 \rightarrow \text{NH}_2 \rightarrow \text{NO}_3^- \rightarrow \text{NO}_2^- \]

nitrogen fixing bacteria + blue algae

The cycle

(Decay causers - dead organisms for food)

Bacteria

\{ Nitriﬁers

Denitriﬁer

Nitrogen ﬁxer \}