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NAAC ACCREDITED A GRADE

- TOPIC :- ORIGN OF LIFE
- COURSE TITLE:- CORE COURSE 4 GEN
- PAPER :- 4-TH
- SEMESTER :- 4
- UNIT:- 5
- NAME OF THE TEACHER:- DR. TRIJIT NANDA
- NAME OF THE DEPARTMENT:- ZOOLOGY (U.G.&P.G)

THE ORIGINS OF LIFE

Biochemical evolution

BY **DR. TRIJIT NANDA**

Biochemical evolution

Life appeared after a period of chemical reactions

According to physical and chemical laws.

Prebiotic Earth

- Conditions on the primitive Earth were not the same as those present today
- No spontaneous generation of life today (Pasteur)…
- because the necessary conditions no longer exist
- Abiogenesis
  Oparin (1924): “Primeval soup” theory
  Haldane (1929): “Hot, dilute soup” theory.

A.I. Oparin

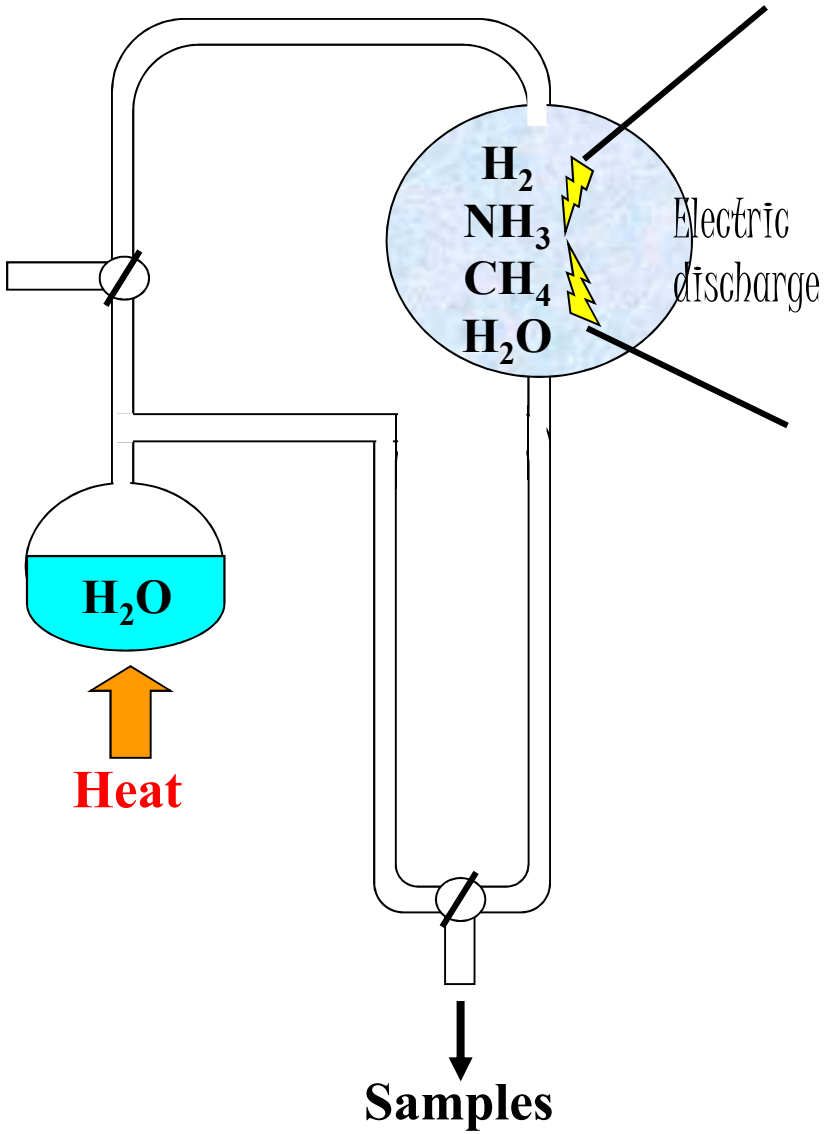
J.B.S. Haldane

Conditions on early Earth

- Reducing atmosphere on the primitive Earth. **No free oxygen (O_2)**
- **Free hydrogen** (H_2) and **saturated hydrides** (CH_4, NH_3 and H_2O)
- **Energy** for chemical reactions between these gases could come from **electric discharge** in storms or **solar energy** (no ozone layer)
- The Earth's surface temperature probably **hotter** than today.

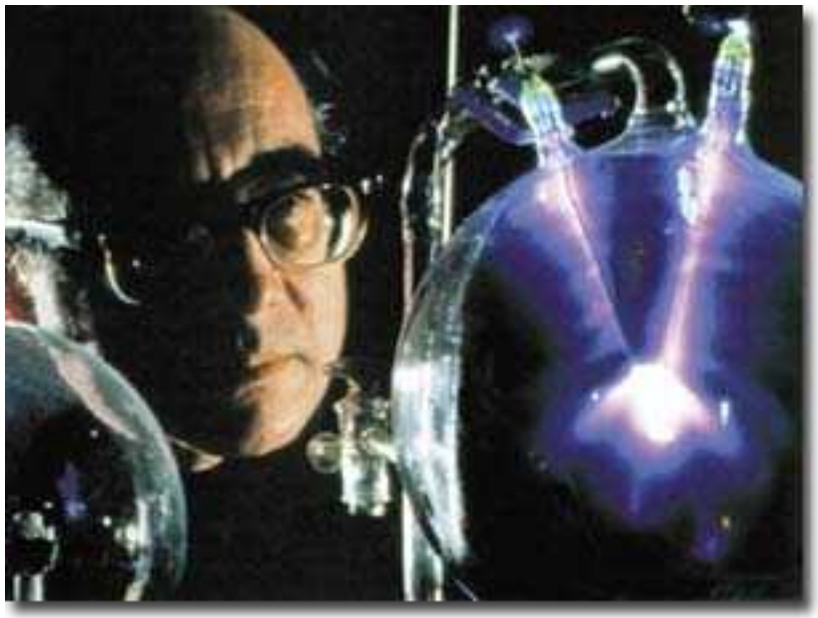
The formation of monomers

- **Miller and Urey** recreate these conditions *in vitro*
- The water is heated and the mixture circulates for many days.



Results

- After a week 15 **amino acids** in the mixture
- Other biologically important molecules had been formed including **ethanoic acid**, **lactic acid** and **urea**
- Later similar experiments were done using CO_2 that produced **nucleotides**
- Additonal organic material may have been delivered by comets.



Stanley Miller

Conclusion

- These experiments cannot reproduce the exact conditions on the primitive Earth
- We shall never know exactly what happened
- BUT basic building blocks for the large macromolecules **can** be synthesised *in vitro* from inorganic compounds.

Comets

- Dirty snowballs
- Formed in the outer part of the solar system
- Contain many organic molecules.

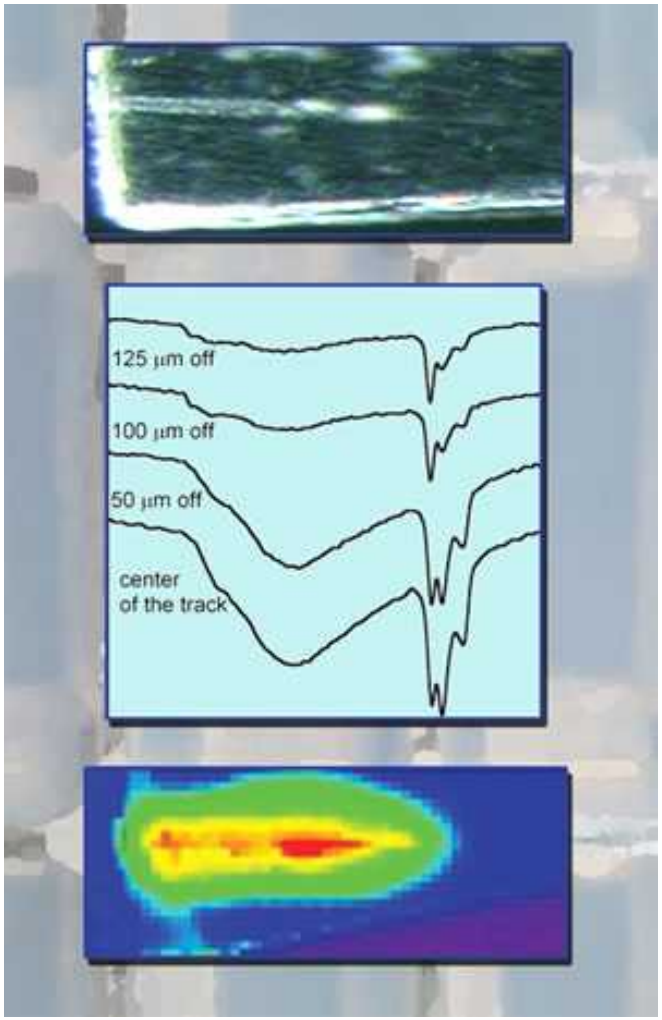
Comet Hale-Bopp 1997

Comet Shoemaker-Levy Collision with Jupiter

July 16 through July 22, 1994

‘Comets giveth and comets taketh away’
Carl Sagan (1934-1997)

- Jan 2006 comet dust sampled
- Wild-2 comet
- Organic compounds, including glycine, found.



Stardust mission 2006

From monomers to polymers

- Amino acids → **polypeptides**, could have occurred when dry or highly concentrated monomers are heated
- Condensation reactions take place forming: **peptide bonds** between amino acids or **phosphodiester bonds** form between nucleotides.

Early catalysts

- As molecules **adsorb** to the **clay mineral particles** they become concentrated (stick to the surface particles)
- Clay particles (coacervates) may have been essential **catalysts** in the formation of polymers.

The first polynucleotides

- **Polynucleotides** show a tendency to copy themselves using complementary base pairing
- This was probably **catalysed** by the presence of clay particles and metal ions
- These single stranded polynucleotides would have been the equivalent of RNA.

The first hereditary information

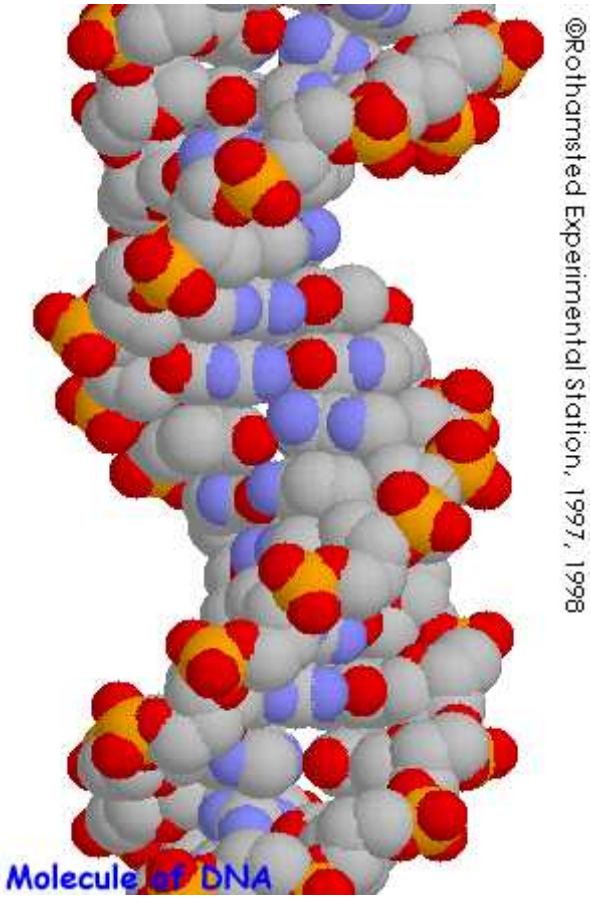
- **RNA** was probably the first hereditary molecule having the ability to copy itself
- **RNA** shows enzymic (**catalytic**) properties – called **ribozymes**
- **Polynucleotides** are very good molecules at **storing and transmitting information** but they lack the versatility for all the chemical functions of a cell.

A great partnership

- **Polypeptides** can form complex 3-dimensional structures (proteins),
  Polypeptides much better at complex cell functions
- A partnership must have formed between the polynucleotides and the polypeptides
- The polynucleotides directed the synthesis of the polypeptides
- Today it is clear that **information only flows from polynucleotides to polypeptides**.
  Translation had started.

The origin of DNA

- Hereditary information was probably stored in the form of **DNA** later
  DNA is more stable than RNA
- The passage of information from RNA to DNA is possible in nature
- The **reverse transcriptase** enzyme of the retro viruses shows this.



DNA

The first membranes, the first cells

- If a piece of RNA codes for a particularly good protein then there is nothing to stop that protein being used by other RNA molecules
- If, however, the RNA is enclosed in a membrane then it can keep its protein to itself and it gains a selective advantage
- So membranes probably pushed evolution by natural selection forwards.

Membranes defined the first cell

- The **phospholipids** form **lipid bilayers** when they are surrounded by water
- All the components of a simple **prokaryotic cell** were now assembled
- They diversified in their metabolism
- By 2 billion years ago free oxygen was appearing in the atmosphere due to the activity of photosynthetic bacteria.

Spontaneous generation, a persistant idea

- Maggots from meat
- Bumble bees from dead horses
- Mice from sweaty shirts and wheat
- 1668 Francesco Redi kept meat in open air/sealed/under gauze.

Microscopy

- Microscopy made the problem worse
- Fresh boiled meat broth contains no microbes
- Allowed to stand it becomes cloudy and putrid – full of microbes
- Needham (1745) sealed flaskes of boiled broth
- Microbes appeared.

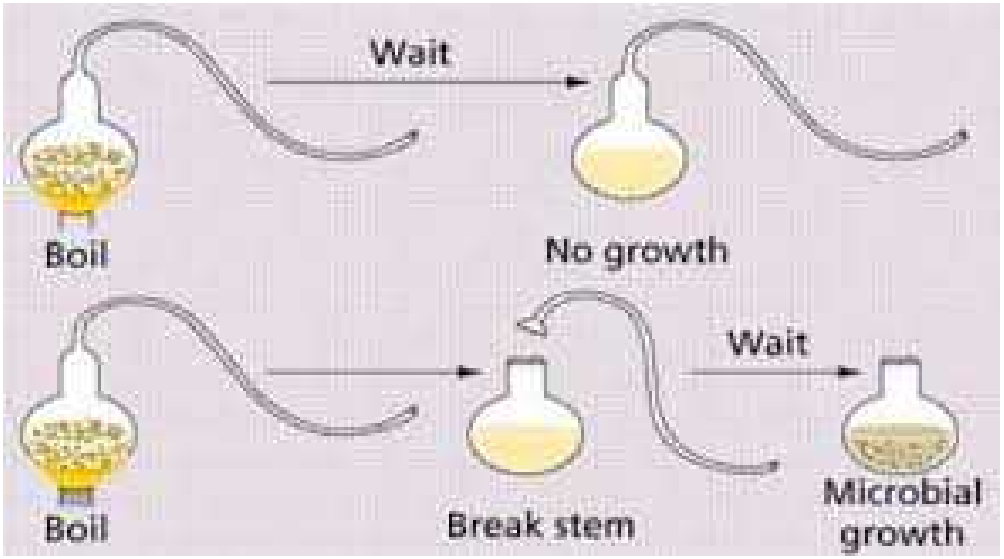
Spallanzani (1770)

- Suspected infection from the air before sealing
- Boiled broth and removed the air
- No microbes appeared

- Criticism spontaneous generation needed air.

Pasteur (1859): All life comes from life

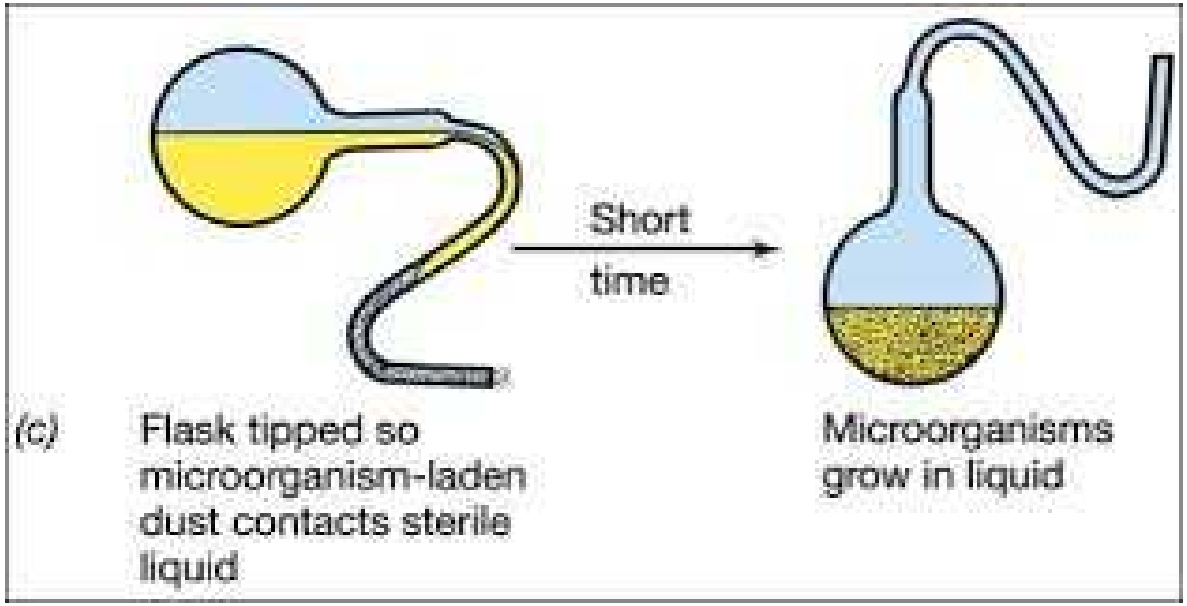
- Sterilised by boiling
- Swan-kneck flask permitted access to air.



Experiment and control

A critical observation

- Dust in the neck



The Germ Theory of Infection

- Microbes are responsible for infection
- Robert Koch, Louis Pasteur and anthrax