MONOMERS

Monomers are atoms or small molecules that bond together to form more complex structures such as polymers.

There are four main types of monomer, including sugars, amino acids, fatty acids, and nucleotides.

Each of these monomer types play important roles in the existence and development of life, and each one can be synthesized abiotically.

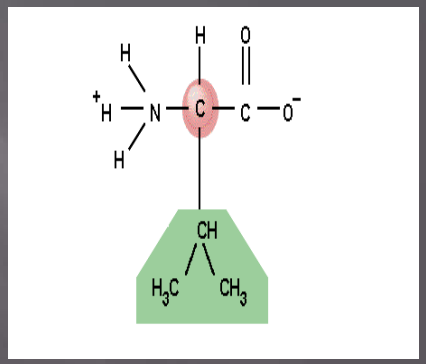
Monomers are commonly found in the interstellar medium, nebulae, and chondritic meteorites.

http://books.google.com/books?id=ZYI6AAAAIAAJ&pg=PA183&lpg=PA183&dq=monomers+interstellar+space&source=bl&ots=5ZgzZyCP_l&sig=_fZw-u4lJ9mXLMgoe3xo0gva0P8&hl=en&ei=bKvBTNm9PIzmsQOmvu2WDA&sa=X&oi=book_result&ct=result&resnum=2&ved=0CBYQ6AEwAQ#v=onepage&q=monomers%20interstellar%20space&f=false

Monomers as Amino Acids

This slide by Katrina Bettencourt

- Amino Acids: The building blocks of protein.
  - Amino acids are the monomers that build a polymer called protein.
  - There are 20 amino acid monomers but they all have a general structure of:
    - A Central Carbon (C)
    - An Amino group (NH3)
    - A carboxyl or acid (COO-)
    - A Hydrogen (H
    - The R group (20 different kinds)

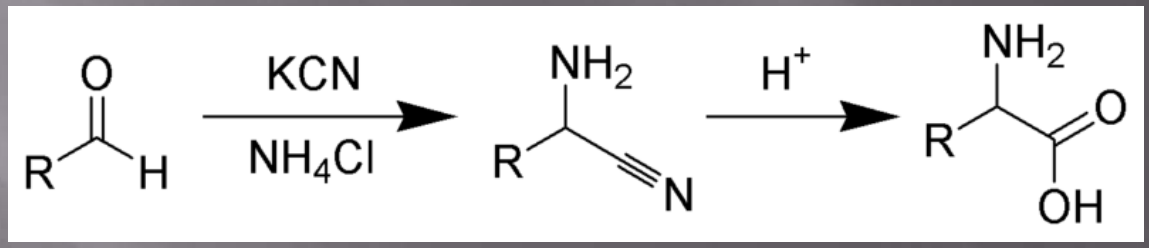


http://www.biology.iupui.edu/biocourses/n100/2k4ch3ptnsnotes.html

Experiments to form Amino Acids

This slide by Jessica Supalla and Katrina Bettencourt

- Streker Synthesis
  - Composed by Adolph Streker, it is a series of chemical reactions that synthesize an amino acid from aldehyde.
  - Aminonitrile is formed from the aldehyde, ammonium chloride and potassium cyanide. It is then hydrolyzed to form an amino acid.



- http://en.wikipedia.org/wiki/File:Strecker_Amino_Acid_Synthesis_Scheme.png
  - http://www2.bc.edu/~strother/GE_146/lectures/9.html

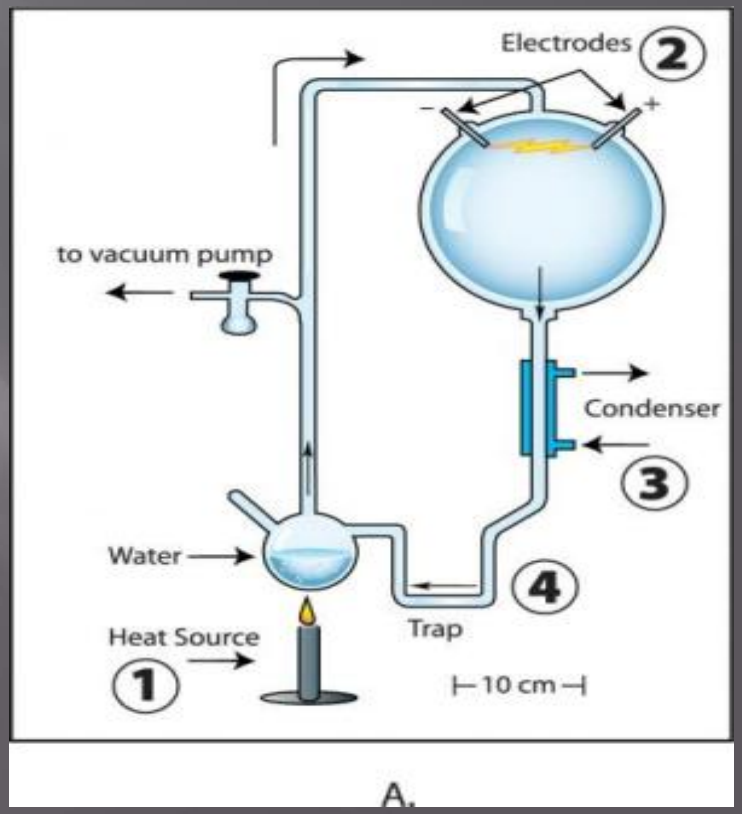
Experiments for Amino Acids Continued…

This Slide by Katrina Bettencourt

- The Miller-Urey Experiment
  - An apparatus built to simulate the conditions of early earth.
  - Simple Amino Acids were generated such as glycine, glycolic acid and alanine. This led to some great discoveries in Chemical Evolution.

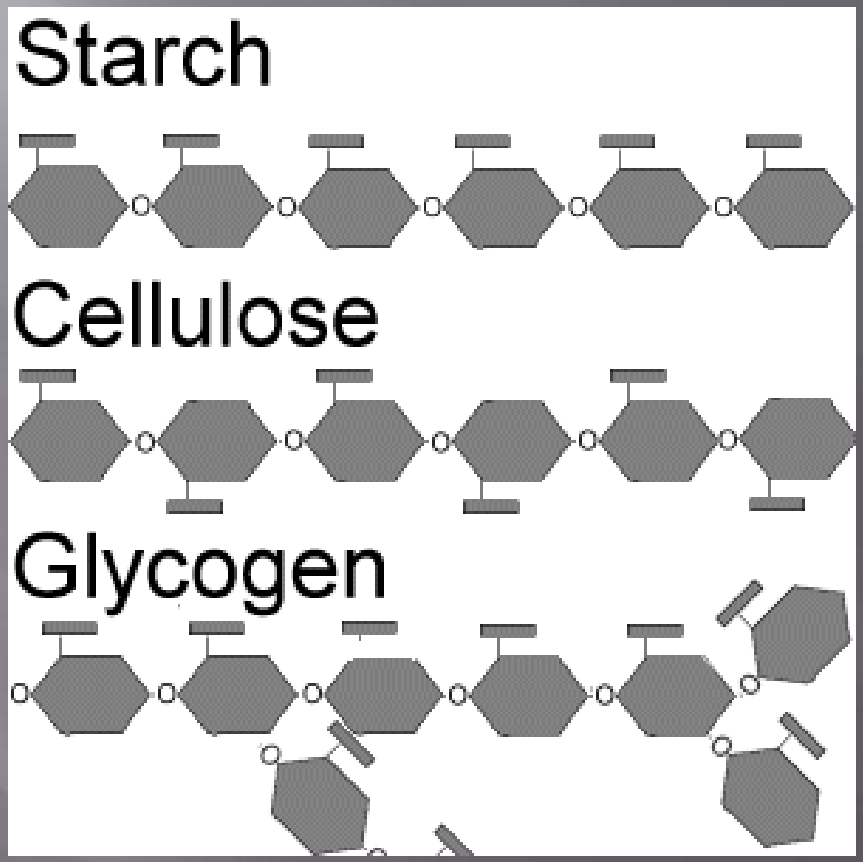
Picture: http://www.internetchemie.info/news/2008/oct08/miller-urey-experiment.html

Info: http://www2.bc.edu/~strother/GE_146/lectures/9.html



Sugar Monomers:

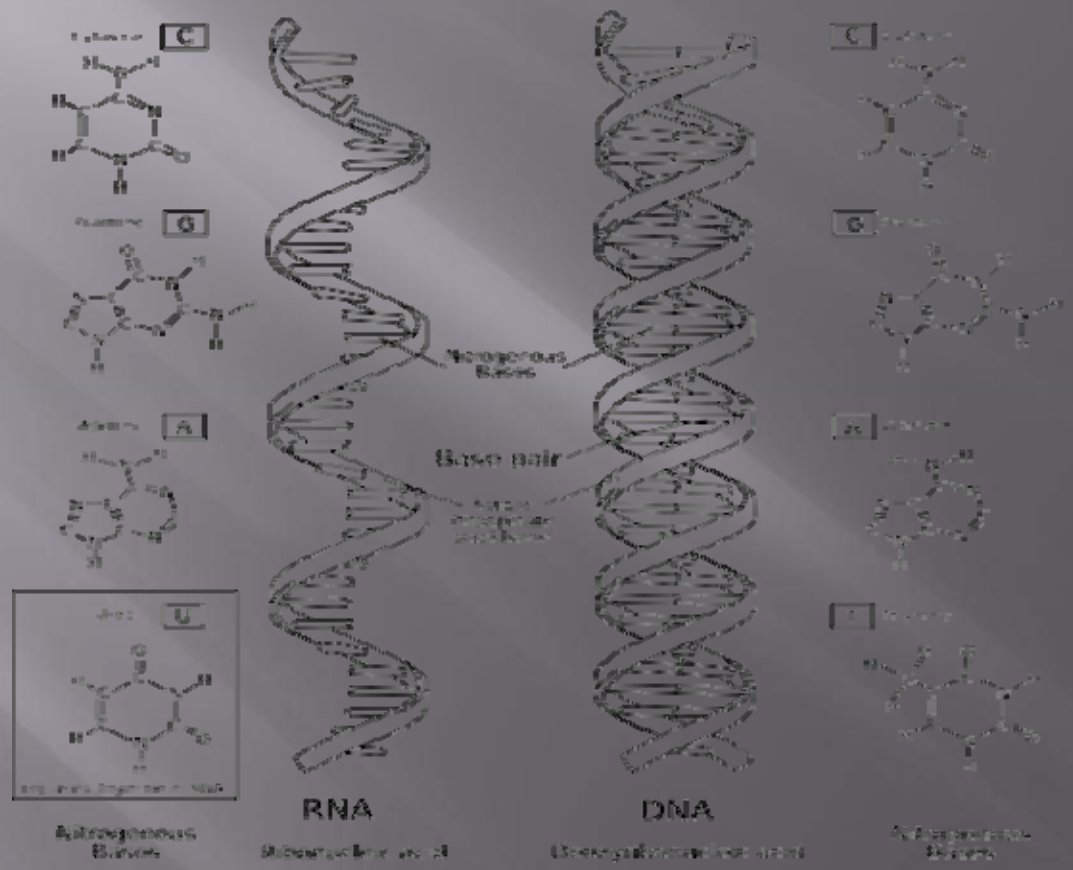
Glucose is the most common natural monomer. It links together to form polymers of Starch, Cellulose and Glycogen. Glucose also provides a vital source of energy for many organisms.



http://bioweb.wku.edu/courses/BIOL115/Wyatt/Biochem/Carbos/Carb_poly.gif

This slide by Johnnie French

Sugars make up the backbone structure of RNA and DNA



http://en.wikipedia.org/wiki/File:RNA-comparedto-DNA_thymineAndUracilCorrected.png

This slide by Johnnie French

Experiments

- Formed in the laboratory by the formose reaction of formaldehyde H_2CO in the presence of Calcium hydroxide ($Ca(OH)_2$), a strong base. Formaldehyde (the precursor to sugars) was probably synthesized photochemically in the early atmosphere, $CO_2 + 2H_2 \rightarrow H_2CO + H_2O$.
- Formaldehyde is very soluble in water, so it is likely to have dissolved in rainwater after synthesis in the upper atmosphere. Calculations have shown that within 10^6 yrs enough H_2CO would have formed to be actively reacting with UV light in solution.

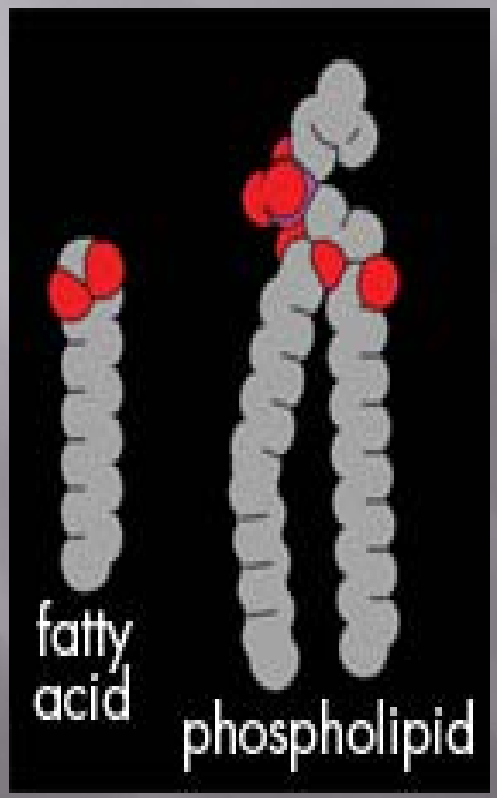
http://www2.bc.edu/~strother/GE_146/lectures/9.html

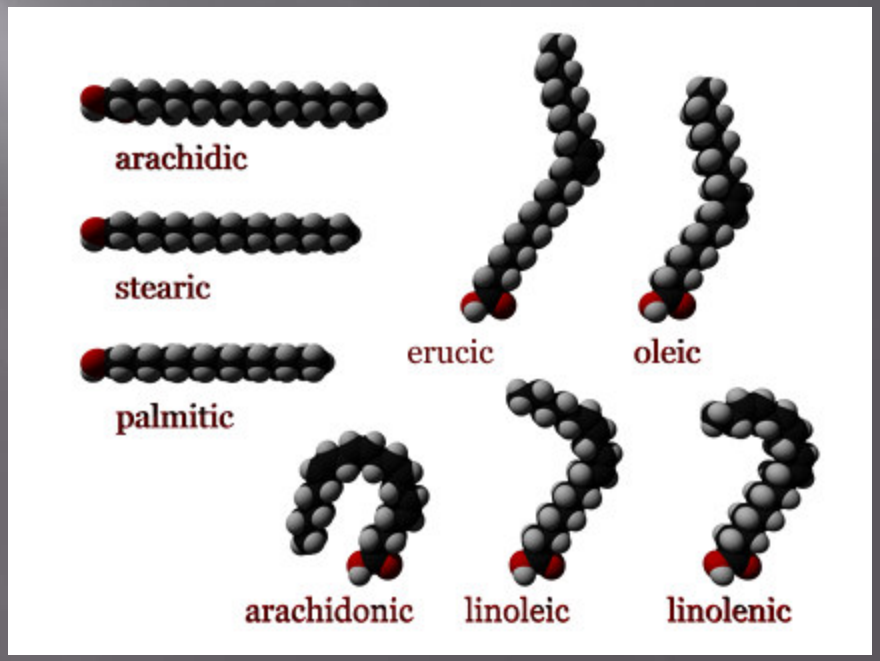
This slide by Johnnie French

Fatty Acids:

Also known as lipids spontaneously arrange themselves when placed in water in order to protect their hydrophobic tails forming membranes, micelles and vesicles. Early forms of life probably used fatty acids instead of more complex phospholipids.

http://exploringorigins.org/fattyacids.html





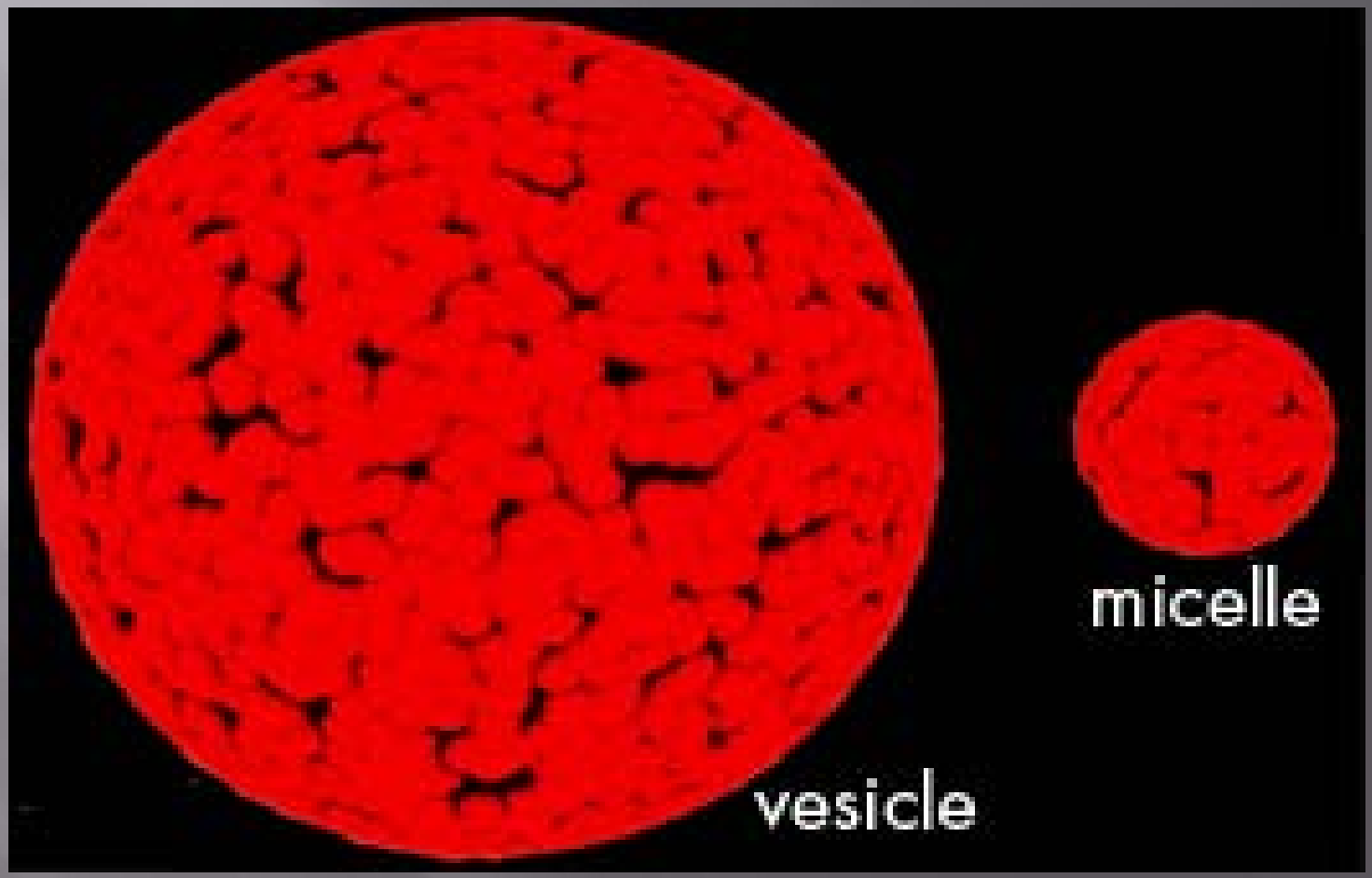
http://exploringorigins.org/fattyacids.html

http://en.wikipedia.org/wiki/File:Rasyslami.jpg

This slide by Johnnie French

The compartments and membranes were probably used to help store important molecules and to protect itself from hazardous molecules outside. They also probably used the membranes and vesicles to store energy in the form of a chemical gradient, much like modern day mitochondria.

http://exploringorigins.org/fattyacids.html



http://exploringorigins.org/fattyacids.html

Experiments

- Step 1: Fischer-Tropsch Reaction. Gaseous carbon passed over a hot catalyst such as powdered iron produces hydrocarbon chains, precursors to fatty acids
- Step 2: Photochemical reactions, esp. UV
- Step 3: Ferrous (iron-rich) clays react with CO_2 and H_2O to produce organic acids which then adsorb onto clays. These complexes can then react to produce stable macromolecular precursors. http://www2.bc.edu/~strother/GE_146/lectures/9.html

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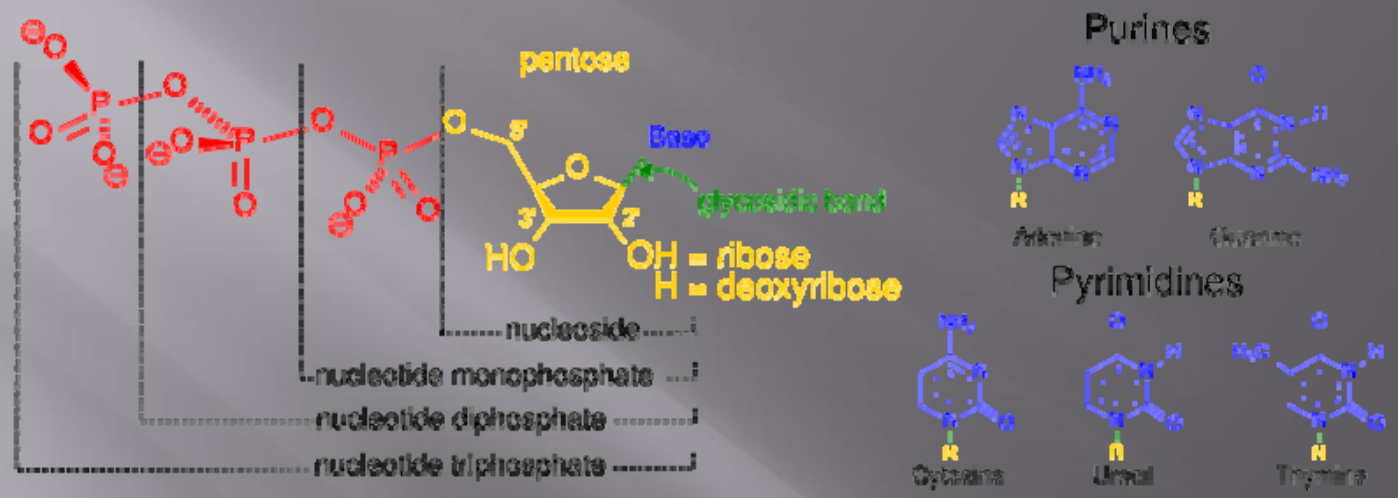
Jessica Supalla

NUCLEOTIDES



Nucleotides are monomers that join together to form the structural units of RNA and DNA, as well as providing an energy source in metabolism.

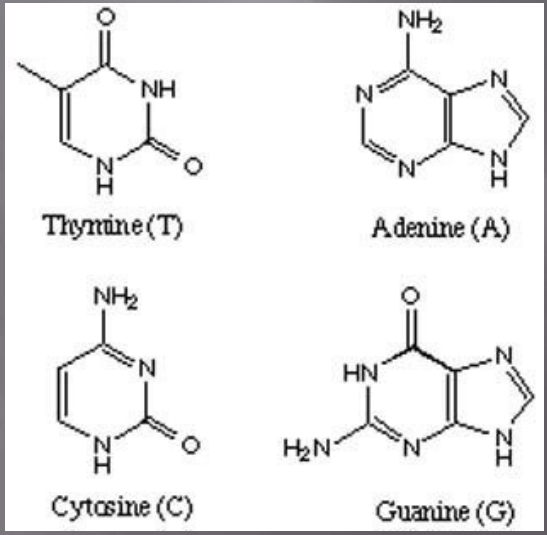
Nucleotides are composed of a nucleobase, a five-carbon sugar (either ribose or deoxyribose), and one to three phosphate groups.

Jessica Supalla

Nucleotides

A nucleobase is one of the five basic nitrogen bases of DNA and RNA --

Cytosine (C), Guanine (G), Adenine (A), Thymine (T), and Uracil (U).



A phosphate is a salt containing phosphorus and oxygen linked to one or more alkyl or aryl molecule.

Jessica Supalla

Experiments producing nucleotides

- Juan Oró synthesized adenine by heating a hydrogen cyanide solution in aqueous ammonia for several days. (**Archives of Biochemistry and Biophysics**, Volume 94, Issue 2, August 1961, Pages 217-227)

- Other experiments were performed over several years, including synthesis in a frozen medium. Each successful experiment demonstrated synthesis from a cyanide compound and ammonia. (ORIGINS OF LIFE AND EVOLUTION OF BIOSPHERES, Volume 32, Number 3, 209-218)

Summary

- Monomers are atoms or small molecules that bond together to form more complex structures such as polymers.
- Each of these monomer types play important roles in the existence and development of life, and each one can be synthesized abiotically in the interstellar medium.