Toward life between the stars

Increasingly complex molecules found in interstellar space suggest to some that life exists before planets are formed

Atom by atom the molecules discovered by radio astronomers in interstellar space approach substances of biochemical interest (SN: 8/8, p. 124). Observation has shown a series of compounds of carbon, the basis of organic chemistry, that starts from the simple cyanogen radical (CN) and runs to the latest, most complicated discovery, cyanoacetylene (HCCCN). The discoveries have led some scientists to speculate on the possibility of interstellar life.

Cyanoacetylene was found in the interstellar gas cloud Sagittarius B2, located at right ascension 17 hours 44 minutes 8 seconds and declination minus 28 degrees and 22 minutes 6 seconds. The discovery was made by Dr. Barry E. Turner of the National Radio Astronomy Observatory in Green Bank, W. Va.

The five atoms of cyanoacetylene are the largest number so far found bound into a single molecule in interstellar space. Furthermore, four of cyanoacetylene's atoms are not hydrogen. Since hydrogen is by far the most abundant element in interstellar space, simple compounds of hydrogen are expected to form most readily. Molecular astronomers use the number of nonhydrogen atoms in a compound as a rule of thumb to express both difficulty of formation and unexpectedness. The previous record for nonhydrogens was two, which appear in several interstellar compounds.

More important than the numbers is the geometry of the cyanoacetylene molecule, says Dr. Turner. The core of the molecule is a chain of three carbon atoms. Carbon chains are characteristic of many organic substances. This is the first evidence that carbon chains can form in interstellar space. Without the possibility of forming carbon chains, astrochemistry could not proceed to the exceedingly complex organic compounds that are important to the functions of living beings.

Beside formation of carbon chains, two other processes are necessary to the formation of complex organic substances: polymerization, and oxidation and reduction.

A line of reasoning that starts from cyanoacetylene can lead to the suggestion that polymerization—the formation of chains of like molecules—also occurs in interstellar space. The presence of cyanoacetylene, says Dr. Turner, strongly suggests the presence of acetylene (C_2H_2). Acetylene is very reactive and has a strong tendency to form polymers, particularly benzene (C_6H_6). Benzene is a main component of a number of amino acids, especially pyridine, one of the main constituents of DNA. The discovery of cyanoacetylene has made some astronomers "willing to try to find pyridine," says Dr. Turner.

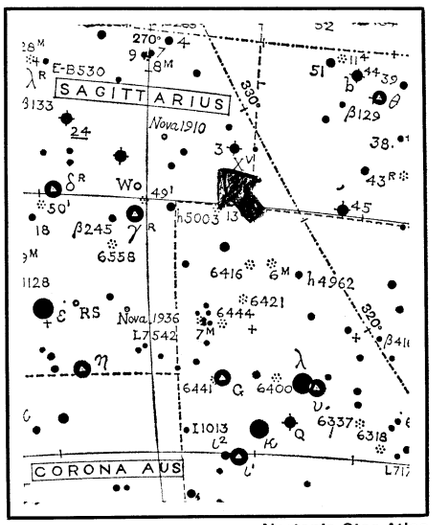
If acetylene is present, combining it with water, which is widely present in interstellar space, it could lead to yet another chain of organic substances. The reaction of water and acetylene yields acetaldehyde (CH_3CHO), from which acetic acid, acetone and alcohol can be formed.

To begin his search for cyanoacetylene, Dr. Turner assumed that the molecule was linear. He calculated the frequencies that such a shape should give off as its rotation changed from one possible state to another.

The main transition between the lowest rotational energy state of such a molecule and the first excited state yields three slightly different frequencies, Dr. Turner found: 9,097.09, 9,098.36 and 9,100.32 megahertz. Of these, the first two were observed in Sagittarius B2. Two out of three, says Dr. Turner, are sufficient for identification. Finding them also indicates that the assumption that the molecule is linear is correct.

The relative brightness of the lines indicates that the cyanoacetylene is in thermodynamic equilibrium with its surroundings and that therefore the molecules are excited by collisions with neighboring molecules. The energy output suggests that the clouds must contain several thousand particles per cubic centimeter. A density this high indicates that the clouds should be gravitationally unstable and liable to condensation under the influence of gravitational forces.

According to one school of theoretical opinion such condensation leads to the formation of stars and their associated planetary systems. This leads some astronomers to suggest that when the planets formed, they were already endowed with complicated organic substances, if not with primitive living matter itself. □



Norton's Star Atlas

Cyanoacetylene in Sagittarius B2.

SPACE-MOLECULE BOX SCORE

Molecules discovered by radio means:

Molecule	Date
Hydroxyl (OH)	Oct. 1963
Ammonia (NH_3)	Nov. 1968
Water (H_2O)	Nov. 1968
Formaldehyde (H_2CO)	March 1969
Carbon monoxide (CO)	March 1970
Cyanogen (CN) (by radio) *	March 1970
Hydrogen cyanide (HCN)	May 1970
Cyanoacetylene (HCCCN)	July 1970

* By optical means, CN and the radical CH were discovered in the late 1930's; H_2, in March 1970.