How the meteorites (and the earth) got their organic compounds

A team of Chicago chemists suggest that nature used partial hydrogenation of carbon monoxide

Astronomers have discovered more than two dozen organic molecules in the clouds of interstellar space. Analyzers of meteorites have found numerous organic compounds in the class called carbonaceous chondrites. Two questions immediately arise: How did the organics get where they are? Does their presence there have anything to do with the presence of life on earth?

New attempts to answer the questions have been made by Edward Anders and Ryoichi Hayatsu of the University of Chicago and Martin H. Studier of Argonne National Laboratory in the Nov. 23 SCIENCE and by Gustav Arrhenius of the University of California at San Diego at the 1973 Conference on Chemistry and Spectroscopy at San Diego. Anders and coworkers used laboratory experiments to show how organic compounds could have formed in a solar nebula. Arrhenius puts forth a theory of how the earth might have coagulated out of a solar nebula, forming from bits of matter that could have been contaminated by organic substances.

Both sides are critical of the contention, exemplified in the classic experiments of Stanley Miller of UCSD, that life might have begun on earth when organic compounds were formed as lightning discharges occurred in a primeval atmosphere rich in methane and ammonia. Miller, following a suggestion of H. C. Urey, showed in the laboratory that amino acids do in fact form when such an atmosphere is subjected to electric discharges. But Arrhenius contends that if actual lightning struck rather than the fairly mild discharges used by Miller, any organics that happened to be present could not have survived.

John H. Douglas

Anders: Organic synthesis in space.

Anders, Hayatsu and Studier point out that the Miller process, whatever it might mean in the history of the earth, cannot account for some features of organic matter in meteorites. They therefore turned their attention to another suggestion of Urey's, which "in the . . . excitement [over the Miller experiments] seems to have been forgotten." This was the possibility of forming complex organic compounds by partial hydrogenation of carbon monoxide.

"Our approach was to see how CO and H_2 behaved in the presence of some natural catalysts expected in the solar nebula: nickel-iron, magnetite, hydrated silicates." They found that the chemical reactions did stop short of complete hydrogenation. Instead of forming stable methane (CH_4), the hydrogenation stopped at metastable products with a hydrogen-to-carbon ratio of about 2 (for example, $C_{20}H_{42}$). This turns out to be in fact the Fischer-Tropsch reaction, which was discovered in 1923 and is used in the production of gasoline.

Anders and associates set out to prove that the Fischer-Tropsch reaction could occur in conditions more like those postulated for the solar nebula than those of the industrial process. It was not possible to mimic the exact conditions of the solar nebula, since, if it had been done, the amount of carbon in a one-liter vessel would have been only five-billionths of a gram. The experiments were done at higher pressures and lower ratios of molecular hydrogen to carbon monoxide than are supposed for the nebula. Nevertheless, the three chemists argue that the results are applicable to the solar nebula.

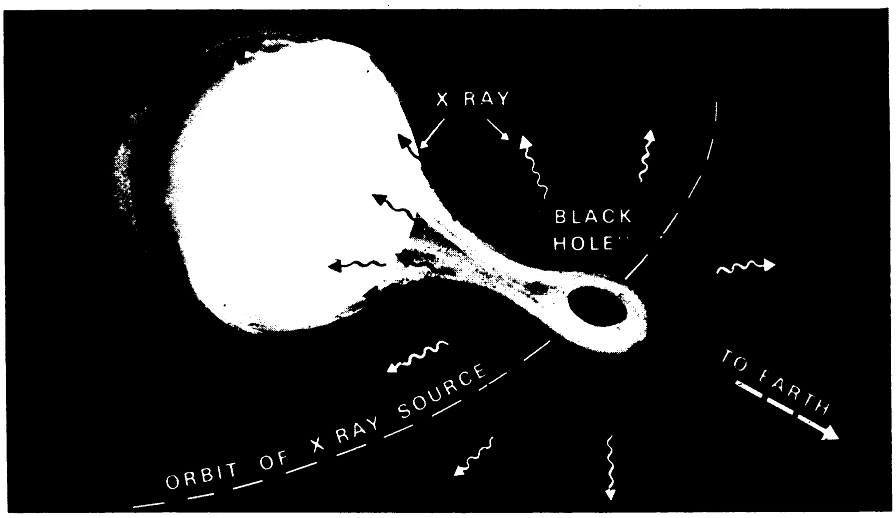
Detailed presentations concerning all of the organic compounds found in meteorites show how they could have been formed by the Fischer-Tropsch process. Anders, Hayatsu and Studier go on to suggest that the polyatomic molecules found in interstellar space are likewise formed in nebulas surrounding stars. Finally they propose that the earth may have gotten its prebiotic materials by meteoritic delivery. "Bodies of meteoritic size (1 to 100 centimeters) would survive atmospheric entry, and deliver their organic compounds intact. Larger bodies would vaporize on impact, causing any organic compounds to revert to CO and H_2. But on expansion and cooling of the gas ball, catalytic reactions would commence on the surfaces of dust grains." These reactions would produce new organics.

If the earth formed very hot, the above scenario would have to take place quite some time after the original formation. There is now great controversy over whether the earth formed hot or cold. Arrhenius suggests a way for the earth to form that would have some organic matter present from the very beginning.

The problem was to show a way for dust particles of the solar nebula to cling together when they collide instead of breaking up. Arrhenius contends that this can be done by electric polarization. Cosmic radiation bombarding the dust particles would polarize them. Particles with opposite polarities would attract each other and stick together. Some of these could be carrying organic compounds. When the polarized particles formed a body of about 100 kilometers diameter, gravitation would take over and drag in more matter until a planetary size was reached. Evidence in favor of this hypothesis is the discovery by Arrhenius and his colleague S. K. Asunmaa that dust particles brought back from the moon, where they are subject to cosmic-ray bombardment, are indeed polarized and do stick together.

All in all, though there is still likely to be much controversy over the details of compound formation and the aggregations of planets and meteorites, there seems to be more and more belief in the general proposition that the first production of organic matter took place outside the earth. □

The case for a black hole in Cygnus X-1



NASA

The suggestion that the X-ray source Cygnus X-1 is a black hole has been around for at least a year (SN: 1/13/73, p. 28). To command the belief of astronomers and specialists in general relativity it requires evidence. Three new pieces of evidence have just come forth. One involves X-ray observations with the Copernicus astronomy satellite, two are independent distance estimates made at the Lick Observatory.

The black-hole model of Cygnus X-1 associates it with the binary star system HDE 226868. One component of the binary is a visible star. The other component is not luminous and is supposed to be the black hole. Matter is continually leaving the luminous body and falling into the black hole. As it falls, the matter emits X-rays.

A group of British observers from University College, London, under the direction of R. L. F. Boyd, with direct observations and data reduction by Peter Sanford, has used the Copernicus satellite to confirm the identification of Cygnus X-1 with HDE 226868. They have also observed the way the X-rays are absorbed as they pass through the atmosphere of the visible star. From this they conclude that the invisible object is very small and very massive. The result leads Sanford to say: "It's a black hole."

Two groups at the Lick Observatory sought to determine the distance to Cygnus X-1 in order to determine the spectral class of the visible object and so to calculate its mass and that of the dark companion. The technique is to compare the extinction by interstellar dust of the light from HDE 226868 and that of other nearby stars. This establishes a relation between distance and extinction. The relation could then be used to decide whether HDE 226868 is a nearby system without a black hole or a distant one with a black hole.

The first group (Bruce Margon, Stuart Bowyer and R. P. S. Stone) measured 50 stars. The second group (Jesse Bregman, Dennis Butler, Edward Kemper, Alan Koski, R. P. Kraft and Stone) measured 42. They came to about the same conclusion. The system is distant, 8,000 light-years or more, and the dark body is very massive. The second group estimates the visible star's mass at 30 times the sun's mass and the dark companion's at six times the solar mass. Any such dark body over about three solar masses is expected to be a black hole. Thus it begins to look more and more as if there really is a black hole there. □

Overweight mice and the genetics of obesity

Insatiable appetites can lead to obesity, and in predisposed individuals, to diabetes. Recent research on two types of "fat" mutant mice at the Jackson Laboratory in Bar Harbor, Me., indicate that obesity may be linked to inherent gene mutations that affect the animals' eating control centers.

Two mutants—one obese and one diabetic—were discovered in different mouse stocks at Jackson Laboratory in 1950 and 1967, respectively. The characteristic traits of each mutant are produced by genes termed *ob* and *db* and are located on different chromosomes. Yet when they are placed on the same genetic background, by cross and intercross breeding, they produce identical syndromes—overeating, obesity, excess blood sugar and a diabetic condition.

In an attempt to better understand obesity, biochemist Douglas Coleman joined together diabetic, obese and normal mice by a surgical technique called parabiosis. The technique allows two animals to share a common system of body fluid such as blood.

When Coleman joined diabetic mice to normal ones, the normal mice stopped eating, lost weight and eventually died. The diabetic partners continued to gain weight. Coleman explains that the normal partners ceased eating because they received a large dosage of the satiety factor, the signal to stop eating, from both themselves and the diabetic mutants. Apparently, the diabetic mice were unable to react to the signal.

The same situation occurred when diabetic mice were linked to obese mice but, in this instance, the obese mice died. This led Coleman to conclude that the recognition factor in obese mice is functional.

Finally, fat mice and normal mice were joined together. Both reduced their food consumption moderately. After separation, the fat partners once again gained weight. This suggests that the obese mice cannot produce a satiety factor of their own though they do have the ability to respond to one. Coleman stresses that there may be other interpretations to these results but these are the simplest to date. The investigation does confirm that the cause of growing fat in the animals is not a metabolic one.

"Our next step," says Coleman, "is to study the satiety factor, isolate it and find how it acts—obviously it has important consequences. For instance, it may affect the pancreas and prevent insulin release. Insulin causes hunger. If it prevents insulin release, this may be what the factor is." □