Amino Acids Indigenous to the Murray Meteorite

Abstract. *Analysis of the Murray meteorite, a type II carbonaceous chondrite, has led to the identification of 17 amino acids. For seven of the amino acids nearly equal amounts of the* D *and* L *isomers are present, and 11 of the amino acids are not found in protein. These results suggest that these amino acids, like the amino acids of the Murchison meteorite, are extraterrestrial in origin.*

Although the presence of organic matter in carbonaceous chondrites has been recognized for over 100 years, the precise identification of many of the compounds has not been possible until recently because the necessary analytical techniques had not yet been developed. The importance of amino acids found earlier in carbonaceous chondrites has, generally, been discounted because the distribution patterns of these amino acids were suggestive of terrestrial contamination (*1*).

However, strong evidence has recently been presented for the indigenous character of the organic matter present in the Murchison meteorite (*2*, *3*). Of special significance is the unequivocal identification of 14 amino acids. Those amino acids with an asymmetric carbon atom and whose diastereoisomeric derivatives could be separated by the gas chromatographic method we used appeared to consist of nearly equal amounts of the D and L isomers. Eight of the amino acids identified are not found in proteins. These two observations are not in accord with the possibility that the amino acids in the Murchison meteorite are terrestrial in origin.

In order to determine if other carbonaceous chondrites contain amino acids resembling those in the Murchison meteorite, a similar analysis was performed on the Murray meteorite, another type II carbonaceous chondrite (*4*). The Murray meteorite was selected because it is very similar in chemical composition to the Murchison meteorite (*5*). The preliminary results of Cronin and Moore (*6*) established the need for a detailed examination of this meteorite. In addition, Oro *et al.* considered that, because of excessive contamination in the particular sample analyzed, their results were somewhat inconclusive (*7*).

For this study, we obtained a piece of the meteorite whose history suggested minimum opportunity for contamination (*8*). The sample was taken from an essentially complete 3.5-kg massive stone that was recovered the morning after the fall, on 20 September 1950. After being exhibited for a short period of time at Vanderbilt University, it was kept in a bank vault by a private collector. This stone was broken for the first time in 1970 and an 11.6-g specimen from the interior was selected for our analysis.

The analytical techniques used in this study have been previously described (*3*). About 3 g of the pulverized meteorite were refluxed with water for 20 hours. The water extract and rinses were evaporated to dryness and further refluxed for 20 hours with 6*N* HCl. The hydrolyzate was evaporated to dryness, dissolved in water, and charged on an ion-exchange column (Dowex 50) which was eluted first with H_2O and then with 2*N* NH_4OH. The NH_4OH eluate was evaporated to dryness, and the *N*-trifluoroacetyl-D-2-butyl ester derivatives of the amino acids were prepared. These derivatives were examined by means of gas chromatography and gas chromatography–mass spectrometry. No amino acids were detected in a procedural blank.

The gas chromatograph used (Perkin-Elmer 900) was fitted with a flame-ionization detector and a UCON 75 H 90,000 wall-coated capillary column, 46 m by 0.05 cm. The gas chromatograph was temperature-programmed from 100° to 150°C at the rate of 1°C per minute. The same column was used on a Perkin-Elmer 881 gas chromatograph, and the effluent was introduced into a mass spectrometer (Consolidated Electrodynamics Corp. 21–491) through a membrane separator.

A detailed examination of the gas chromatograms and mass spectra of the derivatives of the meteoritic amino acid extract has led to the positive identification of 17 amino acids. Six of these (valine, alanine, glycine, proline, aspartic acid, and glutamic acid) are commonly found in protein. The remaining 11 amino acids (isovaline, α-aminoisobutyric acid, *N*-methylalanine, α-amino-*n*-butyric acid, *N*-methylglycine, *N*-ethylglycine, norvaline, β-amino-*n*-butyric acid, pipecolic acid, β-alanine, and γ-amino-*n*-butyric acid) are not known to be present in protein. Although the identification of β-aminoisobutyric acid is only tentative on the basis of the weak mass spectrum, the cochromatography of sample and standard appears to confirm our conclusion. For comparative purposes, the amino

Table 1. Amino acids positively identified (P) and tentatively identified (T) in the Murray and Murchison meteorites.

Amino acids	Murchison meteorite	Murray meteorite
1. Isovaline (DL?)*	P	P
2. α-Aminoisobutyric acid	P	P
3. D-Valine	P	P
4. L-Valine	P	P
5. *N*-Methylalanine (DL?)*	T	P
6. D-α-Amino-*n*-butyric acid	P	P
7. D-α-Alanine	P	P
8. L-α-Amino-*n*-butyric acid	P	P
9. L-α-Alanine	P	P
10. *N*-Methylglycine	P	P
11. *N*-Ethylglycine	T	P
12. D-Norvaline	T	P
13. L-Norvaline	T	P
14. D-β-Aminoisobutyric acid	T	T
15. L-β-Aminoisobutyric acid	T	T
16. β-Amino-*n*-butyric acid (DL?)*	P	P
17. D-Pipecolic acid	P	P
18. L-Pipecolic acid	P	P
19. Glycine	P	P
20. β-Alanine	P	P
21. D-Proline	P	P
22. L-Proline	P	P
23. γ-Amino-*n*-butyric acid	P	P
24. D-Aspartic acid	P	P
25. L-Aspartic acid	P	P
26. D-Glutamic acid	P	P
27. L-Glutamic acid	P	P

* The symbol (DL?) indicates that the amino acid has an asymmetric center but under the chromatographic conditions employed yields only one peak.

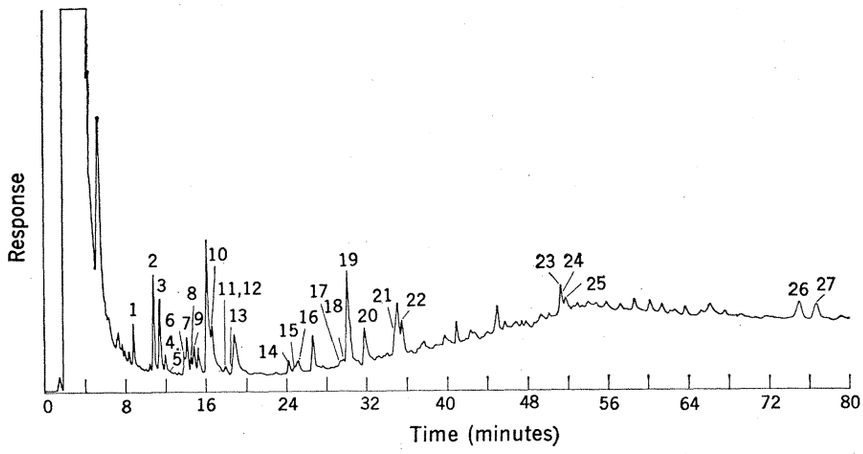

Fig. 1. Gas chromatogram of the *N*-trifluoroacetyl-D-2-butyl esters of amino acids in the acid-hydrolyzed aqueous extract of the Murray meteorite (attenuation: × 16). The identifying numbers correspond to those in Table 1.

acids positively and tentatively identified by us in the Murray meteorite and in the Murchison meteorite are shown in Table 1.

All the amino acids identified in the Murchison meteorite have also been found in the Murray meteorite. We have, in addition, been able to identify positively three amino acids in the Murray meteorite (*N*-methylalanine, *N*-ethylglycine, and norvaline) that had only been tentatively identified in the Murchison meteorite. As in the case of the Murchison meteorite (*3*), identification for the Murray meteorite is based on the equivalence of the mass spectrum of the meteoritic amino acid with that of an authentic standard and the coincidence of the retention times of the meteoritic amino acid with the corresponding standard. Figure 1 illustrates the gas chromatographic separation of the derivatives of the meteoritic amino acids. Of the nine amino acids that give diastereoisomeric derivatives separable by the gas chromatographic method we used, four of these (α-amino-*n*-butyric acid, alanine, pipecolic acid, and glutamic acid) have nearly equal abundances of the D and L isomers (Fig. 1). Although three other amino acids (valine, β-aminoisobutyric acid, and proline) show the interference of the other compounds in Fig. 1, under different gas chromatographic conditions they also appear to have nearly equal abundances of both the D and L isomers. Isomers of both norvaline and aspartic acid are present but their ratios could not be measured by gas chromatography. The data presented here do not permit us to give a precise quantitation of all the amino acids identified. However, an estimate of their abundances can be gauged from the observation that peak 19 in Fig. 1 represents approximately 6 μg per gram of glycine. This assessment is in agreement with results previously obtained by ion-exchange chromatography (*6*). A large number of the other peaks in the gas chromatogram appear to be amino acids, but their identification is impeded by the unavailability of standards.

The identification of several amino acids not found in proteins, the almost equal abundances of D and L isomers for several of the amino acids, and the presence of the C_2, C_3, and all but two of the C_4 aliphatic amino acids suggest that these amino acids are indigenous to the meteorite. Indeed, the results of this study lead us to the conclusion that the amino acids in the Murray meteorite, like those of the Murchison meteorite, may have been formed by an extraterrestrial process.

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Histidase Activity in Cultivated Human Amniotic Fluid Cells

Abstract. *Epithelial and fibroblast cells were obtained from cultures of amniotic fluid cells. Epithelial cells demonstrated high activities of histidase. In contrast, histidase activity was not detected in fibroblasts derived from the same original culture. This observation indicates that cultures of amniotic fluid cells consist of cells with different biochemical properties as well as morphological characteristics.*

Amniotic fluid cells are being used with increasing frequency for the prenatal detection of genetic disorders (*1*). Cultivation of amniotic fluid cells obtained by transabdominal amniocentesis early in the second trimester of pregnancy provides a method for assessing the biochemical and chromosomal integrity of a fetus at high risk for a severe genetic disease.

Amniotic fluid cells in culture give rise to at least two morphologically distinct cell populations (*2*). One type, which is similar to epithelial cells, proliferates in islands usually for a period limited to two to five passages. These cells adhere strongly to the culture flask and demonstrate increased resistance to trypsin and mechanical breakage. The second type, which can be maintained in culture for over 30 passages, has the classical configuration of the fibroblast. Both epithelial and fibroblast cultures proliferate with equal efficiency in short-term cultures. The ratio of one cell type to the other is unpredictable and variable even in cultures derived from the same original sample.

Our study was undertaken to determine if these two morphologically different cell types had distinct biochem-