

cc. of assay medium elicits a half-maximal response with *Leuconostoc citrovorum* 8081. Simultaneously a number of inactive principles are formed in the reaction mixture. Application of the above procedure to folic acid without prior formylation produces material which possesses some activity. Similarly, omission of ascorbic acid greatly reduces the activity of the reaction mixture.

Ascorbic acid, though not specific, appears to enhance the ability of several organisms to convert folic acid to a substance possessing folinic acid-like activity.

Application of the above procedure to N-pteroyl- α -glutamylglutamic acid produces a reaction mixture which gives two active bands on paper chromatograms developed with butanol-water containing acetic acid. One of these bands corresponds to the single band obtained with the reaction mixture derived from folic acid. If N-pteroyldi- γ -glutamylglutamic acid is employed in the above procedure, three bands of active principles are obtained on paper chromatograms developed in the same solvent. Thus, the diglutamate gives rise presumably to the mono-glutamate and an α -glutamylglutamate, and the triglutamate is converted presumably to the mono-glutaminate, a γ -glutamylglutamate and a di- γ -glutamylglutamate containing a modified pteroyl substituent. Pteric acid, itself, subjected to the above procedure forms material possessing slight activity.

The activity of the synthetic material derived from folic acid is destroyed by very dilute acid, peroxides, dilute chlorine solutions, and by dilute nitrous acid. Destruction in very dilute acid occurs with the formation of material which is still effective in promoting the growth of *Streptococcus faecalis* R and *Lactobacillus casei*.

Further investigations concerning the relationship of these synthetic members and the naturally occurring members of the folinic acid group are in progress.

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FOR RESEARCH, AUSTIN, TEXAS LORENE LANE ROGERS
RECEIVED APRIL 20, 1950

ON NEUTRON DEFICIENT ISOTOPES OF BARIUM¹

Sir:

While investigating the spallation reactions occurring when cesium is bombarded with 250 Mev. protons in the Rochester 130-inch cyclotron, two previously unreported positron emitting isotopes of barium were encountered.

Spectroscopically pure cesium chloride in a thin platinum tube was irradiated for periods of 30 and 90 minutes. The latter was used in an attempt

(1) This work was performed under atomic Energy Commission contract AT(30-1)-655.

to produce enough barium activity to make parent-daughter separations feasible. The decay of the barium fraction was followed in the usual manner and also by deflecting the positrons into a counter tube by means of the 4800 gauss field of a permanent magnet. The decay curves of the barium fraction were resolved into half-life periods of 1.8 ± 0.2 hours, 2.4 ± 0.1 days and 11.5 ± 0.2 days. The latter is undoubtedly that assigned to Ba¹³¹ by Katcoff² and Yu, Gideon and Kurbatov.³

A 31-hour cesium activity was isolated from the barium fraction. This is clearly the activity assigned to Cs¹²⁹ by Fink, Reynolds and Templeton.⁴ Parent-daughter separations performed more than 24 hours after the bombardment failed to show any Cs¹²⁹ activity whereas earlier milkings did show the activity. This led to the conclusion that the 1.8-hour barium is Ba¹²⁹. The 2.4-day barium activity had no observable daughter activity.

Energy studies have been made. The 2.4-day barium emits a positron of 3.1 Mev. energy as shown by the end-point in aluminum. Energies have not been obtained for Ba¹²⁹. Measurements made when both Ba¹²⁹ (1.8-hour) and the 2.4-day barium were present showed a β^+ energy of 3.9 Mev., the aluminum absorption curve of which could not be resolved. It is felt that this energy is a combination of the energies of both isotopes, indicating that β^+ from Ba¹²⁹ is hard. On this assumption, the relative yields at the end of bombardment are approximately Ba¹²⁹:Ba^{<129} = 19:1.

The results on these two isotopes⁵ can be summarized.

Isotope	Half-life	Mode of decay and energy	Method of mass assign.
Ba ¹²⁹	1.8 ± 0.2 hr.	β^+ (hard) exact energy unknown	Isolation of daughter Cs ¹²⁹ (31-hr.)
Ba ^{<129}	2.4 ± 0.1 days	β^+ 3.1 \pm 0.3 Mev.	

The coöperation of Professor Sidney S. Barnes and the staff of the 130-inch cyclotron in making these irradiations possible is gratefully acknowledged.

(2) S. Katcoff, *Phys. Rev.*, **72**, 1160 (1947).

(3) Fu-chun Yu, D. Gideon and J. D. Kurbatov, *ibid.*, **71**, 382 (1947).

(4) R. W. Fink, F. L. Reynolds and D. H. Templeton, *ibid.*, **77**, 614 (1950).

(5) Ba¹²⁹ and Ba¹²⁸ have been listed on the General Electric 1950 revised Chart of the Nuclides just received but as yet have not been reported in the literature. A subsequent private communication from Professor Templeton of the University of California Radiation Laboratory indicates that the results of Fink and Templeton are in agreement with those presented here.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF ROCHESTER CHARLES C. THOMAS, JR.
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RECEIVED APRIL 13, 1950

RADIOACTIVE ISOTOPES OF BARIUM¹

Sir:

In this communication we report the results of some preliminary experiments concerning neutron deficient isotopes of barium.

(1) This work was supported by the Atomic Energy Commission.

Spectroscopically pure cesium chloride was bombarded with 85 Mev. protons in the 184-in. Berkeley cyclotron for periods of one to three hours. The induced barium radioactivities, after chemical isolation, were observed with a Geiger counter with a 3 mg./sq. cm. mica window. The decay curve showed half lives of 2.0 ± 0.1 hours and 2.4 ± 0.1 days, as well as longer lived activity due to the well known² Ba^{131} and its daughter Cs^{131} .

Isolation of cesium from the purified barium (after the 2.0-hour activity had effectively decayed) yielded a mixture of the 31-hour³ Cs^{129} and 10-day Cs^{131} . Subsequent separations of cesium from the same barium yielded only Cs^{131} , at a time when the 2.4-day activity was still present. Thus it is probable that the 2.0-hour activity is Ba^{129} produced by the reaction $Cs^{133} (p, 5n)$. The 2.4-day period is not Ba^{127} , otherwise it would produce 5.5-hour³ Cs^{127} as a daughter. The most probable assignment is Ba^{128} from the $p, 6n$ reaction, but this assignment lacks direct proof.

A mass spectrographic analysis of a purified barium fraction showed a line at mass 129 which was proved to be radioactive by the photographic transfer technique. A second line at mass 128 was too weak to be identified as radioactive. The line at 129 is probably due to the cesium daughter, which had time to grow between the purification and the analysis. Cesium is ionized by the thermal ion source with much better efficiency than is barium. The mass scale was fixed by means of a small amount of stable Cs^{133} added to the sample.

Ba^{128} decays to Cs^{128} , which is expected to be short lived³ and to decay to stable Xe^{128} . Our experiments indicate a half life of 30 minutes or less. Thus the radiations we observe for the 2.4-day period include those from both the barium decay and the cesium decay. We have observed positrons of energy limit about 3.0 Mev., electrons of about 0.3 Mev., and gamma rays.

Ba^{129} emits positrons, but we have not characterized its radiations otherwise.

Recently we have learned that Thomas and Wiig have reached some of these same conclusions independently.⁴

We are indebted to the crew of the 184-in. cyclotron for their coöperation in these experiments, and to F. L. Reynolds for assistance with the mass spectrograph.

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RECEIVED MAY 6, 1950

(2) G. T. Seaborg and I. Perlman, *Revs. Mod. Phys.*, **20**, 585 (1948).

(3) Fink, Reynolds, and Templeton, *Phys. Rev.*, **77**, 614 (1950).

(4) C. C. Thomas and E. O. Wiig, *THIS JOURNAL*, **72**, 2818 (1950).

(5) Now at the Knolls Atomic Power Laboratory, Schenectady, N. Y.

INCORPORATION OF THE CARBON OF FORMALDEHYDE AND FORMATE INTO THE METHYL GROUPS OF CHOLINE^{1,2}

Sir:

It has been recently demonstrated in this Laboratory that the carbon of methanol may be incorporated, *in vivo*, into the methyl groups of choline.³ Continuing work along these lines, we have found that the carbon of formaldehyde or of formate may also be utilized. The use of the carbon of bicarbonate for this purpose was not detected.

The compounds, labeled with C^{14} , were injected subcutaneously into rats which were kept in an open circuit metabolism apparatus for the collection of the expired carbon dioxide. For a few days prior to the injections and during the experiments the animals were allowed free access to a diet of the following percentage composition: vitamin-free casein 20; cystine 0.4; sucrose 54.6; Osborne and Mendel salt mixture 4; fat (Covo) 19; corn oil (Mazola) 1, containing 4.0 mg. of α -tocopherol acetate and 0.1 mg. of 2-methyl-1,4-naphthoquinone, 750 I.U. of vitamin A and 125 I.U. of vitamin D; water-soluble vitamin mixture consisting of thiamine hydrochloride, riboflavin, pyridoxine hydrochloride, nicotinic acid and *p*-aminobenzoic acid, 1 mg. each, calcium *d*-pantothenate 5 mg., inositol 10 mg., folic acid 0.4 mg., biotin 0.01 mg., and sucrose to make 1000 mg. Each animal received 3 micrograms of vitamin B_{12} intraperitoneally at the beginning of the experiment.

Over a period of three days, rat no. 804 received daily, in three subcutaneous injections, 2 ml. of a 0.093 molar solution of C^{14} -formaldehyde along with an equimolecular amount of ordinary bicarbonate. The animal was sacrificed three hours after the last injection. Of the 1.30×10^6 counts per minute injected as radioformaldehyde, 1.06×10^6 counts per minute were excreted in the expired carbon dioxide. The choline was isolated from the carcass as the choline chloroplatinate (*Anal. Calcd. for $C_{10}H_{23}N_2O_2 \cdot PtCl_6$: Pt, 31.68. Found: Pt, 31.70*). It was degraded to trimethylamine which was isolated as the chloroplatinate (*Anal. Calcd. for $C_6H_{20}N_2 \cdot PtCl_6$: Pt, 36.96. Found: Pt, 37.08*). The specific activities of these compounds were determined as previously described³ and are given in the table.

Rat no. 808, received daily, in three subcutaneous injections, 2 ml. of a 0.095 molar solution of sodium C^{14} -formate over a three-day period. The animal was sacrificed fourteen hours after the last injection. Of the 8.22×10^6 counts per minute injected as formate, 4.87×10^6 counts per minute

(1) While these experiments were underway, it was announced by Professor H. G. Wood in a Harvey Lecture, February 16, 1950, that Dr. W. Sakami and Professor A. D. Welch have been able to demonstrate the synthesis of "biologically labile" methyl groups from formate *in vivo* in the rat and by rat tissue *in vitro*.

(2) The authors wish to express their appreciation to the Lederle Laboratories Division, American Cyanamid Company, for a research grant which has aided greatly in this work.

(3) du Vigneaud and Verly, *THIS JOURNAL*, **72**, 1049 (1950).