(m. p. 135°) and a **dipicrate** (m. p. 206–207°) of *dl*-sparteine, which they obtained from naturally occurring *dl*-lupanine. As a further proof of identity, our *dl*-sparteine was converted to *dl*-oxysparteine, m. p. 110–111°, by treatment with alkaline potassium ferricyanide. The melting point of *dl*-oxysparteine has been reported as 110–111°,[5] 112–113°,[4] 113°.[7] Finally, the infrared absorption spectra of our synthetic *dl*-sparteine dipicrate and an authentic sample of *l*-sparteine dipicrate (m. p. 208°) were found to be identical in solution.[8]

We are aware of the desirability of resolving *dl*-sparteine and of isolating the other two racemates of I. We also foresee the applicability of our method to the synthesis of other bases related to sparteine.

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(8) The authors are indebted to Mrs. James L. Johnson for determination of the infrared absorption spectra.

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A CRYSTALLINE FACTOR FUNCTIONALLY RELATED TO FOLIC ACID

Sir:

In a systematic study of factors functionally related to *p*-aminobenzoic acid and folic acid and occurring in liver extracts used for the treatment of pernicious anemia, a factor was discovered which prevented the toxic action of methylfolic acid[1] upon the growth of *Leuconostoc mesenteroides* 8293. In a medium previously described[2] but supplemented with 300 γ of thymine per 10 cc., the ratio of methylfolic acid to folic acid just necessary for maximum inhibition was 3,000. The addition of this factor in adequate amounts (equivalent to 0.01–0.03 γ of crystalline material per 10 cc.) increases the antibacterial index about tenfold.

A medium suitable for quantitative assay was obtained by the addition of 0.03 γ of folic acid and 200 γ of methylfolic acid per 10 cc. to the above medium. Under these conditions increasing concentrations of the factor resulted in increasing growth levels.

Employing this assay, a principle has been isolated from hog liver in crystalline form. Recrystallized from isopropyl alcohol, this principle appears as fine, colorless prisms, m. p. 189–190°. Under the testing conditions, the factor is several times as active as folic acid in promoting a half-maximum growth response.

Extracts prepared from either liver, hog duodenal mucosa, or grass are highly active, but milk, muscle tissue and yeast extract are relatively poor sources of active material. Liver extracts used in treatment of pernicious anemia are relatively potent, and some experimental extracts of high potency (determined clinically) assayed by the above method appear to contain as much as 1% of this factor.

Preliminary investigation of the structure of the compound indicated that it was thymidine[3] or a structurally related compound.

We acknowledge our indebtedness to Eli Lilly and Company for their coöperation. Particular thanks are due Drs. Ewald Rohrmann and Edward D. Campbell for their coöperation in furnishing experimental extracts and analytical facilities.

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(1) Crude mixture from the condensation of α,β-dibromobutyraldehyde, 2,4,5-triamino-6-hydroxypyrimidine and *p*-aminobenzoylglutamic acid obtained from Dr. E. L. R. Stokstad [Franklin, *et al.*, *J. Biol. Chem.*, **169**, 427 (1947)].

(2) Snell, *et al.*, *ibid.*, **148**, 519 (1942).

(3) Since this paper was submitted, we have obtained a sample of thymidine originally isolated from desoxyribonucleic acid by Levene and London (*J. Biol. Chem.*, **83**, 793 (1929)). The X-ray diffraction pattern and the biological properties of this sample are identical with those of the isolated factor.

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RECEIVED APRIL 16, 1948

THE KINETICS OF THE POLYMERIZATION OF CARBONIC ANHYDRIDES

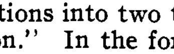
Sir:

Carothers (*Chem. Rev.*, **8**, 353 (1931)) has divided polymerizations into two types, "addition" and "condensation." In the former type, initiation, propagation, transfer and termination reactions are involved (*cf.* Bamford and Dewar, *Proc. Roy. Soc.* (*London*), **192**, 309 (1948)), but in condensation polymerizations only chain-growth occurs, and in this reaction every species reacts with every other. There is, however, a third type of polymerization in which there are only two reactions, initiation, and a propagation reaction where the polymers do not react with each other, but only with the monomer. The polymerizations of carbonic anhydrides (*e. g.*, I) appear to belong to this third type, and are also important since they can be used to synthesize polypeptides of some complexity. The reactions involved are

$$M + A \longrightarrow X + CO_2 \quad (k_1) \qquad (1)$$

$$M + X \longrightarrow X + CO_2 \quad (k_2) \qquad (2)$$

where M denotes the carbonic anhydride, X any polymer species, and A the initiator which may be a hydroxylic or amino compound.



(I)

$MeNHCH_2CO(NMeCH_2CO)_nNMeCH_2CONMe_2$

(II)

Although a complete formal solution of the kinetic equations is impossible, the following methods are available for the absolute determina-