uncorrected but were taken in a Fisher melting point apparatus with a set of Anschütz thermometers which gave correct melting points with various pure reagents.

DEPARTMENT OF CHEMISTRY
HOLY CROSS COLLEGE
WORCESTER, MASSACHUSETTS

RECEIVED JUNE 1, 1936

COMMUNICATIONS TO THE EDITOR

SYNTHETIC SUBSTRATES FOR PROTEIN-DIGESTING ENZYMES

Sir:

Knowledge regarding the specificity of those enzymes which hydrolyze intact proteins (peptic, tryptic and catheptic proteinases) is meager. In general it is assumed that these enzymes react exclusively on high molecular substrates.

Recently it has been possible to study the specificity of proteinases with the aid of synthetic substrates. Such substrates have been found in this Laboratory for the catheptic enzymes, papain, liver-cathepsin and bromelin. The authors have now observed the splitting of α-hippuryl-lysine-amide by tryptic proteinase.

α-Hippuryl-ε-carbobenzoxy-lysine methyl ester was converted into α-hippuryl-ε-carbobenzoxy-lysine amide, m. p. 212°, with the aid of methanolic ammonia. *Anal.* Calcd. for $C_{23}H_{28}N_4O_5$: C, 62.7; H, 6.4; N, 12.7. Found: C, 62.6; H, 6.7; N, 12.8. This amide was hydrogenated catalytically, yielding α-hippuryl-lysine-amide which was isolated as the strongly hygroscopic hydrochloride, m. p. 248°. *Anal.* Calcd. for $C_{15}H_{23}N_4O_3Cl$: C, 52.5; H, 6.8; N, 16.3. Found: C, 52.0; H, 7.0; N, 15.9.

The tryptic proteinase was prepared according to E. Waldschmidt-Leitz and A. Purr [*Ber.*, **62**, 2217 (1929)]. The preparation contained no dipeptidase, aminopeptidase, and no carboxypeptidase; however, protaminase probably was present (Table I).

In contrast to HCN-papain, which splits only one peptide bond, tryptic proteinase splits two. After a complete splitting, hippuric acid was isolated from the digest (over 70% of the theoretical amount). Therefore, the splitting also must have liberated lysine and ammonia. That the free ε-amino group is an essential condition for the enzymic hydrolysis is shown by the fact that the above mentioned α-hippuryl-ε-carbobenzoxy-lysine amide is not hydrolyzed under the conditions of our experiments. The hydrolysis of our substrate by tryptic proteinase is remarkable since tryptic proteinase is supposed to react exclusively on anionic substrates.

TABLE I

ENZYMIC HYDROLYSIS OF α-HIPPURYL-LYSINE-AMIDE AT 40°

(Titration of liberated carboxyl groups)

Enzyme	Time, hrs.	Hydrolysis in % of one peptide bond
Tryptic proteinase, *p*H 8.8	22	123
	72	200
Tryptic proteinase, *p*H 8.8	18	121
	42	175
HCN-Papain, *p*H 5.0	5	58
	24	80
	49	85

It is intended to continue this research by studying the action of pure tryptic proteinases.

THE LABORATORIES OF
THE ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH
NEW YORK, N. Y.

MAX BERGMANN
WILLIAM F. ROSS

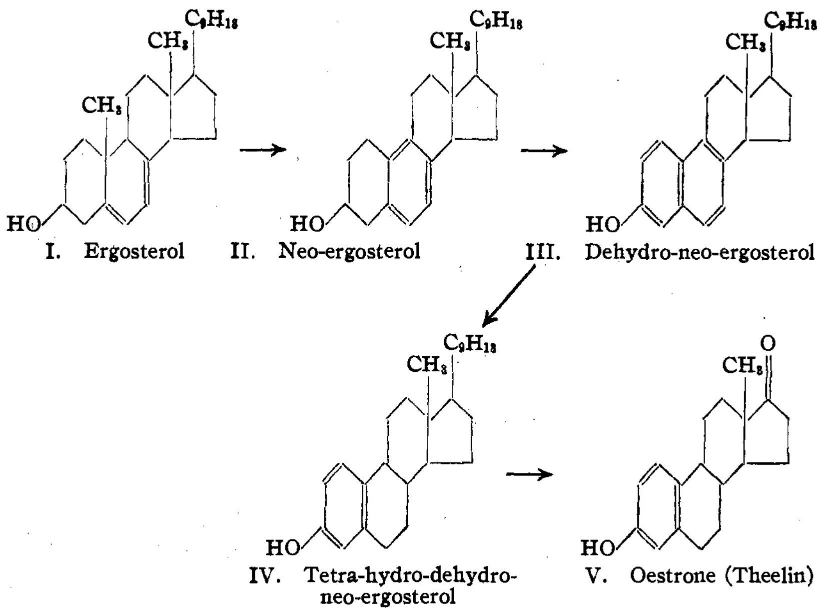
RECEIVED JULY 10, 1936

STEROLS. VI. SYNTHETIC PREPARATION OF OESTRONE (THEELIN)

Sir:

The evidence for the accepted structure of oestrone has recently been reviewed [L. F. Fieser, "Chemistry of Natural Products Related to Phenanthrene," A. C. S. Monograph Series, No. 70]. We have been able to prepare a well crystallized compound from ergosterol which by analysis, derivatives and mixed melting points, is identical with oestrone isolated from pregnancy urine. It has been previously shown that ergosterol may be converted into 3-hydroxy-nor-allo-cholanic acid [Chuang, *Ann.*, **500**, 270 (1933); Fernholz

and Chakravarty, *Ber.*, **67**, 2021 (1934)] which is also obtainable from dihydro-cholesterol. This acid can give rise to isoandrosterone which differs from androsterone only in configuration of the hydroxyl group in the 3-position. Therefore, with the preparation of oestrone from ergosterol, a complete connection between the hormones, male and female, has been established.



I. Ergosterol II. Neo-ergosterol III. Dehydro-neo-ergosterol IV. Tetra-hydro-dehydro-neo-ergosterol V. Oestrone (Theelin)

In the present work, dehydro-neo-ergosterol, III, was prepared from ergosterol by the method of Windaus [Windaus and Borgeaud, *Ann.*, **520**, 235, 460 (1928)], Inhoffen [Inhoffen, *ibid.*, **497**, 130 (1932)], and Honigmann [Honigmann, *ibid.*, **511**, 292 (1934)]. Taking advantage of the fact that naphthalene derivatives may be reduced to tetrahydro derivatives with sodium and amyl alcohol, dehydro-neo-ergosterol, III, m. p. 147–150°, was reduced to give tetrahydro-dehydro-neo-ergosterol, IV, m. p. 170.5–171.5°. This substance is phenolic and forms sodium salts.

Anal. Calcd. for $C_{27}H_{41}O$: C, 85.1; H, 10.8. Found: C, 85.7; H, 10.8.

The tetrahydro-dehydro-neo-ergosterol was then acetylated and this product oxidized with chromic acid. The total neutral oxidation product was hydrolyzed with alcoholic sodium hydroxide and then treated with semicarbazide acetate. The crude semicarbazone was hydrolyzed with alcoholic sulfuric acid to the free ketone, which was then distilled at 200° under high vacuum. The sublimate was crystallized from 95% alcohol to give a white crystalline compound m. p. 259–261.5° (uncorr.). This gave no depression in melting point with a sample of natural oestrone of m. p. 255°. It is soluble in alkali. It gave a rotation of $[\alpha]^{32}D$ +159° in alcohol, c = 514 mg. per 100 cc.

Anal. Calcd. for $C_{18}H_{22}O_2$: C, 79.9; H, 8.3. Found: C, 79.4; H, 8.4.

The product gave a benzoate by the Schotten–Baumann reaction, m. p. 205–207° (uncorr.), which gave no depression to a sample of natural oestrone benzoate m. p. 205° (uncorr.).

Anal. Calcd. for $C_{25}H_{26}O_3$: C, 80.2; H, 7.0. Found: C, 80.6; H, 7.2.

It gave a semicarbazone of m. p. 252–253° (uncorr.). From the analysis this semicarbazone calculates to have one-half molecule of water of crystallization. Butenandt [*Z. physiol. Chem.*, **208**, 129 (1932); **208**, 149 (1932)] observed the same thing on the preparation of the semicarbazone from natural oestrone.

Anal. Calcd. for $(C_{19}H_{25}O_2N_3)_2 \cdot H_2O$: C, 67.9; H, 7.9. Found: C, 68.1; H, 8.2.

This synthesis was repeated independently by two of us. We wish to thank Dr. George H. Fleming of this Laboratory for the micro-analyses reported in this paper.

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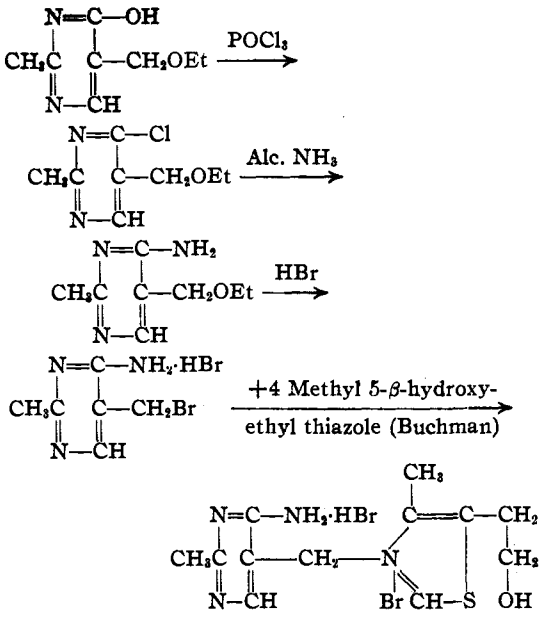
RECEIVED JULY 20, 1936

SYNTHESIS OF VITAMIN B_1

Sir:

As foreshadowed in a recent communication [THIS JOURNAL, **58**, 1063 (1936)] we have effected a synthesis of the vitamin by the following route.

$$EtOCOCH_2CH_2OEt \xrightarrow{+HCOOEt} \underset{O=CH}{EtOCOCHCH_2OEt} \xrightarrow{+NH_2-C(CH_3)=NH}$$



The resulting bromide agreed in molecular absorption with the natural vitamin and when air dried analyzed for the composition $C_{12}H_{17}N_4SOBr\cdot HBr\cdot {}^1/_2H_2O$. The curative dose for polyneuritic rats is 6 $\gamma \pm 1$ γ.

Converted into the chloride, it was found identical with the natural in composition (5 elements) ultraviolet absorption and antineuritic potency (5 γ). Comparing melting points led us to observe two crystal forms in varying proportions in the natural chloride and especially in the picrolonate; the synthetic chloride and picrolonate respectively correspond in appearance to one of these forms. The synthetic chloride melts at 232–234°; our present specimen of natural at 246°; mixed melting point is 242–244°. Kinnersley, O'Brien and Peters have called attention to a variably low melting antineuritic chloride [*Biochem. J.*, **27**, 232 (1933)] and it seems probable that the natural as isolated is often a mixture of two stereoisomers [*cis-trans* on 5 C of pyrimidine? Nishikawa, *T. Mem. Ryojun Coll. Eng.*, **3**, 277 (1931)] of equal potency and that in our synthetic material the low form predominates in higher degree.

The details of structural evidence and of the method of synthesis will appear in forthcoming papers.

In making this announcement the writers wish to express their indebtedness to all those who have participated in the work and whose names have appeared in the authorship of the current series of papers "Studies of Crystalline Vitamin B_1." Mention should also be made of Mr. Jacob Finkelstein, who has performed many syntheses of both known and new compounds.

The senior author is grateful to Dr. E. R. Buchman, who continued to participate in the work when financial support was lacking during the greater part of 1935 and to Mr. R. E. Waterman who joined the writer in meeting this emergency. Through the kindness of Dr. Walter H. Eddy, laboratory space was provided at Teachers College during this as well as earlier phases of the undertaking. More recently funds and facilities have been provided by Merck & Co., Inc., under the auspices of the Research Corporation of New York. Grateful acknowledgment is made to Dr. Eddy and to both of these corporations.

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