glycine and benzoylsarcosine is essentially complete, *i. e.*

$$C_6H_5CONR_1CH_2CO_2H + 2H_2SO_4 \rightleftharpoons \left[C_6H_5C(=O)=NR_1CH_2CO\right]^+ + H_3O^+ + 2HSO_4^-$$

(R_1 = H, CH_3; i = 4)

The similarity in the behavior of the latter two solutes is not disconcerting for there is no feature of any one of the reaction steps which would render the N-methyl compound incapable of cyclization. Indeed this situation may not be unique, for we regard as inconclusive the evidence[8,9] upon which is based the repeated claim[7,8,10] that acylsarcosines cannot cyclize in acetic anhydride.

It has been observed that the acid catalyzed cyclization of α-acylamino acids can also be conducted in the solvent acetic anhydride. Further observations on the cyclization of acylsarcosines and some preparative applications of the above observations will be reported in a subsequent communication.

(8) R. Heard, *Biochem. J.*, **27**, 54 (1933).
(9) V. Deulofeu, *Ber.*, **67**, 1542 (1934).
(10) R. H. Wiley and O. H. Borum, THIS JOURNAL, **72**, 1626 (1950).

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CONTRIBUTION NO. 1466 CARL NIEMANN
RECEIVED AUGUST 28, 1950

TWO HYDROGEN-BONDED SPIRAL CONFIGURATIONS OF THE POLYPEPTIDE CHAIN

Sir:

During the past fifteen years we have been carrying on a program of determination of the detailed atomic arrangements of crystals of amino acids, peptides, and other simple substances related to proteins, in order to obtain structural information that would permit the precise prediction of reasonable configurations of proteins. We have now used this information to construct two hydrogen-bonded spiral configurations of the polypeptide chain, with the residues all equivalent, except for variation in the side chain.

We have attempted to find all configurations for which the residues have the interatomic distances and bond angles found in the simpler substances and are equivalent, and for which also each CO group and NH group is involved in the formation of a hydrogen bond. The plane layer of extended polypeptide chains is a structure of this type, the hydrogen bonds being formed between adjacent chains. In addition there are two spiral structures, in which the plane of the conjugated system C–CO–NH–C is nearly parallel to the spiral axis, and hydrogen bonds are formed between each carbonyl and imino group and an imino or carbonyl group of a residue nearly one turn forward or back along the spiral.

One of these spirals is the three-residue spiral, in which there are about 3.7 residues per turn and each residue is hydrogen-bonded to the third residue from it in each direction along the chain. The unit translation per residue is 1.47 Å. There is evidence that indicates strongly that this configuration is present in α-keratin, contracted myosin, and some other fibrous proteins and also in hemoglobin and other globular proteins.[1]

The second hydrogen-bonded spiral is the five-residue spiral, in which there are about 5.1 residues per turn and each residue is hydrogen-bonded to the fifth residue from it in each direction. The unit translation is 0.96 Å. We believe that this spiral is present in supercontracted keratin, which is formed from α-keratin with a shrinkage of about 35% in the fiber direction.

We are indebted to Drs. H. R. Branson and S. Weinbaum for assistance. Our work has been aided by grants from the Rockefeller Foundation and the National Foundation for Infantile Paralysis. A detailed account of the work will be published soon.

(1) A three-residue spiral described by Huggins (*Chem. Rev.*, **32**, 211 (1943)) is similar to ours, but differs from it in essential structural details.

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RECEIVED OCTOBER 16, 1950

CHEMICAL NATURE AND SYNTHESIS OF THE *LACTOBACILLUS BULGARICUS* FACTOR[1]

Sir:

The presence of 65–75% of bound pantothenic acid in concentrates of the *Lactobacillus bulgaricus* factor (LBF)[2] indicated that the unidentified portion(s) of the molecule must be relatively small in size. Hydrolysates of such preparations[2] had an unpleasant odor reminiscent of sulfur compounds. Application of the iodine-azide reagent[3] to paper chromatograms of LBF confirmed the presence of sulfur. In acid hydrolysates, a sulfur-containing fragment that also gave a color with ninhydrin and with nitroprusside–cyanide reagent appeared on papergrams. Since LBF is essentially neutral and is not destroyed by nitrous acid[4] it contains no free amino or carboxyl groups. An amide linkage between pantothenic acid and a mercaptoamine (or the corresponding disulfide) is thus indicated. Biogenetic and analytical considerations pointed to β-mercaptoethylamine as a possible fragment. Pure β-mercaptoethylamine[5] showed the same R_F value on papergrams (0.43;

(1) Supported in part by grants from Parke, Davis and Co., and the National Institutes of Health.
(2) G. M. Brown, J. A. Craig and E. E. Snell, *Arch. Biochem.*, **27**, 473 (1950).
(3) E. Chargaff, C. Levine and C. Green, *J. Biol. Chem.*, **175**, 67 (1948).
(4) W. L. Williams, E. Hoff-Jorgensen and E. E. Snell, *ibid.*, **177**, 933 (1949).
(5) E. J. Mills and M. T. Bogert, THIS JOURNAL, **62**, 1173 (1940).

pyridine–water (4:1) as solvent) as the sulfur-containing fragment in LBF hydrolysates.

Methyl pantothenate (1.5 moles), β-mercaptoethylamine (1.5 moles) and acetamide (0.0025 mole) were refluxed in two liters of methanol for eleven hours. Assay[2,4] showed 2400 LBF units per mg. of product. Excess methyl pantothenate was hydrolyzed by treatment for one hour at room temperature with *N* methanolic KOH. After neutralization with methanolic HCl and removal of the solvent, the residue was partitioned between *n*-butanol and water. The butanol contained 18,000 LBF units per mg. of solids. After drying, the butanol solution was poured onto a Superfiltrol column (20 g. adsorbent per g. of solids), the latter washed thoroughly with butanol, then developed with water-saturated butanol. The most active fractions contained 29,000 to 30,000 LBF units per mg. of solids.

Though non-crystalline, this product appears essentially pure, and is indistinguishable from LBF prepared from natural sources in (a) R_F values on paper from water-saturated butanol (0.93) or *n*-amyl alcohol (0.76) and (b) activity for *Lactobacillus helveticus*, *Saccharomyces carlsbergensis*, and *Lactobacillus arabinosus*.[2] Both products give an immediate nitroprusside test only after reduction with NaCN; activity for *L. helveticus* was unchanged by such reduction. Both products are destroyed by digestion with a liver enzyme with release of 0.03 μg. of calcium pantothenate per LBF unit. Thus LBF may exist as N-(pantothenyl)-β-aminoethanethiol or as the corresponding disulfide.

Anal. Calcd. for $C_{11}H_{22}O_4N_2S$: N, 10.07; S, 11.52; Found: N, 10.2; S, 12.0. *Pantetheine* and *pantethine* are suggested as names for the thiol and disulfide forms, respectively, of the growth factor. Its relation to coenzyme A was indicated previously.[2]

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RECEIVED OCTOBER 13, 1950

AN EFFICIENT SEPARATION OF DYSPROSIUM AND YTTRIUM[1]

Sir:

A rapid and efficient separation of the difficultly separable rare earth pair, dysprosium and yttrium, has been accomplished by elution with 5% ammonium citrate solution at room temperatures on Nalcite H.C.R. resin. This is achieved because of a shift in the order of elution of yttrium relative to the other rare earths. With 0.1% citrate solution, the order of elution is Dy-Y-Tb,[2] while the order observed with 5% citrate is Dy-Tb-Y. Previously, it had been reported[3] that elution at 100° of tracer amounts of rare earths with 5% citrate showed yttrium eluting ahead of dysprosium.

When eluting with 5% citrate at *p*H values greater than 2.8, the rare earth band immediately precedes the hydrogen band on the column, and results in a square-type band front. At lower *p*H values, the ammonium ions pass the rare earth ions and consequently the rare earths are on an ammonium bed. The resultant band front at these lower *p*H values is sloping and the elution curves resemble those previously obtained with other rare earths using similar conditions.[4] At all *p*H values when 5% ammonium citrate is used as eluant, the observed order of elution is Dy-Tb-Y.

A load of 7.6 g. of oxides was placed on a column containing 450 g. of resin and eluted with 5% citrate. The resin bed length was 60 cm. and the diameter was 4 cm. These oxides, obtained by column fractionation of R_2O_3 from gadolinite ore, had the composition 10% Dy_2O_3, 89% Y_2O_3, 0.5% Ho_2O_3, 0.5% Tb_4O_7. Analyses were made by spectrophotometric and spectrographic methods. At a *p*H value of 2.80, 85% of the available Y_2O_3 was obtained spectrophotometrically pure (>99%). Previous work using 0.1% citrate at *p*H values of 5.5–6.0, eluted less than 10% of the available Y_2O_3 with comparable purity. The total time of a run using 5% citrate at a *p*H of 2.80 is only one-third that required with 0.1% citrate. The concentration of rare earths in the eluate using 5% citrate is correspondingly higher.

It appears that the most efficient way to obtain pure Y_2O_3 and pure Dy_2O_3 from an ore concentrate involves two ion exchange procedures: (1) first a preliminary elution using 0.1% citrate with *p*H values between 5.8 and 6.1, which separates dysprosium and yttrium from the other rare earths; (2) elute the yttrium–dysprosium fractions so obtained with 5% citrate using a *p*H value of 2.8, to obtain the pure salts.

(1) This work was performed in the Ames Laboratory of the Atomic Energy Commission.

(2) F. H. Spedding, E. I. Fulmer, J. E. Powell, T. A. Butler, and I. S. Yaffe, paper presented before the Sept. 1950 meeting of the American Chemical Society in Chicago.

(3) B. H. Ketelle and G. E. Boyd, THIS JOURNAL, **69**, 2800 (1947).

(4) F. H. Spedding, A. F. Voigt, E. M. Gladrow and N. R. Sleight, *ibid.*, **69**, 2777 (1947).

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RECEIVED OCTOBER 26, 1950

THE STRUCTURE OF THE CARYOPHYLLENES

Sir:

An optically inactive α-caryophyllene (humulene), $n^{20}D$ 1.5035, was prepared from hop oil by fractionation in an efficient column with sub-