



Amino acids and serum proteins

Jacob A. Stekol, symposium chairman.

Amino Acids and Serum Proteins

Based on the Richard J. Block
Memorial Symposium sponsored
by the Division of Biological
Chemistry at the 142nd Meeting
of the American Chemical Society,
Atlantic City, N. J., September 11, 1962
Jacob A. Stekol, *Symposium Chairman*

ADVANCES IN CHEMISTRY SERIES

44

AMERICAN CHEMICAL SOCIETY
WASHINGTON, D.C. 1964

Copyright © 1964

American Chemical Society

All Rights Reserved

Library of Congress Catalog Card 64-16321

PRINTED IN THE UNITED STATES OF AMERICA

Advances in Chemistry Series

Robert F. Gould, *Editor*

Advisory Board

Fred Basolo

Raymond F. Boyer

John H. Fletcher

Jack Halpern

Wayne W. Hilty

George W. Irving

Amel R. Menotti

Walter C. Saeman

Leo H. Sommer

AMERICAN CHEMICAL SOCIETY

APPLIED PUBLICATIONS

Contributors

- Richard J. Block, Boyce Thompson Institute for Plant Research, Yonkers, N. Y.
- Amubha Chowdhury, Department of Radiation Biology, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.
- Thomas W. Cook, Boyce Thompson Institute for Plant Research, Yonkers, N. Y.
- Vincent du Vigneaud, Department of Biochemistry, Cornell University Medical College, New York, N. Y.
- Santiago Grisolia, Department of Biochemistry, School of Medicine, University of Kansas Medical Center, Kansas City, Kansas.
- Merton L. Groves, Eastern Regional Research Laboratory, Philadelphia, Pa.
- Helen R. Hanavan, Department of Radiation Biology, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.
- S. Mark Henry, Boyce Thompson Institute for Plant Research, Yonkers, N. Y.
- Norbert J. Hipp, Eastern Regional Research Laboratory, Philadelphia, Pa.
- Joseph T. Holden, Department of Biochemistry, City of Hope Medical Center, Duarte, Calif.
- James M. Manning, Department of Biochemistry, Tufts University School of Medicine, Boston, Mass.
- Thomas L. McMeekin, Eastern Regional Research Laboratory, Philadelphia, Pa.
- Alton Meister, Department of Biochemistry, Tufts University School of Medicine, Boston, Mass.
- Leon L. Miller, Department of Radiation Biology, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.
- Kivie Moldave, Department of Biochemistry, Tufts University School of Medicine, Boston, Mass.
- Fred Plum, Department of Biochemistry, Cornell University Medical College, New York, N. Y.
- Julian R. Rachele, Department of Biochemistry, Cornell University Medical College, New York, N. Y.
- Luisa Raijman, Department of Biochemistry, School of Medicine, University of Kansas, Kansas City, Kansas.
- Lester J. Reed, Department of Biochemistry, Cornell University Medical College, New York, N. Y.
- Julius Schultz, Department of Biochemistry, Hahnemann Medical College, Philadelphia, Pa.
- Jakob A. Stekol, Department of Physiological Chemistry and Nutrition, Institute for Cancer Research, Philadelphia, Pa.

Neville Stone, Department of Biochemistry, Tufts University School of Medicine, Boston, Mass.

Nantha Titthasiri, Department of Radiation Biology, University of Rochester School of Medicine and Dentistry, Rochester, N. Y.

Gerrit Toennies, Department of General Biochemistry, Institute for Cancer Research, Philadelphia, Pa.

John E. Wilson, Department of Biochemistry, Cornell University Medical College, New York, N. Y.

Preface

The tragic death of Dr. Richard J. Block in February 1962 was a great shock to his friends and colleagues. The members of the Executive Committee of the Division of Biological Chemistry who were familiar with his work proposed at the March 1962 meeting in Washington that a symposium be held in recognition of his lifetime efforts in advancing knowledge in amino acid and protein biochemistry. It is particularly important that in spite of Richard Block's reluctance to participate in Society affairs, other than to offer papers for presentation and to accept invitations to take part in symposia, the Executive Committee was willing on the basis of his reputation to sponsor a symposium in his honor at the national meeting of the American Chemical Society held in Atlantic City in September 1962. It is from this symposium that papers of this volume originated, in addition to investigations of other authors, who would have wished to participate but were pressed with other commitments.

The Executive Committee was especially fortunate in the ready acceptance by such an eminent biochemist as Dr. Jack Stekol to take on the duties of both the organization of the Richard J. Block Memorial Symposium and the creation of this volume. Such labors and those of the participants are a reflection of the deep regard in which Dr. Block was held by his colleagues.

It was fitting that Dr. Stekol, a lifetime friend, introduce this volume with a review of Richard Block's life and his scientific work. In the extensive bibliography included in this account, one finds a number of books and reviews, some of which serve today as "bibles" for laboratory procedures both for amino acid and protein research; and how many of us in the past consulted "Block and Bolling" for the amino acid composition of proteins! As students over a quarter of a century ago, some of us wondered why the title of some of Block's papers bore no relation to the contents. This was his way of overcoming "administrative" pressures as to what should be done in the laboratory, a problem that is particularly topical today when Congressional committees are questioning the freedom to "change" the direction of one's research. Block was a pioneer in this respect; the title satisfied the administrators who were not sufficiently knowledgeable to recognize that the research bore no obvious relation to the title. Yet today at the National Institute of Mental Health and Neurological Institutes around the country, basic research on amino acids and proteins, not too much unlike Block's, is prevalent. In this respect the papers included in this volume, though apparently diverse, yet reflect a certain interrelationship well within the scope of Block's general interest and serve as an adequate tribute to his contributions.

JULIUS SCHULTZ,
Secretary

Division of Biological Chemistry,
American Chemical Society

Richard Joseph Block

1906 - 1962

Richard Block and his wife, together with Dr. and Mrs. Jerome A. Uram and 14 other persons, died in a plane crash on February 4, 1962, shortly after leaving Tingo Maria, Peru. The Americans were on a mission sponsored by the National Institutes of Health in connection with the International Program on Nutrition Studies. His untimely death shocked his friends and colleagues, and brought to an abrupt end his active and productive career. The bibliography of his published work, printed on pages xvi through xxiii, will give some idea of the scope of his activities in the past 30 years, during which he collaborated with over 70 scientists. Block left numerous projects "on the fire." Most important of all, he left behind him friends who deeply feel the loss of such a rare human being. This was his greatest achievement.

He was born in Macon, Ga., on May 4, 1906, and received his B.S. in chemistry in 1928 and his Ph.D. in physiological chemistry in 1931 at Yale. While at Yale he received research inspiration, which never left him throughout life, from Professor L. B. Mendel, to whose memory Block remained fiercely loyal. Block was a friend to his friends. While he acknowledged his enemies, he ignored them, not permitting them to affect his way of life or his convictions. To him enemies were like booby traps or dangerous leaks in the roof: They merely required attention of a strictly technical nature.

His heart and mind were in his beloved amino acids and proteins, and among the amino acids those containing sulfur received a great deal of attention from him and his collaborators. In collaboration with R. Jackson, Block was among the first to establish the nutritional role of methionine and to point to the probable pathway of the conversion of its sulfur to that of cysteine. That was accomplished at a time when tracer methodology was only a gleam in the eye of the biochemist, and one's ingenuity and imagination had to be strained to the utmost in order to design and execute experiments which would be next best to a direct demonstration of the convertibility of one metabolite into another.

He studied the synthesis and utilization of sulfur-containing compounds in man, rat, dog, goat, cow, ewe, bacteria, yeasts, cockroach, and algae, constantly being aware that the results are good only as the methods which were employed to obtain them. He devoted a great deal of his time to the development of better and more refined chemical and chromatographic methods for the isolation and determination of amino acids in proteins from a variety of sources, and he had even set up a laboratory in his house for the purpose, where he worked at all hours.

Much time and effort were spent in compiling the analytical and preparative procedures for studying the amino acid composition of proteins of animal and plant origin, which resulted in his first book, "The Determination of the Amino Acids," followed by five more dealing with the amino acid composition of proteins and foods, paper chromatographic and electrophoretic methods, and analytical methods of protein chemistry.

This activity had its practical objective—namely, to establish, in accord with the views of L. B. Mendel and his students, the correlation of the amino acid composition of proteins with their nutritional value. In collaboration with H. H. Mitchell this objective was accomplished.

In 1933 Block proposed the "anlage" hypothesis, which postulates that certain structures of relatively constant composition are common to all the serum proteins. In the last 5 years of his life Block devoted his efforts to further development of this anlage hypothesis, applying more rigorous and newer methods which have become available. Truly, as Max Planck has remarked, scientists never give up their theories, and they appear to give them up only because they die. It would appear that this theory in one form or another, undoubtedly with modifications, deletions, additions, etc., beyond recognition of the original, will be developed further and even, perhaps, linked to the genetic code governing the protein structure and its biological properties.

While engaged in these activities, Block found time and energy to serve as professorial lecturer at New York Medical College; a visiting professor in the Department of Physiology and Biochemistry and an associate member of the Bureau of Biological Research of Rutgers University; chairman of the Sub-Committee on Biological Chemistry of the National Research Council; and a member of the Nutrition Study Section of the National Institutes of Health. He was a member of the American Chemical Society, American Society of Biological Chemists, American Institute of Nutrition, Society for Experimental Biology and Medicine, New York Academy of Sciences, American Institute of Chemists, AAAS, and Sigma Xi.

Block is survived by two daughters, Mrs. Werner Krebser and Mrs. Thomas Montie. Ralph Holman of the University of Minnesota, who was in Lima on a mission similar to that of Block, writes:

I delayed my departure from Lima in order that I could attend the funeral, for I had ascertained from the American Consul the interment was to be in Lima and none of the families would be present. The ceremony was simple and beautiful. Ambassador James Loeb spoke on behalf of the Government and recounted the accomplishments of the deceased and their mission to Latin America. Dr. Orlando Olsesse, President of the Universidad Agraria in Peru, next spoke on behalf of the Peruvians, expressing the gratitude they hold for Drs. Block and Uram in coming to aid in the relief of the nutritional problems of the country. He expressed the grief of the Peruvian scientists in the untimely death of such friends.

A symposium to honor the memory of R. J. Block was organized with the aid of the Division of Biological Chemistry of the American Chemical Society and held in September 1962 in Atlantic City, N. J. The papers presented at this symposium, together with additional contributions from several recognized authorities in their respective fields, are presented in this memorial volume as a tribute to R. J. Block from his friends and colleagues and as a wreath on his lonely grave in a foreign land.

J. A. STEKOL

The Institute for Cancer Research
Philadelphia, Pa.

Bibliography of the Published Work of Richard J. Block

Scientific Papers and Chapters of Books

- (1) The basic amino acids of wool. J. Biol. Chem., 86, 107 (1930). With H. B. Vickery.
- (2) The basic amino acids of silk fibroin. Determination of the basic amino acids yielded by proteins. Ibid., 93, 105 (1931). With H. B. Vickery.
- (3) The basic amino acids of proteins. A chemical relationship between various keratins. Ibid., 93, 113 (1931). With H. B. Vickery.
- (4) Metabolism of cystine and methionine. Science, 74, 414 (1931). With R. W. Jackson.
- (5) The basic amino acids from neurokeratin: Is neurokeratin a true keratin? J. Biol. Chem., 94, 647 (1932).
- (6) The antineuritic vitamin. I. The method of assay, concentration of the vitamin with silver under various conditions, and its solubility in certain organic solvents. Ibid., 94, 765 (1932). With G. R. Cowgill and B. H. Klotz.
- (7) The antineuritic vitamin. II. Removal of impurities by oxidizing agents. Ibid., 96, 127 (1932). With G. R. Cowgill.
- (8) The antineuritic vitamin. III. Removal of impurities by fractional precipitation. Ibid., 97, 421 (1932). With G. R. Cowgill.
- (9) The metabolism of cystine and methionine. Availability of methionine in supplementing a diet deficient in cystine. Ibid., 98, 465 (1932). With R. W. Jackson.
- (10) The antineuritic vitamin. IV. Preparation of a highly potent concentrate. Ibid., 98, 637 (1932). With G. R. Cowgill.
- (11) Studies on vitamin G (B_2). I. Yeast and liver preparations as a source of vitamin G (B_2). Ibid., 103, 643 (1933). With L. R. Farquhar.
- (12) Chemical and immunological investigations on the proteins of the nervous system. Psychiat. Quart., 7, 613 (1933). With E. Brand.
- (13) Metabolism of D- and L- methionine. Proc. Soc. Exptl. Biol. Med., 30, 587 (1933). With R. W. Jackson.
- (14) New type of continuous extractor. J. Biol. Chem., 100, 537 (1933).
- (15) The basic amino acids of keratins. The basic amino acid content of human finger nails and cattle horn. Ibid., 104, 339 (1934).
- (16) The basic amino acids of serum proteins. Ibid., 103, 261 (1933).
- (17) The basic amino acids of serum proteins. II. Effect of heating to 58 degrees. Ibid., 104, 343 (1934).
- (18) The basic amino acids of serum proteins. III. A chemical relationship between serum proteins of various origins. Ibid., 104, 347 (1934). With D. C. Darrow and M. K. Cary.
- (19) The basic amino acids of serum proteins (orosins). IV. A chemical relationship between various avian orosins. A note on some proteins of the egg. Ibid., 105, 455 (1934).
- (20) The antineuritic vitamin. V. Preparation of a vitamin concentrate suitable for parenteral use. Ibid., 105, 463 (1934). With E. H. Stuart and G. R. Cowgill.

- (21) The basic amino acids of three crystalline mammalian hemoglobins. Further evidence for a basic amino acid "anlage" of tissue proteins. Ibid., 105, 663 (1934).
- (22) The effect of dry heat and dilute alkali on the lysine content of casein. Ibid., 105, 667 (1934). With D. B. Jones and C. E. F. Gersdorff.
- (23) The determination of the basic amino acids in small quantities of proteins by the silver precipitation method. Ibid., 106, 457 (1934).
- (24) Nature and origin of proteins. Yale J. Biol. Med., 7, 235 (1935).
- (25) Studies on the vitamin B complex: Further indications for the presence of a third factor. Ibid., 8, 169, (1935). With R. B. Hubbell.
- (26) Basic amino acids of human skin. Proc. Soc. Exptl. Biol. Med., 32, 1574 (1935).
- (27) Cystinuria. IV. Metabolism of homocysteine and homocystine. J. Biol. Chem., 110, 399 (1935). With E. Brand and G. F. Cahill.
- (28) Excretion of follicle-stimulating hormone in urine of mental patients in and past menopause. Proc. Soc. Exptl. Biol. Med., 32, 1576 (1935). With M. M. Harris, E. Brand, and L. E. Hinsie.
- (29) Convenient method for preparation of concentrates of follicle-stimulating hormone from urine. Ibid., 33, 360 (1935). With E. Brand, M. M. Harris, and L. E. Hinsie.
- (30) Does bis-(2-aminoethyl)-disulfide (cystamine) promote growth in the rat limited to an inadequate intake of cystine and methionine? J. Biol. Chem., 113, 135 (1936). With R. W. Jackson.
- (31) Carboxymethylcysteine metabolism, its implications on therapy in cystinuria and on the methionine-cysteine relationship. Proc. Soc. Exptl. Biol. Med., 35, 501 (1936). With E. Brand, B. Kassell, and G. F. Cahill.
- (32) Cystinuria. V. Metabolism of casein and lactalbumin. J. Biol. Chem., 119, 669 (1937). With E. Brand, B. Kassell, and G. F. Cahill.
- (33) Cystinuria. VI. Metabolism of the hydroxy analog of methionine (DL- α -hydroxy- γ -methiobutyric acid.) Ibid., 119, 681, (1937). With E. Brand and G. F. Cahill.
- (34) Cystinuria. VII. Metabolism of S-methylcysteine, of γ -thiobutyric acid, and of γ -dithiobutyric acid. Ibid., 119, 689 (1937). With E. Brand and G. F. Cahill.
- (35) Chemical studies on the neuroproteins. I. Amino acid composition of various mammalian brain proteins. Ibid., 119, 765 (1937).
- (36) Chemical studies on the neuroproteins. II. Effect of age on the amino acid composition of human and mammalian brain proteins. Ibid., 120, 467 (1937).
- (37) The basic amino acids of keratins. Basic amino acid content of porcupine quills and echidna spines. Ibid., 121, 99 (1937). With M. K. Horwitz.
- (38) Chemical studies on the neuroproteins. III. An indication for sex differences in the amino acid composition of primate brain proteins. Ibid., 121, 411 (1937).
- (39) Chemical studies on the neuroproteins. IV. Nature of the proteins of the ectoderm: eukeratins and pseudokeratins. Ibid., 121, 761 (1937).
- (40) Proteins of the nervous system, considered in the light of the prevailing hypotheses on protein structure. Yale J. Biol. Med., 9, 445 (1937).
- (41) Comparative biochemistry of the proteins. Cold Spring Harbor Symp. Quant. Biol. 6, 79 (1938).
- (42) Chemical constitution of the proteins. pp. 278-333 in "The Chemistry of the Amino Acids and Proteins," C. L. A. Schmidt, ed., 1031 pp., Charles C. Thomas, Springfield, Ill., 1938.
- (43) The metabolism of cystine and methionine. II. Availability of D- and L-methionine and their formyl derivatives in the promotion of growth. J. Biol. Chem., 122, 425 (1938). With R. W. Jackson.

- (44) Estimation of histidine. Proc. Soc. Exptl. Biol. Med., 37, 580 (1937).
- (45) The amino acid composition of keratins. Composition of gorgonin, spongin, turtle scutes, and other keratins. J. Biol. Chem., 127, 685 (1939). With D. Bolling.
- (46) The composition of keratins. Amino acid composition of hair, wool, horn, and other eukeratins. Ibid., 128, 181 (1939). With cooperation of D. Bolling, F. C. Brand, and A. Schein.
- (47) Determination of threonine. Proc. Soc. Exptl. Biol. Med., 40, 710 (1939). With D. Bolling.
- (48) Chemical and metabolic studies on phenylalanine. I. Nitration of phenylalanine. J. Biol. Chem., 129, 1 (1939). With D. Bolling.
- (49) Microestimation of threonine. Ibid., 130, 365 (1939). With D. Bolling.
- (50) Microestimation of leucine, isoleucine, and valine. Proc. Soc. Exptl. Biol. Med., 45, 289 (1940). With D. Bolling and A. A. Kondritzer.
- (51) Estimation of histidine. J. Biol. Chem., 133, 67 (1940).
- (52) Basic amino acid content of human serum proteins. Influence of the ingestion of arginine on the composition of the serum proteins. Ibid., 133, 71 (1940).
- (53) Chemical and metabolic studies on phenylalanine. II. Phenylalanine content of the blood and spinal fluid in phenylpyruvic oligophrenia. Ibid., 134, 105 (1940). With G. A. Jervis, D. Bolling, and E. Kanze.
- (54) Chemical and metabolic studies on phenylalanine. III. Amino acid content of tissue proteins of normal and phenylpyruvic oligophrenic individuals. Estimation of phenylalanine. Ibid., 134, 567 (1940). With G. A. Jervis, D. Bolling, and M. Webb.
- (55) New method for separation of the basic amino acids from protein hydrolysates. Proc. Soc. Exptl. Biol. Med., 51, 252 (1942).
- (56) Amino acids yielded by β -lactoglobulin. Arch. Biochem., 2, 93 (1943). With D. Bolling.
- (57) Amino acid yield from various animal and plant proteins after hydrolysis of fat-free tissue. Ibid., 3, 217 (1943). With D. Bolling.
- (58) Essential amino acid requirements of man. Yale J. Biol. Med., 15, 723 (1943).
- (59) The chemical constitution of the proteins. pp. 1089-1103 in "Addendum to the Chemistry of the Amino Acids and Protein Inclusive of Some of the Advances since 1937." C. L. A. Schmidt, ed., Charles C. Thomas, Springfield, Ill., 1943.
- (60) Nutritional opportunities with amino acids. J. Am. Dietet. Assoc., 20, 69 (1944). With D. Bolling.
- (61) Comparative analytical study of meat extension. Ibid., 20, 50 (1944). With D. Melnick, H. W. Himes, and B. L. Oser.
- (62) Essential amino acid distribution in a casein hydrolysate suitable for parenteral injection. Am. J. Pharm., 116, 368 (1944). With D. Bolling.
- (63) Amino acids yielded by yeast, sunflower seed meal, and sesame seed after hydrolysis of the fat-free tissue. Arch. Biochem., 6, 277 (1945). With D. Bolling.
- (64) Constitution of salmin. I. Amino acid composition, Ibid., 6, 419 (1945). With D. Bolling.
- (65) Amino acid composition of food proteins. Advan. Protein Chem., 2, 119 (1945).
- (66) Amino acids yielded by various yeasts after hydrolysis of fat-free material. A comparative investigation. Arch. Biochem., 7, 313 (1945). With D. Bolling.
- (67) Amino acid composition of proteins and foods. Science, 103, 431 (1946). With D. Bolling.

- (68) Amino acids of cataractous and sclerosed human lenses. Arch. Biochem., 10, 277 (1946). With P. W. Salit.
- (69) Effects of baking and toasting on nutritional value of proteins. Ibid., 10, 295 (1946). With P. R. Cannon, R. W. Wissler, C. H. Steffee, R. L. Straube, L. E. Frazier, and R. L. Woolridge.
- (70) Amino acid composition of cow and human milk proteins. Ibid., 10, 359 (1946). With D. Bolling.
- (71) New method for the preparation of basic amino acid concentrates from protein hydrolyzates. Ibid., 11, 235 (1946).
- (72) Chemical and biological properties of tryptic digests of casein and lactalbumin. Ibid., 13, 323 (1947). With D. Bolling and B. F. Chow.
- (73) Isolation and synthesis of the naturally occurring α -amino acids. Chem. Revs., 38, 501 (1946).
- (74) Some relationships between the amino acid contents of proteins and their nutritive values for the rat. J. Biol. Chem., 163, 599 (1946). With H. H. Mitchell.
- (75) Correlation of the amino acid composition of proteins with their nutritive value. Nutrition Abstr. and Rev., 16, 249 (1946). With H. H. Mitchell.
- (76) Detection of sulfur-containing amino acids on paper chromatograms. Science, 108, 506 (1948). With H. M. Winegard and G. Toennies.
- (77) Quantitative estimation of amino acids on paper chromatograms. Ibid., 108, 608 (1948).
- (78) Preparation and amino acid composition of salmon and clupein. Proc. Soc. Exptl. Biol. Med., 70, 494 (1949). With D. Bolling, H. Gershon, and H. A. Sober.
- (79) Quantitative paper chromatography: A simplified procedure. Ibid., 72, 337 (1949).
- (80) Separation of amino acids by ion exchange chromatography. pp. 295-314 in "Ion Exchange Theory and Application," F. C. Nachod, ed., 411 pp., Academic press, Inc., New York, 1949.
- (81) Biological studies on the value of dietary supplements of milk and milk products. J. Am. Dietet. Assoc., 25, 937 (1949).
- (82) Comparative protein chemistry. The composition of the proteins of human teeth and fish scales. J. Dental Res., 28, 518 (1949). With M. K. Horwitt and D. Bolling.
- (83) Paper chromatograms spot amino acids. Two-dimensional microseparation patterns quickly identify them—or other substances—in a mixture. Added tests give concentrations. Food Ind., 22, 824-951 (1950).
- (84) Estimation of amino acids and amines on paper chromatograms. Anal. Chem., 22, 1327 (1950).
- (85) Paper chromatography of amino acids. pp. 181-200 in "Colloid Chemistry; Theoretical and Applied," Vol. 8, J. Alexander, ed., 736 pp., Reinhold, New York, 1950. With H. A. Sober.
- (86) Synthesis of sulfur amino acids from inorganic sulfate by ruminants. Proc. Soc. Exptl. Biol. Med., 73, 391 (1950). With J. A. Stekol.
- (87) Amino acids in posterior pituitary protein. Nature, 165, 975 (1950). With H. B. van Dyke.
- (88) Quantities of amino acids in nonprotein fraction of breast and cow's milk. Arch. Biochem., 25, 350 (1950). With D. Bolling.
- (89) Comparative study on two samples of neurokeratin. Arch. Biochem. Biophys., 31, 266 (1950).
- (90) Some amino acids, peptides, and amines in milk, concentrated milks, and cheese. J. Dairy Sci., 34, 1 (1951).

- (91) Chemical classification of keratins. J. Soc. Cosmetic Chemists, **2**, 235 (1951).
- (92) Synthesis of sulfur amino acids from inorganic sulfate by ruminants. II. Synthesis of cystine and methionine from sodium sulfate by the goat and by the microorganisms of the rumen of the ewe. Arch. Biochem. Biophys., **33**, 353 (1951). With J. A. Stekol and J. K. Loosli.
- (93) The nutrient materials in food, pp. 25-75, in "Food for Life," R. W. Gerard, ed., 306 pp. University of Chicago Press, Chicago, Ill., 1952.
- (94) Amino acids in posterior pituitary protein. Arch. Biochem. Biophys., **36**, 1 (1952). With H. B. van Dyke.
- (95) Effect of heat treatment on the sulfhydryl groups in skim milk and non-fat dry milk. J. Dairy Sci., **36**, 427 (1953). With G. Zweig.
- (96) Studies on bovine whey proteins. I. Preparation of ferric derivatives of whey proteins. Arch. Biochem. Biophys., **47**, 88 (1953). With D. Bolling, K. W. Weiss, and G. Zweig.
- (97) Studies on bovine whey proteins. II. Removal of iron from ferric derivatives of whey proteins. Ibid., **48**, 386 (1954). With G. Zweig.
- (98) Experiments with ion-selective membranes. I. Electrolytic deionization of protein-free whey. J. Dairy Sci., **37**, 932 (1954). With W. H. Winegard.
- (99) Simplified procedure for measuring cellulose digestion by rumen microorganisms. Contribs. Boyce Thompson Inst., **17**, 337 (1954). With R. Henderson and F. E. Hervat.
- (100) Quantitative amino acid composition of the German cockroach, Blattella germanica (L.). Ibid., **17**, 380 (1954). With J. D. Hilchey.
- (101) Studies on bovine whey proteins. IV. Amino acid analyses of crystalline β -lactoglobulins and lactalbumin by quantitative paper chromatography. Arch. Biochem. Biophys., **55**, 315 (1955). With K. W. Weiss.
- (102) Sulfur metabolism of insects. I. Utilization of sulfate for formation of cystine and methionine by the German cockroach, Blattella germanica (L.). Contribs. Boyce Thompson Inst., **18**, 109 (1955). With J. D. Hilchey, L. P. Miller, and R. M. Weed.
- (103) Amino acids. Encyclopedia Americana, **1**, 575 (1955).
- (104) Amino acid composition of southern bean mosaic virus. Contribs. Boyce Thompson Inst., **18**, 371 (1956). With Beatrice S. Magdoff and Diane Block Montie.
- (105) Effect of long-time feeding of a soybean infant food diet to white rats. Ann. Allergy, **14**, 166 (1956). With H. W. Howard, D. W. Anderson, and C. D. Bauer. Bauer.
- (106) Protein requirements of animals including man. Borden's Rev. Nutr. Res., **17**, 75 (1956).
- (107) Effect of supplementing soybean proteins with lysine and other amino acids. A. M. A. J. Diseases Children, **92**, 126 (1956). With D. W. Anderson, H. W. Howard, and C. D. Bauer.
- (108) Comparative study of amino acid composition of commercial samples of a high-protein and a low protein and a low-protein wheat flour. Contribs. Boyce Thompson Inst., **18**, 477 (1957). With R. H. Mandl.
- (109) Pathogenesis of congenital goiter and abnormally high levels of SPI and with mono- and diiodotyrosine in the serum. J. Clin. Endocrinol. Metabolism, **17**, 817 (1957). With S. C. Werner, R. H. Mandl, and A. A. H. Kassenaar.
- (110) Circulating iodoproteins in a nongoitrous adult with primary amenorrhea, body deformities, and normal levels of serum precipitable iodine and thyroidal I^{131} intake. Ibid., **17**, 1141 (1957). With S. C. Werner and R. H. Mandl.
- (111) Nutritive value of bread flour proteins as affected by practical supplementation with lactalbumin, nonfat dry milk solids, soybean proteins, wheat

- gluten, and lysine. J. Nutrition, **64**, 151 (1958). With H. W. Howard, W. J. Monson, and C. D. Bauer.
- (112) Nitrogen requirements of animals and man. Comments on the Folin and Schoenheimer hypotheses. Proc. Intern. Symposium on Enzyme Chem., Tokyo and Kyoto, 1957, 444 (1958).
- (113) Amino acid composition of bread proteins. J. Am. Dietet. Assoc., **34**, 724 (1958). With R. H. Mandl.
- (114) Sulfur metabolism of yeast. I. Study of relative growth of five yeasts on a sulfur-free medium supplemented with small quantities of sulfur compound. Contribs. Boyce Thompson Inst., **19**, 437 (1958). With D. Margolis.
- (115) Amino acid composition of serum proteins. I. Fractionation of bovine serum proteins by ammonium sulfate and comparative amino acid composition of the fractions. Ibid., **19**, 445 (1958). With S. Keller.
- (116) Amino acid composition of the serum proteins. II. Fractionation of human serum proteins by cellulose ion-exchange chromatography and comparative amino acid composition of the fractions. Ibid., **19**, 451 (1958). With S. Keller.
- (117) Method for investigation of the distribution of radiiodine in the serum after small test doses of 131 . Arch. Biochem. Biophys., **73**, 9 (1958).
- (118) Binding of mixtures of iodoamino acids and of inorganic iodide by various serum proteins. Ibid., **75**, 508 (1958). With R. H. Mandl and S. Keller.
- (119) Approximate amino acid composition of wild and hatchery trout (Salvelinus fontinalis) and some of their principal foods (Grammarus and Hexagenia bilineata). Contribs. Boyce Thompson Inst., **20**, 103 (1959).
- (120) Nutritive value of commercial breads. J. Am. Dietet. Assoc., **35**, 345 (1959). With H. W. Howard, W. J. Monson, and C. D. Bauer.
- (121) Methods for qualitative, semiquantitative, and quantitative determination of iodoamino acids and of inorganic iodide in iodoprotein digests and in human serum. Arch. Biochem. Biophys., **81**, 25 (1959). With R. H. Mandl.
- (122) Discrepancy between distribution of iodine in human serum when estimated by iodine-131 and iodine-127. Nature, **183**, 406 (1959). With S. C. Werner.
- (123) Chemical relationship between the protein fractions obtained from fowl serum by cellulose ion-exchange chromatography. Evidence for amino acid "anlage." Arch. Biochem. Biophys., **83**, 426 (1959). With S. Keller and D. W. Meller.
- (124) Amino acid composition of serum proteins. III. Chromatographic isolation of human and bovine serum albumins, and amino acid composition of the fractions. Ibid., **85**, 366 (1959). With S. Keller.
- (125) Separation of Proteins, pp. 1-30 in "A Laboratory Manual of Analytical Methods of Protein Chemistry," Vol. 1, 254 pp., Pergamon Press, London, 1960. With S. Keller.
- (126) Fractionation of proteins by absorption and ion exchange. Part A, pp. 67-87 in "A Laboratory Manual of Analytical Methods of Protein Chemistry," P. Alexander and R. J. Block, eds., Vol. 1, 254 pp., Pergamon Press, London, 1960. With S. Keller.
- (127) Sulfur metabolism of insects. IV. Conversion of inorganic sulfate to organic sulfur compounds in cockroaches. Role of intracellular symbionts. Contribs. Boyce Thompson Inst., **20**, 317 (1960). With S. M. Henry.
- (128) Sulfur metabolism of insects. V. Ability of insects to use sulfate in synthesis of methionine. Ibid., **20**, 363 (1960). With T. H. Haines and S. M. Henry.
- (129) Probable genetic basis for abnormal circulating iodoproteins (butanol-insoluble serum iodine). Study of a family with several hypothyroid members with and without goiter. J. Clin. Endocrinol. Metabolism, **20**, 205 (1960). With S. C. Werner and R. H. Mandl.

- (130) Probable presence of diiodotyrosine and of moniodotyrosine in human serum. Discrepancy between the distribution of iodo compounds when estimated by I^{131} and I^{127} . Arch Biochem. Biophys., 88, 98 (1960). With S. C. Werner, R. H. Mandl, V. V. Row, and I. Radichevich.
- (131) Methods of increasing the nutritive value of foods. B. Addition of amino acids. pp. 508-520 in "Nutritional Evaluation of Food Processing," 612 pp., Robert S. Harris and Harry von Loesecke, eds., 612 pp., Wiley, New York, 1960.
- (132) Dietary protein values. Complete vs. total protein in the evaluation of diets. J. Agr. Food Chem., 8, 486 (1960). With H. W. Howard and C. D. Bauer.
- (133) Amino acid analysis of protein hydrolysates. pp. 1-57 in "A Laboratory Manual of Analytical Methods of Protein Chemistry," P. Alexander and R. J. Block, eds., Vol. 2, 518 pp., Pergamon Press, London, 1960.
- (134) Interrelationships between serum protein fractions isolated by various techniques. Evidence for amino acid anlagen. Contribs. Boyce Thompson Inst., 20, 385 (1960). With S. Keller.
- (135) Sulfur metabolism of insects. VI. Metabolism of the sulfur amino acids and related compounds in the German cockroach, Blatella Germanica (L.). Ibid., 21, 129 (1961). With S. M. Henry.
- (136) Metabolism of the sulfur amino acids and of sulfate in Blatella Germanica. Nature, 191, 392 (1961). With S. M. Henry.
- (137) Curative action of iodine on soybean goiter and the changes in the distribution of iodoamino acids in the serum and in thyroid gland digests. Arch. Biochem. Biophys., 93, 15 (1961). With R. H. Mandl, H. W. Howard, C. D. Bauer, and D. W. Anderson.
- (138) Comment on "Effects of soybean product on thyroid function in humans." pp. 338-339 in "Year Book of Pediatrics, 1960-1961 Series," Gellid, ed., Medical Publishing Co., 1961. With D. W. Anderson and H. W. Howard.
- (139) Chromatography paper. pp. 228-230 in "The Encyclopedia of the Biological Sciences," P. Gray, ed., 1119 pp. Reinhold, New York, 1961.
- (140) Amino acid interrelationships between the various serum proteins obtained by salting out, electrophoresis, and column chromatography. Ann. N. Y. Acad. Sci., 94, 31 (1961).
- (141) Puromycin-induced changes in uredospores of Puccinia sorghi Schw. Science, 134, 739 (1961). With R. C. Staples and R. Syamananda.
- (142) Distribution of I^{131} and I^{127} in sera of patients with nontoxic nodular goiter. In "Advance in Thyroid Research; Trans. of the 4th Internat. Conf. on Goiter, London, 1960," R. Pitt-Rivers, ed., 2 vols. Pergamon Press, London, 1961. With S. C. Werner, I. Radichevich, V. V. Row, and R. H. Mandl.
- (143) Automatic analysis of iodoamino acids in digests of iodinated proteins. Biochem. J., 81, 37P (1961). With R. H. Mandl.
- (144) Sulfur metabolism in algae. I. Synthesis of metabolically inert chloroform-soluble sulfate esters by two chrysomonads and Chlorella pyrenoidesa. J. Protozool., 9, 33 (1962). With T. H. Haines.
- (145) Chromatographic and electrophoretic methods. pp. 165-171 in "The Thyroid," S. C. Werner, ed., 2nd ed., Harper-Hoeber, New York, 1962.

BOOKS

Determination of the Amino Acids. Richard J. Block. 91 pp: Burgess Publishing Co., Minneapolis, Minn., 1938. Revised ed. with Diana Bolling. 58 pp. 1941. Amino Acid Composition of Proteins and Foods. Analytical Methods and Results.