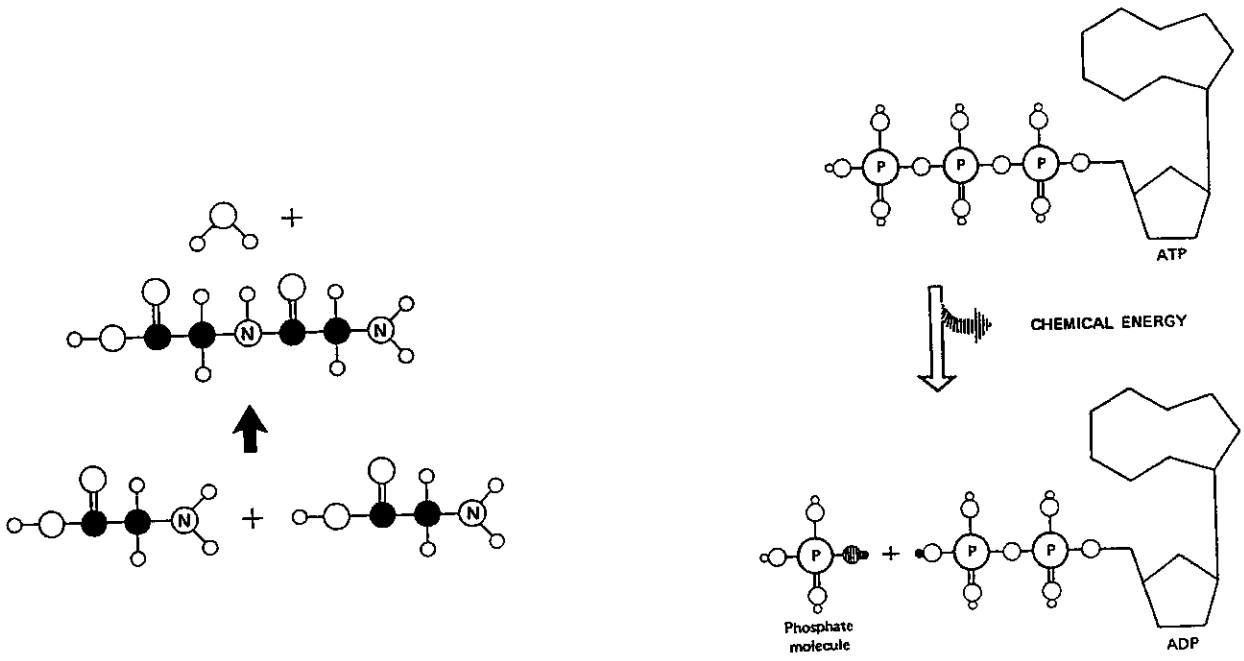
Physiological Chemistry/Biochemistry
The University of Minnesota Medical School
1888-1988

Charles W. Carr
Professor Emeritus
Department of Biochemisty



Minneapolis, Minnesota

October, 1994

Table of Contents

Preface

In 1988 the Minnesota Medical School celebrated its 100th Anniversary. From its beginning the subject matter of Physiological Chemistry/Biochemistry has been a part of its curriculum; however, the organization of the faculty for the teaching and research in this program has gone through several large changes. Because I have been associated with this program for the past 55 years, it has been suggested to me that I write a description of these events. The following is the result of such an effort.

The University of Minnesota Medical School was organized when several proprietary medical schools in the state gave up their charters, and a medical school was then established by the University. The first classes were held in a building in downtown Minneapolis at Sixth Street and Ninth Avenue South. The individual who is generally considered to be the most responsible for the beginning of the Medical School is Dr. Perry Millard, its first Dean. For a comprehensive history of the school, the reader is referred to two histories, one by Dr. J. Arthur Myers and the other by Dr. Leonard Wilson.

In writing this ``history," it was first my intention to put down my recollection primarily of the personnel changes that have occurred during the period of my association with the Department. As I got into the writing, I began to feel that it would be quite incomplete. Having both the time and a newly acquired interest, I have now expanded it to include essentially the entire period of the program at the University.

The first six chapters are a chronological description of the development of the discipline, dealing largely with the individuals involved. For completeness, I have added several more sections: Chapters VII and VIII are a separate history of the graduate program. Chapter IX is a somewhat detailed description of the evolution of the course taught to medical students. (This course, after all, is the *raison d'etre* for the existence of the program.) This chapter also includes descriptions of the courses for the other health science professionals. Chapter X is a description of the growth of space for the program. In Chapter XI are listings of nearly all the graduate students of the program; this includes all recipients of M.S. and Ph.D. degrees and most of the post-doctoral students. Chapter XII includes a chronological listing of the long-term faculty and short-term faculty for the 1888-1988 period.

Much of what is written is a personal memoir or personal recollection of the various events and changes that have taken place during the period 1940-1988. It will suffer from the following: (1) Lack of certain information, (2) Incomplete or inaccurate

memory, and (3) Personal bias. Thus it is not a real history as a professional historian would write it. Much of the remainder of the material that is not a part of my records or my memory has been gleaned from old bulletins that are found in University Archives. It was surprising to me that so much could be put together from this source. I have also made use of information obtained from these five histories: (1) ``The University of Minnesota, 1851-1951'' by James Gray, 1951, (2) ``Masters of Medicine, An Historical Sketch of the College of Medical Sciences, University of Minnesota, 1888-1966'' by J. Arthur Myers, 1968, (3) ``The Development of Physiological Chemistry in the United States'' by Russell Chittenden, 1930, (4) ``From Medical Chemistry to Biochemistry'' by Robert E. Kohler, 1982, (5) ``Medical Revolution in Minnesota, A History of the University of Minnesota Medical School'' by Leonard Wilson, 1989.

For the records of the students, I have made liberal use of American Men and Women of Science, eds. 3-14; Graduate School records of degrees granted; the directory of the Federated American Societies of Experimental Biology; personal inquiries with other faculty members; personnel files from the Departmental office; and my own file of graduate students dating back to 1940. I might also add that I have known personally more than three quarters of these students, and this has been one of the real pleasures of my being in the Department.

Finally I would like to acknowledge with gratitude the assistance of several colleagues. Ms. Barbara Howard has been especially helpful in assembling much of the information concerning the graduate students, and I would like to thank Drs. Leon Singer (dec.), Harry Hogenkamp, Frank Ungar, James Bodley, and Gerald Bratt for reading some parts or all of the manuscript and offering suggestions for improvement. Also the staff of the University Archives has been very helpful in directing me to the sources that they have available, and Dr. Leonard Wilson, Professor of the History of Medicine, has read an earlier version of the manuscript and given helpful advice and encouragement.

Chapter I. Development of the Program - 1888-1914

The University of Minnesota Medical School had its first class in 1888. The course was three years in length, and the students were admitted after they evidenced "possession of a fair degree of preliminary education," which usually meant graduation from high school. From the very beginning there was a solid emphasis on basic science, including chemistry. This is shown in a quote from the first bulletin:

"Laboratory work will be a leading feature of the course in this college. It will include demonstrations in physiology, histology, bacteriology, pathology, chemistry, and urinalysis. In these exercises students will personally participate..... In a word the Faculty will spare no endeavor to put the College upon a plane with the foremost medical institutions in the country."

In the first year of the new curriculum there was a full-year course in chemistry, and it included lectures in general and organic chemistry, and laboratory courses including quantitative analysis, toxicology, and urinalysis. The individual who was responsible for these courses was the Professor of Chemistry, Charles John Bell, who was the first full-time faculty member of the Medical School. Because the teaching of these courses was a full-time job, he was also the first faculty member to receive a salary.

Professor Bell was born in Massachusetts in 1853 and received undergraduate educa-

Students in the College of Medicine and Surgery, ca. 1889. (Photo courtesy of the U. Minn. Archives)

tion at Harvard. He then spent six years in Germany studying with Adolph von Baeyer and August Hofmann. After academic appointments at Penn State and Johns Hopkins Universities, he came to Minnesota in 1888. The chemistry courses for which he was responsible included lectures on medical chemistry; thus Prof. Bell was not only the instructor in chemistry but also to some extent in topics that today could be called physiological chemistry.

Charles J. Bell. (Courtesy of Dr. Leonard Wilson)

The curriculum also had a course in physiology, and, as shown in the textbooks of that time, the course certainly contained topics in physiological chemistry. The Professor of Physiology was Richard Olding Beard, and thus Prof. Beard joins Prof. Bell as being the first instructors in the subject matter of physiological chemistry. Prof. Beard was born in Middlesex England in 1856, and, after coming to this country with his family in 1869, he received the M.D. degree in 1882 at the Northwestern Medical School in Chicago. He then came to Minneapolis to engage in part time private practice, to be Assistant Health Officer of Minneapolis, and to be a member of the Minnesota Hospital College[1].

Prof. Beard was not active in creative scholarship, but for many years he was involved with the administration of the Medical School. He served as secretary of the faculty, a position that appears to be similar to that of assistant or associate dean today. He also served as a consultant in nutritional diseases, and he was the prime mover in the establishment of the School of Nursing in 1909, the first such school on a university campus[2,3].

In 1925 a former medical student had this to say about Prof. Beard with regard to his teaching:

".....After two or more hours in laboratory, we went to the amphitheater on the floor above, where we spent another hour on its straight-backed benches. Here it was that Dr. Beard lectured to us. He was always prompt. Stepping in briskly, he delivered a finished, always polished, discourse on some physiologic topic and then as promptly disappeared. Here was laid the foundation for clinical medicine[4]."

The term, physiological chemistry, had its origins in Europe where there was a gradual change from the older term used in medical

Richard Olding Beard, 1915. (Univ Minn. Archives)

schools, medical chemistry. In the latter part of the 19th century it slowly became apparent that physiological processes could be understood in chemical terms. During this period the teaching of this subject matter gradually evolved from being under the jurisdiction of the chemists to that of the physiologists, and it was not until after the turn of the century that physiological chemistry generally became recognized as a distinct and legitimate subject of its own. Thus the situation at Minnesota in the 1890s reflected the division of responsibilities that existed elsewhere. (See Appendix A concerning the evolution of various names used for this subject).

It should be emphasized here that the coming together of chemistry and medicine was one of the very important events of the last quarter of the nineteenth century. The following is a quotation from a textbook, Elements of Physiological and Pathological Chemistry by T.C. Charles, published in 1884[5].

" Not, indeed, until a close connection was established between chemistry and medicine did any decided advance occur in the latter, and, by its means, the medicine of the future will undoubtedly be still enlightened and extended."

That this was recognized at Minnesota is shown by this statement made by Dr. Justus Ohage to the senior class of the Medical School in May 1894[6]. ``It is important that you continue to study through out your career, for more has been discovered in the last 25 years than in the earlier 2500 years."

In 1892 the Medical School moved onto the campus of the University with the completion of a new building, Medical Hall. According to the 1893 bulletin, the medical curriculum still had the chemistry courses described above. In addition the physiology course was stated to include laboratory and class courses in physiological chemistry. Professors Bell and Beard are still listed as the sole instructors of the subject matter of physiological chemistry.

In addition to the use of one of the well-known texts of the day by M. Foster[7], it also appears that there was available in mimeographed form, the material from the courses being taught by Russell Chittenden at Yale, who had established the foremost laboratory of physiological chemistry in the

country. Harry Parkes Ritchie spent two years studying with Chittenden in 1891-93 and, after obtaining the B.A. degree, came to Minnesota to go to Medical School where his father was on the faculty. (Parkes Ritchie, Professor of Obstetrics, would become the second Dean of the school in 1897). The material from Harry Ritchie's notebooks of the courses at Yale was mimeographed and used as the basic text for physiological chemistry. Thus, the course material used for this subject was as advanced as any in the country.

It is also known that Ritchie participated in the teaching of the subject of physiological chemistry. This information concerning Ritchie's role in the course was obtained from the prefaces of two editions of a textbook published by a later member of the faculty in 1929 and 1936[8]. In addition, it is also stated in his obituary that he ``taught physiological chemistry under Dr. Beard[9].'' This must have helped considerably, for Dr. Beard had had only minimal training in physiological chemistry. There is, however, no listing of Ritchie in the faculty rosters of 1893-96 even as an assistant. When Ritchie finished the M.D. degree in 1896, the rosters show that he became an assistant in Gynecology, and he continued as a clinical instructor in this field and in Surgery for many years.

In 1895 the medical curriculum was expanded to four years, and in 1900 it was further lengthened to six years. In the six-year curriculum general chemistry and quantitative analysis are listed in the first year and organic chemistry, toxicology, and urinalysis in the second year. As before, these courses were taught by the chemistry professor, who was still a member of the medical faculty. In 1895 Hubert C. Carel, a graduate student taking chemistry and physiology became an assistant for Professor Bell in the teaching of medical chemistry. He became an instructor in 1897 and continued to be on the faculty until 1908.

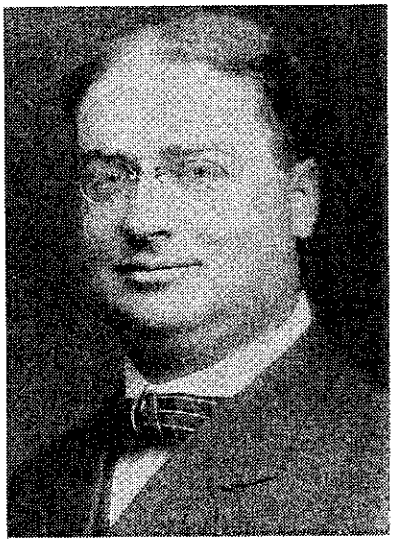
In the six-year curriculum, the physiology courses extended over the third and fourth years, with a course in physiological chemistry and microscopy in the fourth year (chemistry of carbohydrates, fats, and proteins, and the composition of blood, etc.). These courses at that time not only included what physiological chemistry was known but also included pharmacology. The teaching of the physiology courses was still done by Prof. Beard; he was the only listed instructor in the period 1888-98. In 1898-1908 he had the assistance of M. R. Wilcox, Demonstrator in Physiology, 1898-1906, Assistant Professor, 1906-08.

The bulletin for 1910-11 shows very little change in the curriculum from that of 1900. Qualitative analysis and physics were included in the second year; in the third year there were two separate chemistry courses, (1) organic chemistry and (2) toxicology and food analysis. Also in the third year there was a physiology course including some

physiological chemistry, and in the fourth year there was another physiology course which included metabolism and nutrition.

During this period in the early 1900s, appointments to the faculty were made for the first time for specific individuals to teach physiological chemistry, and the first such appointment was Julius Parker Sedgwick. Dr. Sedgwick, who was born in Wrightstown, Wisconsin, in 1876, obtained the B.S. degree at the University of Nebraska in 1896 and the M.D. degree at Rush Medical School in Chicago in 1899. After post-graduate work in Chicago and Berlin, he came to Minnesota and spent two years in Eveleth as a surgeon. He then came to Minneapolis in 1905 to begin a practice in Pediatrics. In 1907 he was appointed as Clinical Assistant in Diseases of Children and Instructor in Physiological Chemistry. He taught in the physiological chemistry courses until 1912 at which time he became a full-time Assistant Professor of Pediatrics. He was a very talented individual, for in 1915 he was appointed as the first Head of the newly established Department of Pediatrics, a position which he held with distinction until he died suddenly in 1922.

Prof. Sedgwick was very active in research. With his strong interest in physiological chemistry, he opened several promising fields for investigation. Among other things he carried out studies on gastric acidity and blood sugar and uric acid levels in newborns, and he introduced dietary innovations in the management of diabetes. Also he hired a chemist, Mildred Ziegler, to carry out the chemical procedures necessary for the research work of the Department. She would stay on in the Department until she retired in 1959. His Department conferred on one its students, Rood Taylor, the world's first degree of Ph.D. in Pediatrics, and with the assistance of Prof. J. C. Litzenberg, he established America's first New Born Clinic under Pediatric supervision[10,11].



Julius Parker Sedgwick, 1909. (Univ Minn. Archives)

In 1908 Frederick H. Scott came to Minnesota as Assistant Professor of Physiology. He was born in Canada and studied at the University of Toronto where he received the M.D. degree in 1904. He carried out graduate research at Toronto, and in 1905 he published a paper in which he concluded that

nerve cells secrete a chemical substance that acts on other cells[12]. Then he went to Europe for study, and while at Cambridge University he published another paper which showed that nerve fibers become fatigued when separated from the neurons[13]. This he attributed to removal of the supply of a stimulating substance from the neuron. Thus Scott foresaw the secretory function of neurons that was clearly demonstrated 15 years later by Otto Loewi[14,15].

Also in 1906-1908 Scott was a co-author of four papers dealing with phosphorus compounds. One of these concerned a reaction for distinguishing phosphoproteins from nucleoproteins[16], and another one was on the transformation in phosphorus compounds in the hen's egg during development[17].

With this background, when Scott came to Minnesota in 1908, he took part in teaching both physiology and physiological chemistry. He was also elected to the American Society for Biological Chemists, the first faculty member of the Department to be in this society. He continued to teach in the physiological chemistry courses until 1912-14 when three new instructors in physiological chemistry joined the faculty. *vide infra.* Scott then spent the rest of his career at Minnesota as a Professor of Physiology[18]. Because of a heavy teaching schedule and little research support, he had no published research from 1908 to 1914. A research paper published in 1915 was in the area of physiology[19], and his research continued to be on physiological topics. Thus he never took up again what appeared to be ground-breaking work in physiological chemistry.

Frederick H. Scott, 1909. (Univ. Minn. Archives)

In 1911 Frederick W. Schlutz was appointed as Instructor in Physiological Chemistry and Pediatrics. Dr. Schlutz was born in Greene, Iowa, in 1880 and received the B.A. degree at Wartburg College in 1898 and the M.D. degree at the University of Maryland in 1902. After several years study in Europe he came to Minnesota in 1911. He taught in the physiological chemistry courses until 1915 at which time he became a full-time member of the new Department of Pediatrics. He became Head of Pediatrics at Minnesota in 1924, and in 1930 he went to the University of Chicago as Head of the Department of Pediatrics. Thus two of the early instructors in physiological chemistry later became heads of departments of pediat-

rics. As determined from Chemical Abstracts they are also the authors of the first research publication to come from the Laboratory of Physiological Chemistry at the University of Minnesota. A paper by J. P. Sedgwick and F. W. Schlutz entitled ``Relationship of Gastric to Pancreatic Fat Digestion in Infants" appeared in 1911 in the American Journal of the Diseases of Children[20]. In that same journal in 1912 there is a paper by F. W. Schlutz entitled ``The Pyrogenic Action of Lactose[21]."

Frederick W. Schlutz. (Univ. Minn. Archives)

In 1911 Robert Gibson, a charter member of the American Society for Biological Chemists, was appointed Assistant Professor of Physiological Chemistry. Dr. Gibson was born in Colorado in 1882 and received his undergraduate and graduate training at Yale, getting the Ph.D. degree in Physiological Chemistry in 1905. His Ph.D. mentor was Lafayette Mendel. Before coming to Minnesota, he had academic positions at the University of Nebraska and then the University of Missouri. He did not stay very long at Minnesota, however, for he left in 1913 to go to the Phillipines to be Professor and Head of Physiology. Then in 1919 he came back to the United States and joined the faculty of the University of Iowa as Assistant Professor of Medicine and Director of the Clinical Laboratory. He later transferred to the Department of Biochemistry at Iowa, and in 1952 he retired. He died in 1959[22].

Prof. Gibson published one paper on research work done while he was at Minnesota. This appeared in 1912 in the Journal of Biological Chemistry and is entitled ``The Nature of the So-Called Artificial Globulin". It deals with the changes in the properties of serum albumin when it is heated, and it is the first paper published in a biochemical journal by a physiological chemistry faculty member[23].

It is interesting to note here that from 1892 to 1911 the Medical School was located in five buildings somewhat north of the present medical campus, in the area just west of Northrop Auditorium. Two of those buildings still remain, one of them being the previously mentioned Medical Hall, which was renamed Millard Hall from 1906 to 1911 at which time it became the Pharmacy Building. In 1942 it was renamed Wulling

Hall in honor of the first dean of the School of Pharmacy. The other remaining building was originally called Laboratory of Medical Sciences and then changed to Wesbrook Hall. The buildings that are now gone were Anatomy, Medical Chemistry Laboratory, and the Institute of Public Health and Pathology.

In 1908 planning was begun to move the Medical School to a new site overlooking the Mississippi River. Money from a private gift and from the legislature led to the construction in 1911 of the first three buildings on what is now the present site. These buildings are the present Millard Hall, the Institute of Anatomy, now Jackson Hall, and Elliot Memorial Hospital. It should be pointed out that when the Flexner Report came out in 1910, Minnesota was already considered to be in the top group of schools in the country with respect to its program and facilities for medical research and education[24]. This was partly because of the new buildings that were being planned.

In 1911 George Vincent succeeded Cyrus Northrop as President of the University. After first reorganizing the Law school, he turned his attention to the Medical School, and early in 1913 he announced that he was going to reorganize the School. This led to a letter of resignation from several faculty members followed by the resignation of the remaining faculty. The Board of Regents then appointed a committee of three faculty members of the Medical School and three alumni to recommend a plan of reorganiza tion and nominations of individuals to b reappointed. Their plan was approved by th Regents, and Vincent proceeded to rehir some of the faculty and also to bring in othe highly qualified individuals from other places The total number of faculty members wa reduced from 184 to 70! It was Presiden Vincent's aim to create a medical school in which both undergraduate and graduate teaching were emphasized and to provide a faculty which was encouraged to and competent to carry out scholarly research[25,26].

Another change occurred in 1913 when Dean Frank Wesbrook resigned in the midst of the reorganization to become President of the University of British Columbia. Vincent then named Elias P. Lyon as the new Dean of the Medical School and Head of the Department of Physiology. Lyon had received his training with Jacques Loeb at the University of Chicago, getting the Ph.D. degree in 1897. He later served as Dean of the Medical School of St. Louis University for seven years before coming to Minnesota.

Shortly before and during the reorganization, three new members were brought into the Physiology Department who were to teach Physiological Chemistry. Chauncey J. Vallette Pettibone came to Minnesota in 1912. He was born in Fond du Lac, Wisconsin and attended the University of Chicago for his Bachelor's degree. He had four different scholarships while at Chicago and graduated with honors in chemistry. He then

studied at the University of Berlin for a year before returning to this country to take up graduate work at Harvard. He was a research assistant for three years with Otto Folin* while completing the Ph.D. degree. He then spent another year in Germany before coming to Minnesota.

Francis Bullard Kingsbury joined the Minnesota faculty in 1913. He was born in Massachusetts in 1886 and obtained both the B.A. and Ph.D. degrees at Harvard, his advisor also being Otto Folin.

In 1914 Jesse Francis McClendon came from Cornell where he had been on the faculty for some time. Jesse McClendon was born in Alabama in 1880 and grew up in Texas. He received the B.S. degree in 1901 and an M.S. degree in 1904 at the University of Texas. He then went to the University of Pennsylvania where he obtained the Ph.D. degree in 1906 with a major in Zoology. In 1906-07 he was on the faculty of Randolph-Macon College, and then in 1907-09 he was an Instructor in Zoology at the University of Missouri. He went to Cornell in 1909 and taught in the Anatomy Department until he came to Minnesota. When he joined the Department of Physiology in 1914, he had already published 44 papers. One of his early accomplishments was the construction of the first micro-manipulator, which he used for studying the development of frogs' eggs[28].

With coming of three new faculty members and a new Department Head in Physiology, Physiological Chemistry was to receive new status. To begin with the primary interest and expertise of the three new faculty members was in physiological chemistry. Secondly, the course for medical students in physiological chemistry was established, separate from the physiology courses. In addition new courses for graduate students were also established including Advanced Physiological Chemistry, Foods and Food Values, and Physical Chemistry of Cells and Tissues. Finally, the Graduate School bulletin stated for the first time that a graduate degree with a major in Physiological Chemistry was possible. Thus 1914 might be said to mark the real beginning of a faculty and curriculum in this subject.

*Otto Folin was born in Sweden and came to Minnesota when he was 15 years old. He obtained the B.S. degree at the Univ. of Minn. and the Ph.D. degree at the Univ. of Chicago. He later joined the Harvard Medical School where he became one of the premier developers of clinical biochemistry[27].

References

1. Beard, R.O. ``The Past of the Medical School of the University of Minnesota" J. Lancet 41 158 (1921); Visscher, M.B. ``The Fiftieth Anniversary of the Medical School of the University of Minnesota" J. Lancet 59 471 (1939)

2. Lyon, E.P. ``Richard Olding Beard, 1856-1936" Minn. Med. 19 683 (1936)

3. Visscher, M.B. ``The Department of Physiology" Univ. Minn. Med. Bull. 36 246 (1965)

4. Myers, J.A. ``Masters of Medicine, An Historical Sketch of the College of Medical Sciences, University of Minnesota, 1888-1966" Warren H. Green, St. Louis, 1968, p. 381-382

5. Charles, T.C. ``Elements of Physiological and Pathological Chemistry" Lea Brothers, Philadelphia, 1884

6. Ohage, J. ``Address to Senior Class" Ariel, May 19, 1894

7. Foster, M. "A Textbood of Physiology" 3rd American Edition, Lea Brothers, Philadelphia, 1885

8. Pettibone, C.J.V. and McClendon, J.F. ``Intermediate Textbook of Physiological Chemistry" 4th ed., 1928, 6th ed., 1936, C. V. Mosby Co., St. Louis

9. Daugherty, L.E., ``Harry Parkes Ritchie, 1873-1942" Minn. Med. 26 208 (1943)

10. Myers' History, p. 571; Stewart, C.A. ``The Development and Progress of Pediatrics in the Northwest" J. Lancet 51 71 (1931)

11. Wilson, L. ``Medical Revolution in Minnesota, A History of the University of Minnesota Medica School" Midewiwin Press, St. Paul, 1989, p. 257

12. Scott, F.H. ``On the Metabolism and Action o Nerve Cells" Brain 28 506 (1905)

13. Scott, F.H. ``On the Relation of Nerve Cells t Fatigue of Their Nerve Fibres" J. Physiol. 34 14 (1906)

14. Loewi, O. ``An Autobiographical Sketch" Perspec Biol. Med. 4 3 (1961)

15. Wilson's History, p. 377

16. Plimmers, R.H. Aders and Scott, F.H. ``A Reactio Distinguishing Phosphoprotein from Nucleoprotei and the Distribution of Phosphorus in Tissues" J Chem. Soc. 1908 1699

17. *ibid.* ``The Transformation of Hen's Egg Durin Development" J. Physiol. 38 247 (1909)

18. Visscher, M.B. ``Dr. Scott, An Appreciation" J Lancet 71 509 (1951); Myers' History, p. 382

19. Scott, F.H. ``The Effect of Isotonic Ringer Solutio on Blood Corpuscles" J. Physiol. 50 128 (1915)

20. Sedgwick, J.P. and Schlutz, F.W. ``Relationship o Gastric to Pancreatic Fat Digestion in Infants" Am J. Dis. Children 2 243 (1911)

21. Schlutz, F.W. ``The Pyrogenic Action of Lactose *ibid.* 3 95 (1912)

22. Berg, P. ``Iowa and Biochemistry" pp. 55,57,58 University of Iowa, Iowa City, 1980

23. Gibson, R.B. ``The Nature of the Artificia Globulin" J. Biol. Chem. 12 61 (1912)

24. Flexner, A. ``Medical Education in the Unite

States and Canada" p. 249, 1910

25. Wangensteen, O.H. ``Our Teachers" J. Med. Educ. 37 698 (1962); Myers, J.A. ``Tommy Bell" Journal Lancet 84 237 (1964); Ref. No. 1

26. Myers' History, pp. 90-92; Wilson's History, pp. 141-156

27. Shaffer, P.A. ``Otto Folin, 1867-1934" Proc. Natl. Acad. Sci., Biog. Mem. 27 47 (1952); Meites, S. ``Otto Folin's Decade in Minnesota, 1882-1892: A Brief Review" Clin. Chem. 28 2173 (1982)

28. McClendon, J.F. ``Experiments on the Eggs *Chaetopterus* and *Asterias* from Which the Chromatin Was Removed" Biol. Bull. 12 141 (1907); Armstrong, W.D., Talk given at dedication of the Jesse F. McLendon Reading Room, Dept. of Biochemistry, 1979; McKinnell, R.G., ``Cloning of Frogs, Mice, and Other Animals" Univ. Minn. Press, 2nd ed., 1985, p. 30

Chapter II. Development of the Program - 1914-1939

Of the three new faculty members in Physiological Chemistry, it is clear that Prof. McClendon was to be the most active in development of the program. Prof. McClendon continued to carry out research at Minnesota, one of his interests at this time being the role of hydrogen ion in biological systems. He was one of the earliest investigators to work in this area, and he constructed his own equipment for these studies. He devised a hydrogen electrode for measuring pH specially for biological systems[1], and it was marketed by A. H. Thomas Co.[2]. He also designed his potentiometer system so that it read directly in pH units, another first for the time. With this equipment he carried out studies which related carbon dioxide tension and carbon dioxide content to blood pH. In the publication of this work he put the Henderson equation into a logarithmic form, the same year that this was done independently by Hasselbalch. Also he included one of the first nomograms which shows the relationship of these three variables[3].

Another interesting study of his concerned the measurement of the pH of the gastrointestinal tract. For measurements in adult humans he devised a hydrogen electrode system that could be swallowed, just like a stomach tube[1]. He used himself as his first subject and later had some of his students swallow the electrode. The electrode could be kept in place for several days while the subjects continued with their normal activities. Among other things this work showed that the pH of the duodenum was more acid than it had previously been believed[4].

Prof. McClendon was also carrying out work on other problems, the breadth of his research interests being shown in this list of papers that appeared in ``Publications of the Faculty" for 1915:

1. ``Acidity Curves in Stomachs and Duodenums of Adults and Infants," Am. J. Physiol. 38, 191 (1915).

2. ``A Direct Reading Potentiometer for Hydrogen Ion Concentration," *ibid.* 186.

3. ``New Hydrogen Electrodes and Rapid Methods of Determination of Hydrogen Ion Concentration" *ibid.* 180.

4. ``Preservation of the Life of the Frog's Egg and Initiation of Development by Increase in Permeability," *ibid.* 163.

5. ``The Action of Anesthetics in Preventing Increase in Cell Permeability," *ibid.* 173.

6. ``Oxidation in the Red Corpuscles of the Goose," *ibid.* 36 4 (1915).

7. ``Oxidizing Power of Hemoglobin", *ibi*d. 366.

8. ``On the Formation of Fats from Proteins," J. Biol. Chem. 21, 269 (1915).

9. ``On the Oxidizing Power of Hemoglobin and Erythrocytes" *ibid.* 275.

10. ``On the Acceleration of the Oxidation of Aluminum by Means of Mercury," Biochem. Bull. 4 96 (1915).

11. ``Differences in the Digestion of Adults and Infants, J. Am. Med. Assn. 65 12 (1915).

12. ``Fertilization and Artificial Parthenogenesis of the Egg", Popular Science Monthly, June 1915, pp. 568-575.

Also in 1917 he had published by the University of Princeton Press a monograph of 240 pages, "The Physical Chemistry of Vital Phenomena[5]. A search of the literature indicates that it is the first monograph published in this country dealing with physical biochemistry. As a result of his research activities, he was a starred scientist in the directory "American Men of Science," indicating that he was in the group of the one thousand most eminent. A most startling aspect of these accomplishments is that he was trained as an invertebrate zoologist. He was largely self-taught in the area of physical chemistry, and let us remember that the concept of pH was not published until after he finished his graduate work.

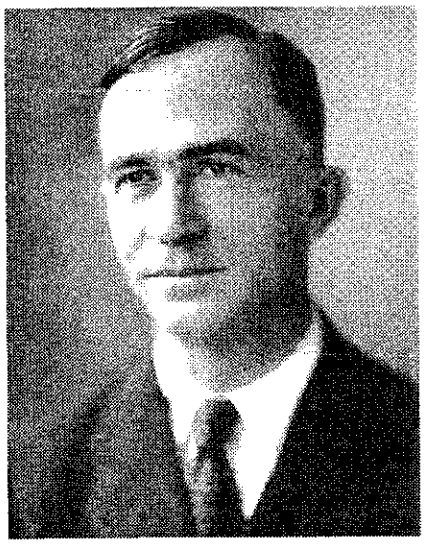
Professor McClendon was on leave of absence during World War I, serving with the Foods and Nutrition Branch of the Medical Corps. During this time there were two different surveys of army recruits, both of which led to much of his work in his later career. In the first survey it was shown that the prevalence of enlarged thyroid glands was considerably greater in recruits coming from states bordering on the Great Lakes and in the Pacific Northwest. The enlarged thyroid glands were diagnosed by the fact these recruits could not button the collar of their uniforms! The incidence of this symptom varied from 27 per 1000 recruits from Idaho to one in 4000 in recruits from Florida[6]. (It was 8 per 1000 in Minnesota).

After the war McClendon made extensive studies of the iodine content of the water and foods grown in these areas and showed that there was a considerably lower iodine content than in other parts of the United States. Using the Army data, McLendon and Hathaway published maps of the United States showing the high correlation between low iodine content and the distribution of goiter*. This led to the concept of a ``goiter belt" which became a strong impetus for the introduction of the use of iodized salt by the general population. The incidence of goiter then dropped dramatically[7].

In a second survey it was discovered that the incidence of dental caries was much lower in recruits from the southwestern states compared with other states, and this

*In Minnesota McClendon showed that there was a lower iodine content in the cabbage grown in the eastern part of the state compared with the western part, and this was correlated with the fact that there were twice as many goiters as in the west.

was inferred by McClendon to be caused by some difference in dietary intake. In 1922 he published an article in which he pointed out the relative hardness of fluoroapatite compared with the normal bone mineral, apatite, and he then speculated that this might be involved with resistance to dental caries[8]. In 1929 when Wallace Armstrong came to Minnesota as a graduate student, he wanted to work on the biosynthesis of choline for his thesis; however, McClendon convinced him that his work should be concerned with the biology of fluoride, especially with respect to fluoride in teeth. Wallace started this project at that time and then spent the rest of his career following it up with great success. ***vide infra.***



Jesse F. McClendon, 1923. (Univ. Minn. Archives)

When Prof. McClendon returned to the Minnesota campus at the end of World War I, the graduate program in Physiological Chemistry was begun in earnest. The graduate program now included the faculty at the Mayo Clinic at Rochester, for in 1917 the state legislature and the Board of Regents agreed that the Mayo faculty could become a part of the Graduate Faculty of the University of Minnesota[9], an arrangement that continued to exist until 1982.

In 1920 there was one member of the Mayo faculty in Biochemistry who was carrying out significant research, Professor Edward C. Kendall. Professor Kendall was born in Norwalk, Connecticut in 1886 and received the B.S. degree in 1906, the M.A. degree in 1908, and the Ph.D. degree in 1910, all at Columbia University. After working at the Parke-Davis Co. and later at the Jewish Hospital in New York City, he came to Rochester in 1914. In that first year at the Mayo Clinic he became the first investigator to isolate thyroxine in a pure form from the thyroid gland[10]. In the early 1920s he carried out important studies on the oxidation-reduction properties of glutathione, and he was the first one to show the correct structure for glutathione[11].

Kendall then turned his attention to the isolation and identification of steroid hormones from the adrenal gland[12]. For this latter work he shared the Nobel Prize in Medicine in 1949 with his colleague, Phillip Hench, and a Swiss scientist, Thaddeus Reichstein. Kendall was a member of the National Academy of Science, and he served as President of the American Society of Biological Chemists in 1925. He was also the advisor for the first student to obtain the

M.S. and Ph.D. degrees in Physiological Chemistry at the University of Minnesota. That student was Arnold Osterberg, who obtained the M.S. in 1921 and the Ph.D. in 1925. (See Appendix B concerning other significant biochemical research being carried out at Rochester in the 1920s by individuals whose appointments were in other areas.)

Edward C. Kendall. (Univ. Minn. Archives)

In 1926 the second Ph.D. degree in Physiological Chemistry was awarded to Arthur Mulder, who did his work with Prof. McClendon. In fact, from the beginning of the program until McClendon left in 1939, there were 15 Ph.D. degrees awarded in Physiological Chemistry, and for all of them the major advisor was either McClendon (10) or Kendall (5). In one case Earle Arnow had a joint advisor with McLendon, Wilhem Stenstrom, a radiologist, who was on the Physiology faculty at that time. There were also 15 M.S. degrees awarded during this time, and McLendon was the advisor for 13 and Kendall the advisor for one.

In addition to teaching medical students and advising graduate students, McClendon also was introducing advanced courses. The Graduate School bulletin of 1920 lists three new courses taught by him: (1) The Physical Chemistry of Vital Substances - osmotic presure, surface tension, electrical conductivity, hydrogen ion activity, (2) Mineral Metabolism, and (3) Vitamines. A more detailed description of the graduate program will be given in Chapters VII and VIII.

In 1919 the course in physiological chemistry for medical students was expanded to two quarters, with the course numbers being 100 and 101, and the credit hours being 12. This two-quarter arrangement and these course numbers have remained the same right up to 1988. The necessary changes in content that have been made throughout the years will be dealt with in more detail in Chapter IX.

In the decade of the 1920s several changes in the faculty occurred. In 1918 Esther Greisheimer, with a fresh Ph.D. in Physiology from the University of Chicago, had come to Minnesota to go to medical school and be Instructor in Physiology. She was a native of Pennsylvania and got her B.A. at Ohio University and M.S. at Clark University. She received the M.D. degree at Minnesota in 1923.

Although she was trained as a physiologist, she participated in teaching not only

in the physiology courses but also in the physiological chemistry course for medical students and the physiological chemistry course for nursing and dental hygiene students. She wrote the laboratory manual that was used in that latter course, ``Physiological Chemistry and Physiology for Nurses, Laboratory Manual[13].''

Esther M. Greisheimer. (Univ. Minn. Archives)

Prof. Greisheimer carried out a great deal of research while she was Minnesota, for she published more than 40 papers in the period 1921-1935. Most of this work dealt with two general areas: (1) Studies on the levels of many of the major blood constituents in normal subjects and in subjects with some abnormal condition[14], and (2) Studies on the effect of certain diets on the formation of liver glycogen[15]. If it is assumed that this work could be classified more closely with physiological chemistry than physiology, then she would be the second most prolific researcher in the program during this period.

Dr. Greisheimer was appointed Assistant Professor of Physiology in 1922 and Associate Professor in 1931. In 1935 she went to Womens' Medical College in Philadelphia as Professor and Head of Physiology, and in 1944 she became Professor of Physiology at Temple Medical School, the position from which she retired in 1968. In 1980 she was elected to the Ohio Women's Hall of Fame. She died in 1982 at the age of 90[16].

In 1923 Prof. Kingsbury resigned to take a position as Chemist in charge of the Biochemical Laboratories of the Metropolitan Life Insurance Company. (Kingsbury's Ph.D. mentor, Otto Folin, had been a long-time consultant for the Company.) Prof. Kingsbury contributed a great deal to the teaching and service function of the program, and his research activities led to the publication of at least ten papers. In collaboration with Prof. E. T. Bell of the Pathology Department, he showed that the conversion of benzoate to hippuric acid in the body did not occur in the kidneys as it had previously been thought[17]. Prof. Kingsbury then went on to demonstrate that this conversion of benzoate to hippuric acid and the rapid excretion of hippuric acid could be used as a test for renal function[18].

A tragic loss from the faculty occurred with the death of Professor Pettibone by suicide in 1929. One morning Dean Lyon received a note from Pettibone in which he

said that he had been in bad health and that he could not sleep at night. When Dean Lyon went to his apartment, he found that Pettibone had taken his life by gas poisoning the night before[19].

Francis B. Kingsbury. (Univ. Minn. Archives)

In his obituary it is stated that Prof. Pettibone was a very personable individual and that he easily won the confidence of students. This was especially valuable to the University, for he not only taught in all of the physiological chemistry courses, but he also served as advisor for the pre-medical students and the freshmen medical students for many years[20].

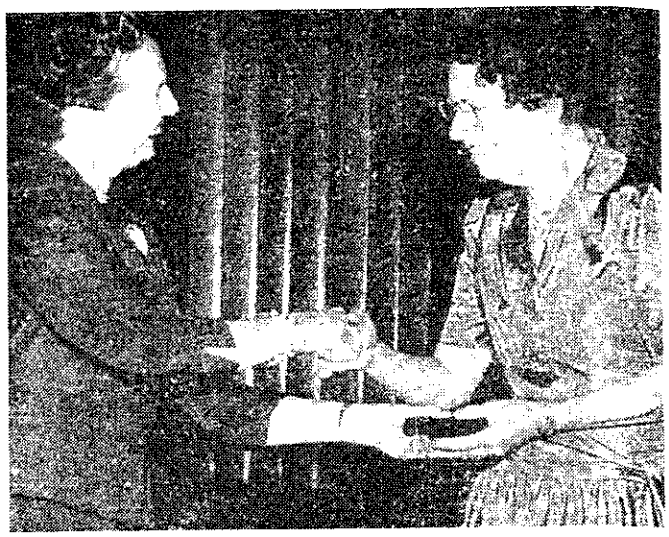
He had very little research published, however, for I have found reference to only four papers, two in 1915, one in 1916, and one in 1922. Two of these, in collaboration with Prof. Schlutz, *vide supra*, were studies of the non-protein nitrogen and amino acids in the blood of children[21]; another, in collaboration with Prof. Cornelia Kennedy of Agricultural Biochemistry, was entitled ``Translocation of Protein Reserves in the Growing Corn Seedling[22];" the fourth was a review of the vitamins[23]. In 1918 he published a textbook, ``Physiological Chemistry," and the second edition came out in 1922 and the third in 1926[24]. He died before the fourth edition could be finished, but it was completed by Prof. McClendon and published in 1930.

Chauncey J. V. "Jack" Pettibone. (Univ. Minn. Archives)

In 1924 Grace Medes joined the faculty. Dr. Medes, who was born in Keokuk, Iowa, in 1882, obtained the B.A. degree at the University of Kansas in 1904 and the Ph.D. degree at Bryn Mawr in 1916. After teaching at Vassar and Wellesley, she came to the University of Minnesota as Assistant Professor of Physiological Chemistry.

Before coming to Minnesota, she had already collaborated with Prof. McClendon with two publications dealing with the effects of anesthetics on living cells. This work was carried out at the Marine Laboratory of the Carnegie Institute of Washington on the Dry Tortugas Islands near Key West Florida[25]. In 1925 she was a co-author with McClendon of the monograph, ``Physical Chemistry in Biology and Medicine[26]."

In 1926 Dr. Medes became the Head of the research laboratory in the Department of Medicine at the University of Minnesota while maintaining her appointment in the Physiology Department. She was the author of numerous papers concerning her research in the Medicine Department. The most significant, undoubtedly, was the discovery of a disease which is an inborn error of the metabolism of tyrosine. A male patient who was first admitted to Minneapolis General Hospital and later to the University Hospital in 1927 was diagnosed as having myasthenia gravis. Follow up studies in which urine analyses were made failed to support the diagnosis. Dr. Medes then made extensive metabolic studies and showed that tyrosine breakdown stopped at the level of p-hydroxy-phenyl pyruvic acid. Homogentisic acid, on the other hand, was completely metabolized by the individual. Thus it was clearly different from phenyl ketonuria. In her definitive paper concerning this case in the Biochemical Journal she coined the term ``tyrosinosis" to describe the condition[27].



Grace Medes, right, receiving the Garvan Medal[30]

For the next twenty five years no other cases were reported of a disorder like this. Since 1957, however, many cases called tyrosinosis have been found in several places in the world, including Sweden, Norway, India, Japan, and Canada. They are very much like this first one in their biochemical aspects but are quite different in etiology and prognosis. Nevertheless, it was stated in a review published in 1963, ``The procedure used by Grace Medes in investigating her unique case has served as a model for work on any of these disorders of tyrosine metabolism[28]." In 1930 she was awarded the $250 prize of the Minnesota Society of Internal Medicine for this work[29].

Dr. Medes left the University in 1932 to become Head of the Department of Metabolic Chemistry at the Lankenau Hospital Research Institute in Philadelphia. Here she carried on significant research in cysteine metabolism, acetyl Coenzyme A, and later,

isotope tracer studies when the Lankenau Institute merged with the Institute for Cancer Research. In 1955 she was awarded the Garvan Medal by the American Chemical Society for being an outstanding woman chemist[30]. Her pioneering contribution to the knowledge of tyrosinosis was recognized by a symposium in her honor in June, 1965, in Oslo, Norway. She died in 1968 at the age of 86[31].

In 1926 Truman Pascoe became a teaching assistant and later an instructor in Physiological Chemistry while he was completing a Ph.D. degree in Agricultural Biochemistry. In 1930 Dr. Pascoe joined the Nekoosa-Edwards Paper Co. where he worked as Technical Director until 1953. He then went to the Port Edwards Paper Co. as Research Director until 1962 when he went to Western Michigan University in Kalamazoo as Assistant Professor in the Department of Paper Technology, a position from which he retired in the late sixties.

In 1929 Allan Hemingway joined the Physiology Department as an Assistant Professor in Physiological Chemistry. He was born in Leeds, England, in 1902 and came to Canada and obtained a B.A. degree at the University of British Columbia in 1925. He then came to Minnesota and received a Ph.D. in 1929 with a major in Physics and minor in Mathematics, his advisor being Prof. Stenstrom, who, as previously mentioned, was on the Physiology faculty. With

Allan Hemingway. (Univ. Minn. Archives)

this strong background in physical science, he became a teacher and researcher in Physiology and Physiological Chemistry.

Prof. Hemingway was quite active in the teaching and research program of Physiological Chemistry. As a graduate student he had been an assistant for Prof. McClendon, and in the early 1930s he continued to work with McClendon on research in the area of biophysics, especially on the electrical conductivity of biological materials. For this work they built a high frequency conductivity apparatus that almost filled a room[32]. (In a paper describing this work, Prof. McClendon states, "I took a course in radio-engineering and spent seven years in improving a Wheatstone bridge for high frequency measurements[33].") Prof. Hemingway also published some work on improvements in the use of the glass electrode and on the use of diathermy as a therapeutic procedure[34].

In 1930 Jesse Cavett also became a member of the faculty as Instructor. He came here from the University of Iowa where he had just completed his Ph.D., working with Robert Gibson, who, as previously mentioned, had been at Minnesota in 1911-1913. Dr. Cavett stayed until 1937 when he left to join Dr. Salisbury's Laboratory in Charles City, Iowa, where he had the position of Biochemist. During his stay at Minnesota, Cavett had at least seven research publications. Four were concerned with clinical biochemistry[35], and three were collaborations with McClendon involving studies on thyroid hormone[36].

In the 1930s Prof. McClendon continued to lead the program in Physiological Chemistry; however it was still only a program within the Department of Physiology. McClendon, although not named as such, since 1920 was essentially *de facto* Director of Physiological Chemistry within the Department of Physiology.

Those faculty members who were called physiological chemists taught courses in physiological chemistry and carried out research in this field, but the program had no independent status. The Head of the Physiology Department, Elias P. Lyon, was also the Dean of the Medical School, and it has been surmised that he gave less attention to his own department than to the other Medical School departments not only because of the press of other duties but also because he did not want to show favoritism for his own department[37].

Meanwhile, at other medical schools in the United States, more attention and facilities were accorded to Biochemistry. In the first quarter of this century, the establishment of independent departments of biochemistry in medical schools was the rule, and thus Minnesota was an exception. By 1925, for example, a partial list of schools with separate Departments of Biochemistry included Yale, Harvard, Johns Hopkins, Columbia, Michigan, Chicago, Wisconsin, Cincinnati, Washington (St. Louis), and California (Berkeley). In addition during this time, there was a flourishing Department of Agricultural Biochemistry at Minnesota on the St. Paul campus. Thus it is perhaps not surprising that the science historian, Robert E. Kohler, in his book, ``From Medical Chemistry to Biochemistry," should write that by 1930 at Minnesota ``physiological chemistry steadily eroded until it finally was a scandal both in the University and in the profession[38]." (For a retrospective on this period, see Appendix C).

It is interesting to note here that the Minnesota Medical School was for many years a leader in introducing teaching programs in new areas. For example, the first Nursing School at a university was established here in 1909; the introduction of the internship year originated here in 1911, and the first four-year course in Medical Technology was begun here in 1922. Unfortu-

iately, Physiological Chemistry was not to enjoy such attention.

Changes in the situation with respect to Physiological Chemistry came about but only slowly. Three of Prof. McClendon's graduate students, who were all very competent, were appointed as Instructors when they finished their degrees. These were Robert Hamilton, Wallace Armstrong, and L. Earle Arnow. Hamilton became an instructor in 1933, Armstrong in 1934, and Arnow in 1935; however, Hamilton left in 1935 for a position at Temple Medical School. He became Head of their Biochemistry Department in 1944 and retired from that position in 1969. Armstrong and Arnow remained at Minnesota during the remainder of the 1930s.

A large effort was made in 1930 by some of the Medical School faculty to oust Dean Lyon, but he had strong support of some faculty members and especially President Coffman and Guy Stanton Ford, Dean of the Graduate School. Nevertheless, a major change in administration occurred in 1932 when the College of Medical Sciences was formed to include the Medical School, the School of Nursing, and the Hospital, and Richard Scammon came back from the University of Chicago to be Dean of the new College. Prof. Lyon remained in charge of the Medical School but with reduced responsibilities[39]. He retired from the University and as Head of Physiology in 1936, and he died in 1938.

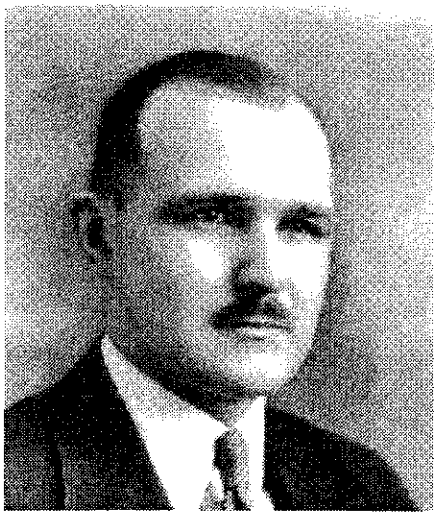
Dean Elias P. Lyon. (Univ. Minn. Archives)

All through his tenure as Dean, Prof. Lyon was subjected to many criticisms. Although he did not originate it, he had to administer much of the reorganization that occurred in 1913, and many of the faculty were unhappy about it. In addition he backed the Mayo affiliation in 1917 which was opposed by many Twin City physicians; also he was the Dean of a Medical School without an M.D. degree.

Nevertheless, he rode out these difficult times with equanimity and great strength of character. Physiology and physiological chemistry did not prosper greatly during Dean Lyon's tenure, but the Medical School as a whole achieved a first class ranking. It is my opinion from what I have read and heard, that the achievements of the Medical School in the 1920s and 1930s were in large part the result of his courageous and far-seeing administration[40].

In 1935 Harold Diehl was named Dean of the College of Medical Sciences and of

the Medical School, and one of his first actions was to appoint Maurice Visscher to succeed Lyon as Department Head in Physiology. Prof. Visscher was born in Michigan in 1901, and he obtained the Ph.D. degree in Physiology at Minnesota in 1925 with Frederick Scott as his advisor. He then spent a year of post-doctoral work with Prof. Starling in London and then returned to this country for another year of research with Prof. A. J. Carlson at the University of Chicago. Then followed academic appointments at the University of Tennessee and the University of Southern California for four years. In 1931 he became the Head of the Department Physiology at the University of Illinois, the position he held until coming back to Minnesota in 1936.



Maurice B. Visscher, ca. 1940. (Univ. Minn. Archives)

One of Prof. Visscher's primary tasks was to strengthen Physiological Chemistry. Thus, when he came, the first thing that he did was to take over the administration of the entire Department. He made his first new appointment to the faculty in Physiological Chemistry in 1937 when Leo Samuels came here as Assistant Professor.

Prof. Samuel's research specialty was in the relatively new and rapidly growing field of steroid biochemistry. Samuels was born in Indiana in 1899, he received the B.A. degree at Emmanuel College in 1925, and then he obtained a Ph.D. in Biochemistry at the University of Chicago in 1930. He served as Director of the White Memorial Hospital Research Laboratories in Los Angeles from 1930 to 1934. In 1934 he received an academic appointment at the University of Southern California where he stayed until he came to Minnesota.

Dean Lyon, as Head of the Physiology Department, had given McClendon essentially full responsibility for Physological Chemistry for many years, and when Visscher took over the administration of Physiological Chemistry, McClendon was not very happy. At this time the University administration was not happy with McClendon either, and President Ford asked him to resign. The records show that McClendon, while being a very prolific researcher, was not very well received as a lecturer by the medical and dental students, and he had had some difficulties in dealing with his faculty members. From the many stories and anecdotes that I heard about him after I came to Millard Hall in late 1939, it seemed to me that McClendon was a real ``character'' and

somewhat eccentric. Former students were still telling "McClendon stories" in 1988. With Dr. Visscher's help, it was arranged that McClendon could accept a position as Research Professor at Hahneman Medical School in Philadelphia[41].

While at Minnesota, McClendon published 170 papers and 6 books. (See Appendix D). In addition to his own record of research, another measure of his contributions is the record of his students. The following shows that most of McClendon's students had distinguished careers. Arthur Mulder (Ph.D. 1926) was Professor of Physiology at the University of Tennessee for 20 years and Professor of Physiology at the Stritch Medical School in Chicago for seven years. Raymond Gregory (Ph.D. 1927, M.D. 1929) was Professor and Head at the Department of Internal Medicine of the University of Texas Medical School in Houston. Wallace Armstrong (Ph.D. 1932, M.D. 1937) was Head of the Department of Biochemistry at the University of Minnesota Medical School from 1946 to 1974. Robert Hamilton (Ph.D.1933) was Head of the Department of Biochemistry at Temple Medical School from 1944 to 1971. L. Earle Arnow (Ph.D. 1934, M.D. 1940) was Research Director in two different pharmaceutical companies and later was President of the Warner-Lambert Research Institute and Vice President of the Warner-Lambert Company. Harold Lundgren (Ph.D. 1935) served as Chief of two different divisions at the Western Regional Laboratories of the U. S. Department of Agriculture from 1953 to 1974. William Stone was Professor of Physiology at the University of Wisconsin Medical School from 1947 until he retired.

At Hahneman Prof. McClendon continued his work, primarily in the area of iodine and fluorine metabolism. From 1939 until he retired from that position in 1954 he published some 34 papers. He continued with research work at Albert Einstein Medical School until 1962, publishing another 16 papers, and after 1962 he continued with private research. In 1965 in collaboration with Dr. Blaustein of the Booth Memorial Hospital, Flushing, N. Y., it was shown that rats with severe osteoporosis could be cured with calcium supplements in their diets[42]. Thus at the age of 85, he was still publishing meaningful research. Prof. McClendon died in 1976 at the age of 96. With his leaving Minnesota in 1939, an era encompassing 25 years in the program of Physiological Chemistry came to an end.

References

1. McClendon, J.F. ``New Hydrogen Electrodes and Rapid Methods of Determination of H-Ion Concentration" Am. J. Physiol. 38 180 (1915)

2. Arnow, L.E., Letter written at the time of the dedication of the Jesse F. McClendon Reading Room, 1979

3. McClendon, J.F., Shedlov, A., and Thomson, W. ``Tables for Finding Alkaline Reserve of Blood Serum in Health and in Acidosis from Total Carbon Dioxide or the Alveolar Carbon Dioxide or pH at Known Carbon Dioxide Tension" J. Biol. Chem. 31 519 (1917)

4. McClendon, J,F. ``Acidity Curves in the Stomach and Duodenum of Adults and Infants Plotted with the Aid of Improved Methods of Measuring Hydrogen Ion Concentration" Am. J. Physiol. 38 191 (1915)

5. McClendon, J.F. ``The Physical Chemistry of Vital Phenomena" Univ. of Princeton Press, 1917, 240 pp.

6. Davis and Love ``Defects Found in Drafted Men" War Department, Washington, D.C., 1920; McClendon, J.F. ``Iodine and the Incidence of Goiter" Univ. of Minnesota Press, 1939, p. 4

7. McClendon, J.F. and Hathaway, J.C. ``Inverse Relationship between Iodine in Food and Drink and Goiter, Simple and Exophthalmic" J. Am. Med. Assoc. 82 1668 (1924); McClendon, J.F. ``Distribution of Iodine with Special Reference to Goiter" Physiol. Revs. 7 189 (1927); McClendon, J.F. ``Iodine and the Incidence of Goiter" Univ. of Minnesota Press, 1939, p. 59

8. McClendon, J.F. ``Rock Products in the Diet. III. Fluorine in the Diet. IV. Apatite for Teeth and Bones" Rock Products 26 27 (1923)

9. Wilson's History, pp. 159-212

10. Kendall, E.C. ``Isolation in Crystalline Form of the Compound Containing Iodine Which Occurs in the Thyroid, Its Chemical Nature and Physiological Activity" Trans. Assoc. Am. Physicians 30 420 (1915); *ibid.* ``Thyroid Secretion" Harvey Lectures, Ser.15 40 (1919-20)

11. Kendall, E.C., McKenzie, B.F., and Mason, H.L. ``A Study of Glutathione. I. Its Preparation in Crystalline Form and Its Identification" J. Biol. Chem. 84 657 (1929)

12. Kendall, E.C., Mason, H.L., Hoehn, W.M., and McKenzie, B.F. ``Studies in the Chemistry of the Suprarenal Cortex. The Structure and Physiological Activity of Compound B: Its Relation to Compound A and Reichstein's Corticosterone" Proc. Staff Meetings Mayo Clinic 12 136 (1937); Mason, H.S., Hoehn, W.M., McKenzie, B.F., and Kendall, E.C. ``Chemical Studies of the Suprarenal Cortex. III. The Structures of Compounds A, B, and H" J. Biol. Chem. 120 (1937); Kendall, E.C. ``Hormones of the Adrenal Cortex" Endocrinology 30 853 (1942)

13. Greisheimer, E.M. ``Physiological Chemistry and Physiology for Nurses, Laboratory Manual" Mimeographed, Univ. of Minnesota

14. e. g., Greisheimer, E.M., and Van Winkle, C.C. ``Plasma Calcium in Tuberculosis Adults" Ann. Rev. Tuberculosis 15 270 (1927); Holt, G. Watterman and Greisheimer, E.M. ``Individual Variation in Fasting Blood Sugar" Proc. Soc. Exptl. Biol. Med.

764 (1931); Greisheimer, E.M. and Arny, F.P. ariation in Certain Constituents of the Blood of atively Normal Individuals" J. Lab. Clin. Med. 18) (1933)

e.g., Greisheimer, E.M. ``Glycogen Formation in ats. V. Carbohydrate-Free Diets" J. Nutrit. 4 411 931)

In Memoriam, Univ. Minn. Med. Bull., Summer)82; Univ. Minn. Alum. Weekly, 81 (7) 53 (1982)

Kingsbury, F.C. and Bell, E.T. ``The Synthesis of ippuric Acid in Nephrectomized Dogs" J. Biol. hem. 21 297 (1915)

Kingsbury, F.C. ``The Benzoate Test for Renal unction" Proc. Soc. Exptl. Biol. Med. 55 21 (1923); *ibid.* ``The Benzoate Test for Renal Function II." rch. Int. Med. 32 175 (1923

Univ. Minnesota Alumni Weekly, 1928-29, p. 438

. Senate Minutes, 1929, Obit. for C.J.V. Pettibone

. Pettibone, C.J.V. and Schlutz, F.W. ``Quantitative )etermination of Non-Protein Nitrogen in Blood of he New Born" Am. J. Dis. Children 10 206 (1915); *ibid.* ``Amino Acid Nitrogen in the Systemic Blood f Children in Health and Disease" J. Am. Med. ssoc. 67 262 (1916)

Pettibone, C.J.V. and Kennedy, C. ``Translocation Protein Reserves in the Growing Corn Seedling" Biol. Chem. 26 519 (1916)

Pettibone, C.J.V. ``The Vitamines, A Review" urnal Lancet 42 288 (1922)

Pettibone. C.J.V. ``Physiological Chemistry" C. V. sby Co., St. Louis, 3 editions, 1918, 1922, 1926.

25. Medes, G. and McClendon, J.F. ``The Effects of Anesthetics on Living Cells" Proc. Natl. Acad. Sci. 6 243 (1920); *ibid.* ``Effect of Anesthetics on Various Cell Activities" J. Biol. Chem. 42 541 (1920)

26. McClendon, J.F. and Medes, G. ``Physical Chemistry in Biology and Medicine" W.B. Saunders Co., New York, 1925, 425 pp.

27. Medes, G. ``A New Error of Tyrosine Metabolism: Tyrosinosis, The Intermediary Metabolism of Tyrosine and Phenylalanine" Biochem. J. 24 917 (1932)

28. Woolf, L.I. ``Phenylalanine and Tyrosine Metabolism" Adv. Clin. Med. 6 97 1963)

29. Anon.,, Univ. Minnesota Alumni Weekly 30 483 (1930)

30. Anon.., Chem. Eng. News 32 3825, 3826 (1955); *ibid.* 33 1515

31. *ibid.*, 46 (10) 68 (1968)

32. Hemingway, A. and McClendon, J.F. ``An AC Wheatstone Bridge for Audio- and Radiofrequency Measurements" Physics 2 393 (1932); *ibid.* ``The High Frequency Resistance of Human Tissue" Am. J. Physiol. 102 56 (1932)

33. McClendon, J.F. ``Electric Impedance and Permeability of Living Cells" Science 84 184 (1936)

34. e.g., Hemingway, A. ``A Direct-Reading pH Meter for Glass, Quinhydrone, and Hydrogen Electrodes" Ind. Eng. Chem., Anal. Ed. 7 203 (1935); Hemingway, A. ``Heat Production in Diathermy Treatments" Radiology 22 84 (1934)

35. Cavett, J. and Holdridge, C. ``A New Plasma Chloride Method'' J. Lab. Clin. Med. 18 944 (1933); Cavett, J. ``The Determination of Alcohol in Blo*od''* ibid. 23 543 (1938)

36. Cavett, J., Rice, C., and McClendon, J.F. ``Is the High Basal Metabolism Rate in Hyperthyroidism Due to Thyroxine?'' Science 80 19 (1934)

37. Zarkin, D.A. ``Visiting Dr. Maurice B. Visscher'' Univ. Minn. Med. Bull., Spring 1982, p. 2

38. Kohler, R.E. ``From Medical Chemistry to Biochemistry'' Cambridge University Press, Cambridge, 1982, p. 190

39. Wilson's History, p. 305

40. ``Elias Potter Lyon, Minnesota's Leader in Medical Education'' Collected Essays, O.H. Wangensteen, ed., Warren H. Green, Inc., St. Louis, 1981; See also ref. No. 25, Chap. I

41. Department of Physiology Files for J.F. McClendon; Wilson's History, p. 400

42. McClendon, J.F. and Blaustein, A. ``Reversal of Osteoporosis in Lactating Female Rats by Tricalcium Phosphate'' Nature *205 95 (1965)*

Chapter III. Development of the Program - 1939-1946

After Prof. McClendon left the University in 1939, it was realized that it was necessary to give Physiological Chemistry greater independence, but the University administration was not yet ready to accord it departmental status. It did, however, establish a formal division of Physiological Chemistry within the Physiology Department, and Professor George Burr was appointed as the Director in 1940.

George Burr was born in Arkansas in 1896 and obtained a B.A. at Hendrix College in 1916 and a Master's degree at the University of Arkansas in 1920. He then came to Minnesota as a graduate student in Prof. Ross Gortner's laboratory on the St. Paul campus and received his Ph.D. in Agricultural Biochemistry in 1922. During the summers while in Graduate School, he worked in the Utah and Arizona deserts with Prof. J. Arthur Harris on a study of plant distribution and plant saps as affected by soil condition and climate[1]. (Prof. Harris was a biometrician and secondarily a plant physiologist with the Carnegie Institute in Washington, D.C.)

After Burr obtained the Ph.D., he went to the University of California, Berkeley, where he worked in Professor Herbert Evans' laboratory. Vitamin E had recently been discovered there, and he worked with that group in its effort to determine its identity. (While at Berkeley, Burr married his co-worker, Mildred Lawson.) The work that was carried out there resulted in several publications, and Burr is credited with contributing to the discovery of Vitamin E[2].

George O. Burr. (Univ. Minn. Archives)

In 1927 Burr was offered a position at Minnesota as Assistant Professor of Plant Physiology. J. Arthur Harris was now Head of the Botany Department, and he was quite impressed with Burr's earlier work with him. After a considerable period of negotiation, Burr agreed to come back to Minnesota, and he joined the Department in September, 1928[3]. Harris told Burr that he did not care

what he worked on just as long as it was good. Later one of Burr's colleagues would say this about Burr's being in the Department: ''Burr was not a botanist -- and was often puzzled about identities of whole plants. But when function was divorced from form and became an intricate problem in biochemistry, he was very much at home[4].'' It would also became recognized later that the appointment of Burr was one of the real successes of Harris' administration[3].

At Berkeley, Burr had become convinced that the dietary fats had some function other than to supply calories. At Minnesota he and his wife, Mildred, continued their studies on rats using the fat-free diets that had been used in the Vitamin E studies. They had also brought two cages of Long-Evans rats from California because they thought that strain would stand the colder Minnesota climate better than the Wistar strain being used in Minnesota. The animals for this study were housed on the fourth floor of the Anatomy building through the cooperation of the Head of the Anatomy Department, Professor Jackson, who was making anatomical studies of rats on fat-free diets. Thus we have the Botany Department with a biometrician as Head hiring a biochemist to do research in the Anatomy Department!

It was during the next two years that the Burrs discovered the essential fatty acids (EFA). They showed that rats fed on the fat-free diets developed very scaly skin and tails, and this was soon followed by severe pathology of the kidney and cessation of growth. In 1929 they published a paper which showed that these symptoms were caused by a deficiency of fatty acids[5]. In a paper the next year they showed that linoleic acid specifically and possibly other unsaturated fatty acids were responsible for the deficiency symptoms[6]. At that time they introduced the concept of ''essential fatty acids.''

That fatty acids could be ''essential'' was received with much skepticism and doubt by nutritionists and physiologists. Even Herbert Evans told Burr that he was sticking his neck out. But as Ralph Holman points out ''.....Burr is a gentle man, who merely kept working quietly, amassing the evidence[7].'' Within a year confirming results came from other laboratories, and thus the controversy was short-lived.

In the early 1930s Arild Hansen, a physician in the Department of Pediatrics, worked with Burr and showed that certain skin diseases in children could be successfully treated by feeding them oils containing appreciable amounts of the essential fatty acids (EFA), such as corn oil or linseed oil[8]. Further studies on normal adult humans on very low fat diets showed that it was very difficult to produce deficiency symptoms, for the body stores were able to prevent the appearance of any such symptoms for at least six months. It was shown in such studies, however, that the blood levels of the

dropped dramatically[9].

Although Vitamin E and the EFA were overed at nearly the same time, Vitamin was given much more publicity. For her of them has there been found clearly ned deficiency symptoms in the general ulation in the same manner that beri beri, rvy, rickets, and pellagra were found to associated with the deficiency of Vitamins , C, D, and niacin[10]. Nevertheless, after orld War II, the dietary role of EFA or the lyunsaturated fatty acids (PUFA) has been e of the highlights of nutrition research d one of the major factors in the concerns er healthy nutrition. This, of course, came out with the discovery of the relationship the dietary PUFA to the regulation of lood cholesterol levels and its association with cardiovascular disease. Thus the Burrs identification of the PUFA (EFA) as essential nutrients, while not being commonly associated with a deficiency disease, eventually led to the knowledge of their role in preventing the build-up of high blood cholesterol levels. A Symposium was held at the University of Minnesota in 1980 in recognition of the 50th anniversary of this discovery of the essential atty acids by the Burrs[11].

With this background of a solid training in iochemistry and an excellent research ecord, it is not difficult to see why Maurice Visscher asked Prof. Burr to be the Director f Physiological Chemistry. His appointment as for 2/3 time in Physiological Chemistry hile maintaining a 1/3 time appointment in Plant Physiology[12]. Other faculty members of the Department of Physiology who were "physiological chemists" included Wallace Armstrong, L. Earle Arnow, Allan Hemingway, and Leo Samuels. (The latter three taught Physiological Chemistry 100, 101 in the summer of 1940 when I took the course).

By 1940 there was developing what proved to be a short but remarkable period of research productivity in Physiological Chemistry. In 1939 George Burr had obtained a grant of $15,000 from the Rockefeller Foundation plus two smaller grants from the National Livestock and Meat Board and the Hormel Foundation. There were several other bursts of research activity. Wallace Armstrong returned from a six-month leave in Copenhagen in 1939, ready to continue his mineralized tissue research, Earle Arnow was now becoming a first rate researcher in protein chemistry, and Leo Samuels was beginning to publish extensively in the field of endocrinology. Also in 1937 Maurice Visscher had obtained a large grant from the Rockefeller Foundation for the study of intestinal absorbtion, and this would produce very significant results in what would be both Physiological Chemistry and Physiology. As James Gray states in his history of the University of Minnesota, "Visscher was to create a research unit of extraordinary brilliance and productivity[13]."

This increase in research activity was also

accompanied by several significant changes in the faculty. Firstly, more faculty members were brought in because the research grants of Drs. Burr and Visscher allowed the recruitment of several individuals. Secondly, some individuals left because it was during the time of World War II when there were many more positions becoming available for competent scientists. The faculty changes that occurred during this time were the following:

(1) In 1942 Earle Arnow left to join Sharpe and Dohme, the drug division of the Merck Chemical Company. He went there as Director of Biochemical Research, and shortly thereafter he was appointed Director of Research and Vice President. He later became President of the Warner-Lambert Research Institute, a position from which he eventually retired.

Dr. Arnow was born in Florida in 1909 and received the B.A. degree at the University of Florida in 1930. He then came to Minnesota for graduate work and received the Ph.D. degree in 1934 and the M.D. degree in 1940. He was appointed Instructor in 1934 and later was Assistant Professor on the staff until he left in 1942. Before he left Minnesota, he had established an excellent research record in the field of protein chemistry. In a two-year period in 1939-41 he published 10 papers, mostly dealing with the chemistry of glutamic acid, its occurrence in certain proteins, and its possible significance in certain disease states[14].

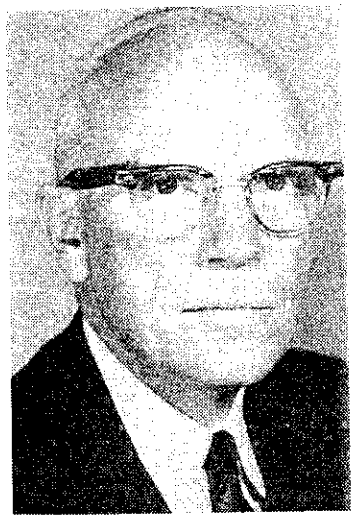
L. Earle Arnow receiving the Distinguished Alumni Achievement Award from Pres. Morrill, 1955. (Univ. Minn. Archives)

Dr. Arnow was also known as an excellent teacher, and his notes for the course in Physiological Chemistry for students of Nursing were incorporated into a textbook. This book, after many revisions, was still being used at the time of his retirement[15]. In view of his accomplishments he received the Distinguished Alumni Achievement Award from the University of Minnesota in 1955.

(2) In 1940 Richard Barnes finished his Ph.D. with Prof. Burr, was appointed an Assistant Professor, and continued some collaboration with Burr. Between 1939 and 1944 he was an author of more than 20 publications; some of these were with Burr, including one major review, "Non-Caloric Functions of Dietary Fats[16]." Then in 1944 he also left to join the staff of Sharpe and Dohme as Biochemist, and he was later named Director of Biochemical Research.

Barnes left the company in 1956 to go to Cornell Univerity in Ithaca, N.Y., where he

had a distinguished career as Dean of the Graduate School of Nutrition (1956-1973). He not only established an excellent research record in the field of nutrition, he also was prominent in professional organizations. He was Chairman of the Division of Biological Chemistry of the American Chemical Society in 1951-52, President of the American Institute of Nutrition in 1968-69, President of the Federation of the American Societies for Experimental Biology in 1973-74, and Editor of the Journal of Nutrition from 1959 to 1969. Prof. Barnes died in 1979.



Richard H. Barnes. J. Nutrition 109 1510 (1979)

In an interview in 1981 Maurice Visscher speculates that he might have been partly responsible for the leaving of Arnow and Barnes. He thought that they might have left "because I hadn't seen to the conversion to a full department status soon enough[18]."

(3) In 1940 Cyrus Barnum, Jr., finished his Ph.D. in Physiological Chemistry. His co-advisor was Dr. Visscher, and his thesis involved the technique of polarography, the title being "Polarographic Investigations of the Cystine-Cysteine System." Thus he had a co-advisor, Dr. Kolthoff of the School of Chemistry, the country's foremost authority on polarography[19]. After postdoctoral work at the Scripps Metabolic Laboratory in La Jolla, California, Dr. Barnum returned to Minnesota where he was appointed Assistant Professor of Physiological Chemistry in 1942. Dr. Barnum was a native of Minneapolis, born here in 1913, and he received his undergraduate training at the University of Minnesota, getting the B.A. degree in 1935.

(4) Allan Hemingway took a leave of absence in 1942 to join the Armed Services as Chief of the Laboratory of Biophysics at Randolph Field, Texas.

(5) In 1944 Leo Samuels went to the University of Utah as Professor and Head of the Department of Biochemistry. During his tenure at Minnesota he carried out research in endocrinolgy, mostly dealing with the steroid hormones, publishing somewhat more than twenty papers[20]. He was the advisor for three Ph.D. students and one M.S. student.

When Samuels came to Minnesota, a unique tradition was introduced. The teaching of Endocrinology became the responsibility of the program in Physiological Chemistry; at all other medical schools this subject was included in other basic science departments, usually Physiology. This tradition has continued right up to the present

time. When Samuels went to Utah, he introduced this concept there, and thus Utah became the only other school in the United States with Endocrinology located in the Biochemistry Department[21].

Leo T. Samuels. Endocrinology 103 997 (1978)

Prof. Samuels remained as Head of the Department at Utah until 1964; he continued as Professor until 1968 when he became Professor Emeritus. He was well-known for his research in the basic aspects of steriod biochemistry, and he was especially noted for the discovery of delta-5, 3-beta hydroxy-steroid dehydrogenase-isomerase, an enzyme system important in the biosynthesis of steroid hormones in the endocrine glands. He also maintained an interest in the clinical applications, and he was the mentor for many young clinical investigators. He died in 1978 at the age of 79[22].

(6) In 1944 Ralph Holman finished his Ph.D. with Dr. Burr and became an Instructor in the Department. Ralph was born in Minneapolis in 1918. He received the B.S. degree at the University of Minnesota in 1939 and the M.S. degree at Rutgers University in 1941. With the departure of both Barnes and Samuels in 1944 in the middle of World War II, the Division was fortunate to have someone of Ralph's competence to fill one of the vacated positions.

(7) In 1945 David Glick received an adjunct appointment to do some teaching while he was working for Russell-Miller Milling Company (now International Multi-Foods). He had come to Minneapolis in 1943 as Head of the Vitamin and Enzyme Research for the Milling Company.

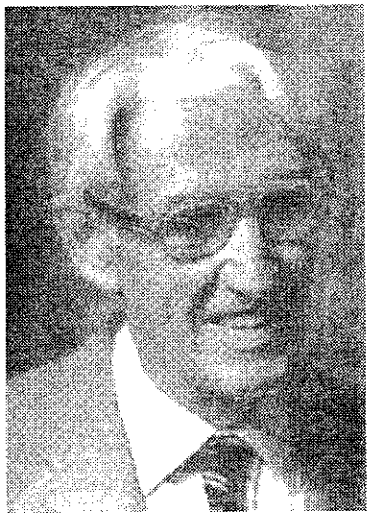
In addition to the faculty mentioned above, there were several members of the Physiology Department who by training and expertise were qualified to be "physiological chemists", but their appointments sometimes listed them as physiologists, and their appointments were on research grants. Nevertheless, they did some classroom teaching in Physiological Chemistry, and they contributed greatly to the graduate program. These individuals were the following:

(1) Harland Wood came from Iowa State University in 1943 to be Associate Professor. He was born in Delaven, Minnesota, in 1910, and he received the B.A. degree at Macalester College in St. Paul in 1931. He went to Iowa State University for graduate work and received the Ph.D. degree in Bacteriology in 1935, working with Professor Werkman. His thesis resulted in

the discovery of the utilization of carbon dioxide by heterotrophic bacteria, heretofore considered to be impossible. He did post-doctoral work at Wisconsin and returned to Iowa State to work with Prof. Werkman. Out of this work came the proposal for the now well-known Wood-Werkman reaction as the mechanism by which carbon dioxide and pyruvate unite to form oxalate[23].

In his memoir in a recent Annual Reviews of Biochemistry, Dr. Wood says that in 1939 he wanted to go to Berkeley, California, to make use of the short-lived radioactive isotope of carbon, carbon-11, which was available there[24]. He wished to confirm the metabolic pathway which had been proposed, but Prof. Werkman would not let him go. In 1940 he heard from his brother, a graduate student in the Department of Physiology at Minnesota, that a heavy isotope of carbon was being used at the University for metabolic studies. Prof. Werkman did allow Wood to come to Minneapolis where he collaborated with Prof. Alfred Nier of the Physics Department. With the help of Prof. Hemingway in the Division of Physiological Chemistry, with Nier's mass spectrometer, and with the use of the stable heavy isotope, carbon-13, experiments were carried out following metabolic pathways. This work was very fruitful, for it confirmed completely the Wood-Werkman mechanism[25].

In 1943 Dr. Wood was offered an Associate Professorship at Minnesota but turned it down because he wanted to stay at Iowa State. Shortly after that when he bought a house in Ames, Prof. Werkman told him that he could not stay indefinitely at Ames, so Wood immediately accepted the position that he had earlier refused.



Harland G. Wood. (Trends in Biochem. Sci. Vol. 2, p. N195 (1977)

(2) Merton Utter, who had been working with Harland Wood at Iowa State, followed Harland here 1944. Both Dr. Wood and Dr. Utter were supported by a grant that Dr. Visscher had obtained from the National Foundation for Infantile Paralysis.

(3) Herbert Freundlich, a refugee from Nazi Germany, joined the faculty of the University of Minnesota in 1938. He was born in Berlin in 1880, and after spending two years at the University of Munich, he went to the University of Leipzig where he obtained the Ph.D. in Chemistry with Wilhelm Ostwald. In 1919 he became Associate Director of the Kaiser-Wilhelm Institute for Physical Chemistry and Electrochemistry and

Chief of the Division of Colloid Chemistry. In 1933 Hitler demanded that Fritz Haber (Director of the Institute) and Freundlich dismiss all of their associates who were not of "pure Aryan race." They both refused and then resigned their positions, and Freundlich secretly left Berlin to go to London. In London he was offered a temporary position in Prof. F. G. Donnan's laboratory at Cambridge[26].

In 1925 and again in 1937 Freundlich was invited to the United States as the foreign guest of the National Colloid Symposia of the American Chemical Society which in those two years were held at the University of Minnesota in June. Both years he stayed on for six weeks and gave lectures in colloid chemistry. When it became apparent that he could not stay permanently in England, Ross Gortner, I. M. Kolthoff, and Lloyd Reyerson persuaded President Ford to offer Freundlich a position at Minnesota. Thus he came here in 1938 as Distinguished Service Professor of Colloid Chemistry without departmental assignment; he would interact with faculty and students primarily in four areas, chemistry, agricultural biochemistry, physiology, and physiological chemistry. Tragically, Prof. Freundlich died suddenly in the late spring of 1940. Among other things, his death was a major deterrent for plans to expand the program in colloid chemistry at the University. (See Appendix H).

(4) Karl Sollner, a physical biochemist and Jewish refugee from Germany, came to the Department in 1938. Dr. Sollner was born in Vienna in 1903 and received his Ph.D. in chemistry from the University of Vienna in 1926. In 1927 he went to Berlin to work with Prof. Freundlich in the Kaiser Wilhelm Institute. In 1933 he accompanied Freundlich in leaving Berlin to go to London, and he also joined the laboratory of Prof. Donnan. In 1937 Dr. Sollner came to the United States and spent one year in the Agronomy Department of Cornell University before coming to Minnesota in 1938. He was invited here to take part in Dr. Visscher's major research project on intestinal absorbtion. Dr. Sollner gave a few lectures in the physiological chemistry course for medical students, and he served on the Graduate Faculty, being an advisor for several graduate students in Physiological Chemistry.

Dr. Sollner had already established his reputation in the field of membrane science in 1930-32. In 1930 he published two papers on the theory of anomalous osmosis. This theory invoked the concept of heterogeneous pore size and the resultant development of micro-electrical circuits which in turn produced electro-osmosis. Two more papers with model membrane systems confirmed this idea[27].

In 1932 in a paper on mosaic membranes, membranes with charge groups of different sign, he showed that in such a system, electrical circuits would result. This also was also confirmed in model experiments[28]. The concept of microelectrical circuits in mem-

branes was later used by Peter Mitchell in his Nobel Prize-winning chemi-osmotic theory for the synthesis of adenosine triphosphate (ATP) in mitochondria[29].

Karl Sollner

(5) In 1937 Frank McCormick, Head of the Physical Education Department and Director of Athletics, discussed with Maurice Visscher the possibility of a joint study on the physiological effects of physical performance[30]. With funds from the receipts of intercollegiate athletics, a Laboratory of Physiological Hygiene was established in the Physiology Department. Ancel Keys, who had come to the Mayo Clinic the year before as a Professor of Biochemistry, was invited to direct this new laboratory. In 1942 this laboratory group was moved to newly constructed laboratories in Memorial Stadium. In 1946 it was split off from Physiology, and it became the Laboratory of Physiological Hygiene in the School of Public Health.

Dr. Keys was well-prepared to start a program such as this, for he had spent several years as one of the key investigators in the Fatigue Laboratory of Harvard University of which Lawrence J. Henderson was one of the founders. In 1935 Keys led a high-altitude expedition in the Andes Mountains in Chile, obtaining masses of data on the physiological effects of an altitude of 20,000 feet[31].

(6) Olaf Mickelson, Hospital Chemist, did considerable teaching in one of the Nurses courses in Physiological Chemistry in 1940 and 1941. In 1942 he joined Ancel Keys' new program in Physiological Hygiene but continued with teaching in our program during the remainder of World War II.

(7) In 1942 the Hormel Institute was started in Austin, Minnesota, as a unit of the University's Graduate School, and Walter Lundberg, who had been working in Prof. Burr's group, joined its staff. Dr. Lundberg had previously obtained the Ph.D. degree at Johns Hopkins in 1934 and came to Minnesota to work with Burr in 1938. He was appointed Research Director at the Institute in 1944, and he was given a faculty appointment in Physiological Chemistry. (See Appendix E concerning the organization of the Hormel Institute).

(8) Isadore Fankuchen, a crystallographer who had earlier worked with Prof. Bernal in England, came to the Physiology Department in 1941[32]. He was appointed Assistant Professor of Physiological Chemistry, and he

was co-director of the Anderson Biological Research Institute. This institute was formed by Dr.Visscher in 1941 with money from the Anderson family in Red Wing, Minnesota[33]. (Dr. Anderson, trained as a botanist and bacteriologist, carried out private research and had made his fortune through the invention of puffed cereal). The institute was housed in Red Wing where Dr. Anderson had previously constructed two laboratories.

This Institute existed for only a short time, presumably because it was during war-time, and money and staff would be hard to get for basic biological research. In 1941-42 Prof. Fankuchen offered a graduate course, "X-Ray Diffraction Studies of Biological Compounds," and one paper was published by Fankuchen during his tenure at the Institute[34]. He left here in 1942 to join the faculty of the Brooklyn Polytechnic Institute. Thus for a short time during this era, our program had an outstanding crystallographer on its faculty.

It can also be mentioned here that Ephriam Racker, now a very well-known biochemist, was a research associate at the Anderson Institute during 1941-42. His work was involved with possible changes that might occur in nerve tissue when it is invaded by polio virus. He had two publications of work that was carried out at the Anderson Institute, one in which he was given encouragement and advice by Prof. Fankuchen, "Crystallization of a Protein from Poliomyelitis-Infected Mouse Brain[35]." The protein was highly infectious, but no claim could be made that it was the polio virus. Racker left the Institute in 1942 and went to New York where he has been spending the rest of his career.

At the end of World War II, it was finally realized that the program in Physiological Chemistry had grown enough to become a separate department. Thus in early 1946 the University administration agreed to form the Department of Physiological Chemistry, the official date for this change being July 1, 1946. This illustrated again what Maurice Visscher once said, "The Department of Physiology served a kind of marsupial function for other emerging disciplines[36]." Very early on Pharmacology had been split off to become a separate department in 1913. In 1946 Physiological Hygiene was split off and later Cancer Biology and Chronobiology would be transferred to the Pathology Department. Even individual professors left to join other disciplines. In the early days of the Department, Prof. Sedgwick left to be Head of a new Department of Pediatrics, and Prof. Schlutz later joined him and eventually became Head of that Department. Prof. K. Wilhelm Stenstrom, a biophysicist, after being in Physiology for 12 years, in 1938 joined the Radiology Department. Dr. Frederick Kottke, who received his training in Physiology and was Instructor there for a while, joined the Division of Physical Medicine in 1947 and became the first Head of a new Department of Physical Medicine and

Rehabilitation in 1952.

This period in the program's history, 1939-1946, was comparitively short, but it was very intense and highly productive. Perhaps it is not much of an exaggeration for Dr. Visscher to say many years later, "the Division of Physiological Chemistry at Minnesota perhaps was one of the leading divisions of biochemistry in the world from a research viewpoint[36]" Certainly the overall scientific competence of the faculty has never been greater than during this time. This, added to the fact that the scientific quality throughout the physical-biomedical science community of the University was also at its heighth contributed to a truly exciting and wonderful atmosphere for research. Lucky was the graduate student who was at the University in any of these disciplines during this time. (See Appendix F).

The beginning of World War II in Europe and the later U.S. involvement, which encompassed this entire period, added to the excitement and intensity of everyone's effort. After December 7, 1941, male graduate students were expected to finish their work as quickly as possible and then get into some war-related activity. In addition the curricula for the Health Science professional students were accelerated, with no break for the summer months. For example, a new medical class began every three quarters, and our elementary course for nurses was taught twice a year. As was true throughout the country, the pace of every endeavor was stepped up.

Among the more significant research accomplishments of the program during this time are included the following:

(1) In 1938 Dr. Armstrong, in collaboration with Dr. Peter Brekhus of the Dental School, had shown that carious teeth tended to have less fluoride than non-carious teeth[37]. In a Master's thesis, Mabel Perry, a student working with Dr. Armstrong in 1941, showed that in rats enamel could pick up fluoride from drinking water[38]. Dr. Armstrong then collaborated with Dr. John Knutson from the U.S. Public Health Service to show that topical treatment of the teeth of children with fluoride solutions would considerably reduce the incidence of dental caries[39]. Studies of this kind by others yielded similar results, and there followed large-scale testing of the fluoridation of municipal water supplies in 1944-1950. The positive results of these tests led to a general introduction of fluoridation of water supplies in this country.

(2) In Prof. Burr's group extensive research was carried on dealing with fatty acids and other lipids. Although Moore had shown earlier that the unsaturated fatty acids could be conjugated by treatment with alkali[40], Kass and Burr proved this independently in 1941[41]. This procedure was used in Burr's laboratory as a method for converting vegetable oils into unsaturated oils with quick drying properties. These oils could be used for various kinds of paints and var-

nishes in place of natural tung oil, no longer available in this country during the war. Burr received two patents for this work[42].

Alkaline isomerization of the polyunsaturated fatty acids was also used to develop new methods for the analysis of these acids[43]. The conjugated fatty acids become strongly absorbing in the ultraviolet region, and their analysis can then be carried out by ultraviolet spectrometry.

Work on the metabolism of the unsaturated fatty acids in this laboratory resulted in several papers, one of which showed that in the state of an essential fatty acid deficiency, there was an accumulation of 5,8,11 eicosatrienoic acid in the tissues of rats. This fatty acid was thus established as a marker for essential fatty acid deficiency. The paper describing these results was later republished as a Nutrition Classic[44].

It should also be emphasized here that the appointment to the Hormel Institute of individuals who had worked in Burr's laboratory (Dr. Lundberg, 1938-1942 and Dr. Holman 1940-1945) would result in that Institute's becoming one of the world's leading lipid research laboratories. In fact some of the initial research projects of the Institute were started in Burr's laboratory. (See Appendix E).

(3) As indicated earlier, in 1940-41 Harland Wood of Iowa State University had collaborated with Alfred Nier of the Physics Department and Allan Hemingway in Physiological Chemistry in the use of heavy carbon to confirm the mechanism of the Wood-Werkman reaction for the fixation of carbon dioxide in bacteria. After collaborating with Wood on the use of heavy carbon, Allan Hemingway became the advisor for two graduate students who used this procedure in their thesis work in 1941-42[45].

When Wood in 1943 and Merton Utter in 1944 moved to Minnesota, they continued studies on metabolic reactions. In 1944 Wood and Utter showed that carbon dioxide labeled with heavy carbon was incorporated into pyruvate in pigeon liver, one of the early demonstrations that carbon dioxide is actively taken up in such tissues[46].

In 1945 Wood, with Nathan Lifson and Victor Lorber of the Physiology Department, showed with labeled carbon dioxide that the carbon atom of carbon dioxide was incorporated into glucose only at the number 3 or 4 position of glucose. This work along with their other work, led to complete confirmation of the Krebs citric acid cycle[47].

(4) In 1943 in Karl Sollner's laboratory, "permselective membranes" were invented. These are thin films that have at the same time relatively low resistance and nearly perfect selectivity for cations vs. anions and *vice versa*[48]. Prof. Sollner coined the term "permselective," a new concept in the field of artificial membranes. He also pointed out the usefulness of these membranes as electrodes for the determination of the activity of just about all small cations and anions[49].

In 1950 the University of Minnesota received the first patent for these kinds of membranes; unfortunately for the University, however, the patent did not include a superior way for making membranes with these properties that was developed elsewhere after World War II. Nevertheless, this work opened up a new field in membrane technology that led to the development of membranes for the electrodialytic desalination of salt water, specific membrane electrodes, and artificial kidney membranes[50].

(5) Although he was not in Physiological Chemistry, Ancel Keys' work was in the research area of physiological chemistry of that time. In 1941 the well-known K-rations for combat troops in World War II was developed in his laboratory. In 1944-45 the Keys' laboratory conducted a major study of human starvation. Using conscientious objectors as subjects, they kept 36 men on a semi-starvation diet for 24 weeks, following the physiological and psychological changes in great detail. This was followed with a 12-week period in which recovery was studied. A two-volume publication of the results in 1950 still remains as one of the most complete scientific studies of human starvation[51].

References

1. Holman, R.T. "George O. Burr and the Discovery of the Essential Fatty Acids" J. Nutrit. 118 535 (1988)

2. Evans, H.M., Burr, G.O., and Althausen, T.L. "Antisterility Vitamin, Fat Soluble E" Mem. Univ. Calif. 8 1 (1927); Harris, R.S. "Chemistry of Vitamin E" in "The Vitamins", Vol. VIII, Sebrell, W.H. and Harris, R.S., eds., Academic Press, New York, 1954, p. 484; Hoffman-Ostenhof, O. "Vitamin E" Trends in Biochem. Sci. 2 284 (1977)

3. Bartlett, S.L. "The History of the Department of Botany, 1889-1989" p. 31-33

4. Abbe, E.C. "An Informal History of the Department of Botany, University of Minnesota, 1887-1950, p. 8

5. Burr, G.O. and Burr, M.M. "A New Deficiency Disease Produced by the Rigid Exclusion of Fat from the Diet" J. Biol. Chem. 82 345 (1929)

6. *ibid.* "The Nature and Role of the Fatty Acids Essential in Nutrition" J. Biol. Chem. 86 587 (1930)

7. Ref. No. 1, p. 537

8. Hansen, A.E. "Serum Lipid Changes and Therapeutic Effects of of Various Oils in Infantile Eczema" Proc. Soc. Exptl. Biol. Med. 31 160 (1933); *ibid.* "Serum Lipids in Eczema and Other Pathological Conditions" Am. J. Dis. Children 53 933 (1939)

9. Brown, W.R., Hansen, A.E., Burr, G.O., and McQuarrie, I. "Effects of Prolonged Use of Extremely Low Fat Diet on an Adult Human Subject" J. Nutrit. 16 511 (1938)

10. Jukes, T.H. Footnote in Ref. No. 1

11. Holman, R.T., ed. "Golden Jubilee International Congress on Essential Fatty Acids and Prostaglandins" Prog. Lip. Res. Vol. 20, Pergamon Press, Oxford, 1982

12. Ref. No. 3, p. 47

13. Gray, J. "The University of Minnesota, 1851-1951" Univ. Minn. Press, 1951, p. 514

14. e.g., Arnow, L.E. "Phenylalanine Content of Hen-Egg Albumin" Proc. Soc. Exptl. Biol. Med. 41 499 (1939); *ibid.* "Configuration of the Glutamic Acid of Adenocarcinoma Protein" Science 90 257 (1939); Arnow, L.E. and Opsahl, J.O. "Configuration of Glutamic Acid Isolated from Proteins of Pig and Chick Embryo Tissue" Proc. Soc. Exptl. Biol. Med. 43 767 (1940); *ibid.* "Racemization of Glutamic Acid with Alkalies" Science 93 214 (1940)

15. Arnow, L.E. "Introduction to Physiological and Pathological Chemistry" C.V. Mosby Co., St. Louis, 1939. Also eds. 2-9

16. Burr, G.O. and Barnes, R.H. "Non-Caloric Functions of Dietary Fat" Physiol. Revs. 23 256 (1943)

17. Roe, D.A. "Richard Henry Barnes (1911-1978). A Biographical Sketch" J. Nutrit. 109 1510 (1979)

18. Ref. No. 37, Chap. II

19. Kolthoff, I.M. and Barnum, C.P., Jr., "The Anodic Wave of Cysteine at the Dropping Mercury Electrode and the Platinum Micro Electrode" J. Am. Chem. Soc. 62 3061 (1940); *ibid.* "Reduction of Cystine at the Dropping Mercury Electrode" 63 520 (1941)

20. e.g., Szego, C. and Samuels, L.T. "A New Reagent for Quantitative Estimation of Estrone" Proc. Soc. Exptl. Biol. Med. 43 263 (1940); Samuels, L.T., Reineke, R.R., and Peterson, W.E. "Relation of Nutrition to Mammary Growth after Estradiol Administration to Hypophysectomized Rats" *ibid.* 46 379 (1941); Samuels, L.T. "Important Advances in the Physiology of Sex Hormones" Journal Lancet 62 419 (1942); Szego, C. and Samuels, L.T. "The Metabolism of Estrone in Surviving Rabbit, Bovine, and Human Endometrium" J. Biol. Chem. 151 587 (1943)

21. Ungar, F. Personal Communication

22. Engel, L.L. "Leo Tolstoy Samuels" Endocrinology 103 997 (1978)

23. Wood, H.G. and Werkman, C.H. "The Relationship of Bacterial Utilization of Carbon Dioxide to Succinic Acid Formation" Biochem. J. 34 129 (1940)

24. Wood, H.G. "Then and Now" Ann. Rev. Biochem. 34 1 (1985)

25. Wood, H.G., Werkman, C.H., Hemingway, A., and Nier, A.O. "Heavy Carbon As A Tracer in Bacterial Fixation of Carbon Dioxide" J. Biol. Chem. 135 788 (1940); *ibid.* 139 373 (1941)

26. R.O. Gortner and L.H. Reyerson Papers, Letters concerning the negotiations of Freundlich's appointment, Univ. of Minn. Archives; Donnan, F.G. "Herbert Freundlich, 1880-1941" J. Chem. Soc. 1942 646; Ford, G.S. "Herbert Freundlich Obituary" Univ. Minn. Senate Minutes, May 15, 1941; Heller, W. "Herbert Freundlich, A Biographical Essay in Commemoration of His 100th Birthday" 55th Annual Colloid and Surface Science

mposium, Am. Chem. Soc., Case Western serve Univ., Cleveland, June 1981

Sollner, K. "Zur Erklarung der Abnormen Osmose 1 Nicht Quellbaren Membranen. I Teil" Z. lektrochem. 36 36 (1930); *ibid.* "II Teil" 36 234 1930); Grollman, A. and Sollner, K. "Experimental Verification of A New Theory Concerning the Mechanism of Anomalous Osmosis" Trans. Electrochem. Soc. 61 487 (1932)

28. Sollner, K. "Uber Mosaikmembranen" Biochem. Z. 244 370 (1932); Neihof, R. and Sollner, K. "Quantitative Electrochemical Theory of Electrolyte Permeabilbity of Mosiac Membranes Composed of Selectively Aniom-Permeable and Cation-Permeable Parts and Its Experimental Verification; J. Gen. Physiol. 38 613 (1955)

29. Mitchell, P. "Chemi-osmotic Coupling in Oxidative and Photosynthetic Phosphorylation" Biochem. J. 79 23P (1961)

30. Gray's History, p. 515

31. Chapman, C.B. "The Long Reach of Harvard's Fatigue Laboratory" Perspect. Biol. Med. 34 17 (1990)

32. Bernal, J.D., Fankuchen, I., and Perutz, M. "An X-Ray Study of Chymotrypsin and Hemoglobin" Nature 141 523 (1938)

33. M.B. Visscher's Papers, Letters from Prof. Visscher to Dean Diehl, Univ. Minn. Arch.

34. Fankuchen, I. "X-Ray and Optic Measurements on Beta Lactoglobulin" J. Am. Chem. Soc. 64 2504 (1942)

35. Kabat, H. and Racker, E. "Metabolism of the Central Nervous System in Experimental Poliomyelitis" J. Exptl. Med. 76 579 (1942); Racker, E. "Crystallization of a Protein from Poliomyelitis-Infected Mouse Brain" Science 96 364 (1942)

36. Ref. No. 37, Chap. II

37. Armstrong, W.D. and Brekhus, P.J. "Possible Relationship between the Fluorine Content of Enamel and Resistance to Dental Caries" J. Dent. Res. 17 5 (1938)

38. Perry, M.W. and Armstrong, W.D. "On the Manner of Acquisition of Fluorine by Mature Teeth" J. Nutrit. 21 35 (1941)

39. Knutson, J.W. and Armstrong, W.D. "The Effect of Topically Applied Sodium Fluoride on Dental Caries Experience" Publ. Health Repts. 58 1701 (1943); Knutson, J.W. and Armstrong, W.D. "Post-war Implications of Fluorine and Dental Health. The Use of Topically Applied Fluoride" Am. J. Publ. Health 34 239 (1944)

40. Moore, T. "XVII. Spectroscopic Changes in the Absorbtion Spectra of Various Fats Induced by Treatment with Potassium Hydroxide" Biochem. J. 31 138 (1937)

41. Kass, J.P. and Burr, G.O. "Pseudo-eleostearic Acid" J. Am. Chem. Soc. 61 3292 (1941)

42. Burr, G.O. U.S. Patent No. 2,242,230 "Producing Conjugation in Unconjugated Fatty Acids;" U.S. Patent No. 2,358,623 "Fast Drying Liquid Coating Composition;" Also see Wilson's History, p. 402

43. Burr, G.O. and Miller, E.S. "Ultraviolet Absorbtion Spectra of Fatty Acids and Their Application to Chemical Problems" Chem. Revs. 29 419 (1941); Holman, R.T. and Burr, G.O. "Alkali Conjugation of the Unsaturated Fatty Acids" Arch. Bioch. 19

474 (1948)

44. Rieckehoff, I.G., Holman, R.T., and Burr, G.O. "Polyethenoid Fatty Acid Metabolism. Effect of Dietary Fat on Polyethenoid Fatty Acids of Rat Tissues" Arch. Biochem. 20 331 (1949), (reprinted as a Nutrition Classic, Nutrition Revs. 38 247 (1980)

45. Swendseid, M., Barnes, R.H., Hemingway, A., and Nier, A.O. "Formation of Acetone Bodies from Acetic Acid" J. Biol. Chem. 142 47 (1942); Olsen, N.S., Hemingway, A., and Nier, A.O. "Metabolism of Glycine". I. Studies with the Stable Isotope of Carbon" *ibid.* 148 611 (1943)

46. Utter, M. and Wood, H.G. "Fixation of Carbon Dioxide in Oxalacetate by Pigeon Liver" J. Biol. Chem. 160 375 (1945)

47. Wood, H.G., Lifson, N., and Lorber, V. "The Position of Fixed Carbon in Glucose from Rat Liver Glycogen" J. Biol. Chem. 159 (1945); Wood, H.G. "The Fixation of Carbon Dioxide and the Inter-relationship of the TCA Cycle" Physiol. Revs. 26 198 (1946); Cori, C. and Cori, G.T. "Carbohydrate Metabolism" Ann. Rev. Biochem. 15 194 (1946)

48. Carr, C.W. and Sollner, K. "The Structure of the Collodion Membrane and Its Electrical Behavior. XI. The Preparation and Properties of 'Permselective' Collodion Membranes Combining Extreme Ionic Selectivity with High Permeability" J. Gen Physiol. 28 119 (1944); Carr, C.W., Gregor, H.P., and Sollner, K. "*ibid.* XII. The Preparation and Properties of 'Permselective' Protamine Collodion Membranes Combining Extreme Ionic Selectivity with High Permeability" *ibid.* 28 179 (1945)

49. Sollner K. "New Potentiometric Method to Determine Cations and Anions with Collodion and Protamine-Collodion Membrane Electrodes" J. Am. Chem. Soc. 65 2260 (1943)

50. Sollner, K., Carr, C.W., and Gregor,, H.P., U.S. Patent No. 2,510,262 "Ionic Membranes"

51. Wilson's History, p. 407-409; Keys, A., Brozek, J., Henschel, A., Mickelson, O., and Taylor, H.L. "The Biology of Starvation" Vols. I and II, The Univ. of Minn. Press, Minneapolis, 1950

Chapter IV. Development of the Program - 1946-1960

With the ending of World War II in 1945 and the formation of a new department in 1946, many changes in the staff took place. Several faculty members left, each one for a different reason.

(1) George Burr decided to give up Minnesota winters and went to Hawaii where he became Head of Biochemical and Physiological Research for the Hawaiian Sugar Planters Association. In Prof. Wilson's history of the Medical School he shows that the University administration was unwilling to give Prof. Burr a salary anywhere near what he deserved for his position and accomplishments, and this might also have been an incentive for him to leave[1]. He stayed with the sugar research position until he retired in 1965.

Burr's research in Hawaii, among other things led to the discovery of the 4-carbon pathway for photosynthesis[2]. Burr had once more come up with a discovery that was not easily accepted. He and his co-workers had the results by 1961, but it was four years before it could be published in an appropriate journal.

After he retired in Hawaii, he served as consultant for seven years for the Taiwan Sugar Planters Association. In 1988 he is in his nineties and is still living in Hawaii. In 1955 he was given the Distinguished Alumni Achievement Award by the University of Minnesota. An excellent and more extensive detailing of the life and accomplishments of George Burr, written by Ralph Holman, appears in the Journal of Nutrition[3].

(2) Harland Wood went to Western Reserve University as Chairman of the Department of Biochemistry in the Medical School. He was the Chairman there from 1946 until 1965; he became Dean of Science in 1967 and was named University Professor in 1970. He has served as President of the American Society of Biological Chemists, as General Secretary of International Union of Biochemistry and is a member of the National Academy of Sciences. In 1988 he is in his eighties and still carrying out research[4].

(3) Merton Utter also went to Western Reserve where he became Professor in 1956 and Chairman of the Department in 1965 when Dr. Wood stepped down. He died in 1982.

Although Drs. Wood and Utter were at Minnesota for only three years, their accomplishments left a very significant imprint on biochemical research here for many years. For example, Nathan Lifson of the Physiology Department, who had worked with Wood and Utter, *vide supra*, continued with studies on the use of isotopes in following

metabolic reactions and used the procedure to devise a method to calculate energy expenditure. This work of his in the 1950s led to his being awarded in 1987 the prestigious Rank Prize of England for outstanding work in human and animal nutrition[5].

(4) Allan Hemingway elected to stay in the Department of Physiology and decided to change his field of research to respiration physiology. His wife had died earlier, and in 1951 he married Claire Conklin Carr. She had been a graduate student in the Physiological Chemistry Program at the same time that Hemingway was completing his graduate work. She obtained an M.S. degree with McClendon in 1929 and left the University and later married. When her husband died, she returned to work in the Physiology Department in 1946, and she renewed her friendship with Professor Hemingway. Shortly after they were married, he went to the University of California at Los Angeles as Professor of Physiology[6]. He retired from UCLA in 1969 and for a while was Chief of the Cardiopulmonary Laboratory of the San Fernando Veterans Administration Hospital. He died in 1972. Mrs. Hemingway has established the Allan Hemingway Scholarship in the Physiology Department for deserving graduate students.

(5) Karl Sollner left the Department of Physiological Chemistry in the fall of 1946 to become Head of a Laboratory of Physical Biology at the National Institutes of Health. Although he was assured of funding at Minnesota from the Rockefeller Foundation, the University administration would not establish the research professorship that he wanted[7].

(6) In 1946 Ralph Holman received a Fellowship to spend a year with Hugo Theorell in Sweden and went on leave in September.

The staff of the new Department of Physiological Chemistry in the fall of 1946 would include the following:

(1) Five individuals remained from the old Division: Wallace Armstrong was appointed as the Head of the Department, Cy Barnum continued as Assistant Professor, Walter Lundberg retained his appointment at the Hormel Institute, Karl Sollner was at the National Institutes of Health but retained his graduate faculty appointment in the Department, and I replaced Ralph Holman temporarily, changing from Research Fellow to Instructor. (See Appendix I).

(2) David Glick left his position at Russell-Miller Milling Company and came into the new Department on a full-time basis. Dr. Glick was born in Pennsylvania in 1908 and received his undergraduate and graduate training at the University of Pittsburgh, getting the Ph.D. degree in 1932. He then served in several hospitals in this country and also spent three years in the Carlsberg Laboratories in Copenhagen in 1933-36. He had come to Minneapolis in 1943.

(3) Saul Cohen was brought here as a replacement for Leo Samuels in the field of steroid biochemistry. Saul was born in Brandon, Manitoba, in 1913 and received a B.A. degree there in 1932. He then obtained the Ph.D. degree at the University of Toronto in 1936. After a year of post-doctoral work in Switzerland, he held positions on the faculties of Ohio State University and the University of Michigan before coming to Minnesota.

(4) Elizabeth Frame came to the University with a half-time appointment in the Hospital Laboratories and a half-time appointment in Physiological Chemistry. Dr. Frame was born in Lunenberg, Nova Scotia, in 1908 and attended Dalhousie University where she received the B.A. degree in 1928 and an M.S. in 1929. She was an Assistant Professor of Zoology at Smith College from 1930-39, and in 1942 she obtained a Ph.D. in Physiological Chemistry at Yale University. She then served as a Fellow at Harvard and later as Instructor in Urology at Johns Hopkins University before coming to Minnesota. Her research interest was in the field of amino acid metabolism.

With these changes, the on-campus staff for the Department in the fall of 1946 included: Armstrong, Barnum, Carr, Cohen, Frame, and Glick, and there were two off-campus appointments, Lundberg and Sollner. Thus began a period of 28 years in which Wallace Armstrong served as Head of the Department, with the beginning of the period requiring a major program of re-building. There were only 5 1/2 faculty positions on-campus, and the space was considerably less than adequate. In addition the graduate program had been greatly weakened by the departure of several very competent individuals.

Dr. Armstrong was born in Texas in 1905 and received the B.A. degree at the University of Texas in 1926. He then went to New York University where he obtained an M.S. degree in organic chemistry. He worked for an oil company for a year and then decided to go back to graduate school in a different research area. Without knowing much about physiological chemistry, he came to the University of Minnesota in 1929 as a Teaching Assistant in Physiological Chemistry. He chose Minnesota because a college friend of his from Texas, Robert Hamilton, was already here as graduate student in Physiological Chemistry.

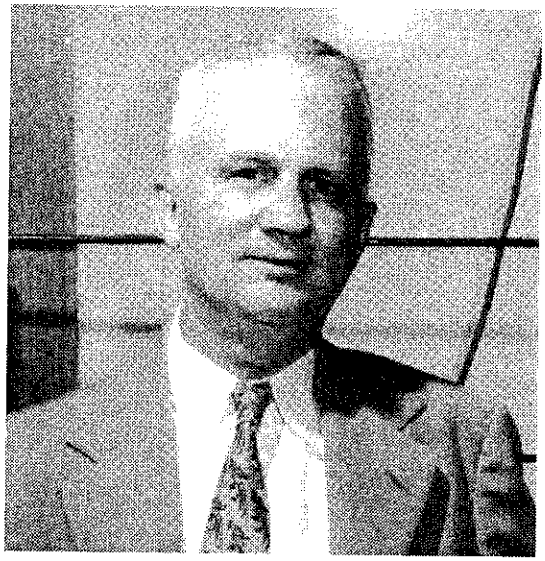
As indicated earlier, Wallace received the Ph.D. degree with Professor McClendon as his advisor. His thesis was entitled "Studies on Fluorine Analysis[8]." He worked with fluorine because Prof. McClendon had done much work with iodine, and he told Wallace that fluorine was the only halogen that had not been studied in biological systems, and McClendon also suspected that it might contribute to the hardness of dental apatite.

After Wallace finished his graduate work, he decided to go to Medical School while being an instructor in Physiological Chemis-

try, teaching in the first year course for dental students. (He once told me that he did this because he could not get a another job with his newly obtained Ph.D. degree). In 1934-1937 Wallace continued studies with fluorine, and with Prof. Brekhus of the Dental School, examined the fluoride content of extracted teeth. *vide supra*[9].

After finishing the M.D. degree in 1937, Wallace went to Copenhagen to study phosphorus metabolism with Prof. G. Hevesy. Hevesy was the first investigator to use radioactive phosphorus in his studies, and Wallace was introduced to these techniques. When he returned to Minnesota, he built his own equipment for radioactive measurements. This included constructing the Geiger tubes and the necessary electrical apparatus. With this equipment he not only carried out his own studies on calcified tissues and mineral metabolism, but he also made the equipment available to other research groups. For example, much of the work in Prof. Visscher's intestinal absorbtion research made use of radio tracers (1940-1943)[10]. Thus Wallace played a major role in introducing the use of radio-isotopes in medical research at this Medical School.

Between 1934 and 1944 Wallace's appointments were made through the School of Dentistry, and he was listed on the faculties of both Dentistry and Physiological Chemistry. He was promoted to Professor in 1943, and in 1945 he became Professor in the Division of Physiological Chemistry through the Medical School. Because he had been in Physiological Chemistry for 17 years, had taught Physiological Chemistry, had done excellent research, and had the M.D. degree, it was quite appropriate for Dean Diehl in 1946 to ask Wallace to be the Head of the newly established Department of Physiological Chemistry.



Wallace Armstrong, ca. 1940

In 1947 Wallace set up a research position in his laboratory and brought Jack Schubert here as Assistant Professor. At the end of the academic year, Jack left, and Sidney Zbarsky took his place. At the end of the 1948-49 year Sidney left, and a new recruit, Leon Singer, joined the Department in the fall of 1949. When Leon came, he planned to stay only 1 or 2 years, but it did not quite work out that way, for he stayed here until he retired!

Leon was born in 1918 in Gainesville, Florida. He received his B.S. degree in 1939

and an M.S. in 1941 at the University of Florida in Gainesville. He was in the Armed Services until 1946, and then he returned to the University of Florida, getting the Ph.D. degree in 1949, just before coming to Minnesota.

In the spring of 1947 Ralph Holman indicated that he was going to stay in Sweden for another year, and, as a result, I stayed on in the Department for another year in his place. Later that year Ralph accepted a faculty position at Texas A. and M. for the following year. Thus, I was asked to stay on in the Department in a tenure-track position.

In the 1947-48 academic year, the Department took on the teaching of a two-quarter course for students in the newly-established College of Veterinary Medicine, and, as a result, the laboratory teaching was getting to be quite a handful. In the winter quarter of 1948 we had 10 three-hour laboratory sessions per week, and I was in charge of all of them. Near the end of that quarter, Wallace arranged for a senior graduate student in Physiology, E. B. Brown, to help me with the laboratory teaching. E. B. stayed with us through the 1949-50 academic year. After E. B. received his Ph.D. degree, he stayed on in the Department of Physiology until 1961. At that time he accepted a position as Professor of Physiology and Vice Chancellor of the Faculty and Academic Affairs at the University of Kansas Medical Center.

In the summer of 1949 Wallace was able to obtain a new tenure-track position in the Department. As a result, Bryant Dunshee joined the staff in the fall of 1949; Bryant came from the University of Wisconsin where he had just completed his Ph.D in Biochemistry. Also in 1949 Walter Lundberg changed his University affiliation to the Department of Agricultural Biochemistry on the St. Paul campus.

In 1950 Wallace received a grant from the Atomic Energy Commission to study the effect of radiation on bones and other tissues. To help with this project, he hired William Caster, who had obtained a Ph.D. in Physiological Chemistry, working with Olaf Mickelson and Ancel Keys in Physiological Hygiene. Bill was born in Topeka, Kansas, in 1919 and later attended the University of Wisconsin, receiving the B.A. degree in 1942 and the M.S. in 1944. He then came to Minnesota and received the Ph.D. degree in 1948.

At the end of the 1950-51 academic year, the faculty included: Armstrong, Barnum, Carr, Caster, Cohen, Dunshee, Frame, Glick, and Singer on campus and Sollner at the National Institutes of Health.

In the next few years several changes took place, at least two of which were catastrophic. At the beginning of the fifties decade, enrollment at the University began to drop off considerably from the surge that followed the end of World War II. Accordingly, the legislature decided to reduce the University's appropriation by an amount that

required most departments to reduce their staff. For us it meant that we had to give up the position that we had gained two years earlier. The person who had to be let go had to be the most recently hired individual, who was Bryant Dunshee. (He had come just one month after Leon Singer!). We suggested two other alternatives to the Dean: (1) Each of the faculty members would take a proportionate reduction in salary, or (2) we would eliminate four teaching assistantship positions. However, this was not in accord with the policy adopted University-wide, and neither suggestion was approved. Thus, Bryant had to leave; nevertheless, he was fortunate because he was hired by General Mills, where he spent the remainder of his career. This period was a very difficult time for the University as a whole, for quite a number of faculty members had to be let go for what is now called "fiscal exigency".

In the spring of 1952 Saul Cohen began to have some physical disability of unknown origin. In June he went into a coma, and he remained in a coma all summer. In spite of the best medical experts both here and at the Mayo Clinic, his condition remained undiagnosed. He came out of the coma that fall, and during the year appeared to improve somewhat but not enough to resume his work. In 1954-1955 he was a little better, and he tried to do some teaching and other activities; however, it was not very satisfactory. The following year he went down hill again, and it was finally agreed that he would have to give up his position.

In late 1956 the Cohens moved to Toronto where they had several relatives. During the next year he was seen in a hospital in Toronto where one of their physicians diagnosed his condition as Wilson's disease, an excess accumulation of copper in the body. They immediately began to treat him with penicillamine which complexed the copper so that it could be readily excreted. The result was astounding, for he recovered the functioning of his nervous system almost completely, especially with the brain. However, some muscular funcion did not recover completely, so he continued to walk with a shuffling gait, and his speech remained somewhat slurred. The next year he accepted a position as Research Associate at the University of Toronto to carry on with his steroid research, and he has kept on with this right up to the present. In 1967 he received the Ortho Award of the Society of Obstetrics and Gynecology of Canada for his work[11].

While at Minnesota Saul continued the tradition of teaching of Endocrinology which was incorporated in the Physiological Chemistry course for medical students. He also introduced a graduate course in Endocrinology which enrolled students from many Departments in the Medical School. He was the advisor for 2 students who received the Ph.D. degree and 3 M.S. students.

In 1953 we lost another member of our

staff when Elizabeth Frame accepted a position as Chief of Biochemical Services in the Department of Clinical Pathology at the Clinical Center of the National Institutes of Health. In 1960 she transferred to administrative work at NIH, first serving as Executive Secretary of the training grant branch and later in the research fellowship branch of the National Institute of General Medical Sciences. Dr. Frame was the advisor for one student who received the Ph.D. degree and two students who received the M.S. degree.

In order to take up the slack in teaching and research caused by this loss of faculty members, a search was instituted in 1954 for a new person. This resulted in Jack Van Pilsum coming to the Department in the fall of 1954.

Jack was born in Iowa in 1922 and attended the University of Iowa, getting the B.S. degree in 1943. After being in the Armed Services in 1943-46, he came back to the University of Iowa and obtained the Ph.D. degree in Biochemistry in 1949. He was on the faculty of the Medical School at Long Island University in 1949-51 and at the University of Utah in 1951-54. Jack's research interest is with guanidinium compound metabolism, especially dealing with the regulation of creatine biosynthetic enzymes.

In 1954 the Medical School obtained money from the Hill Foundation (now the Northwest Foundation) to establish a research professorship in each of the basic science departments. The Foundation was to support the position for ten years after which it would be up to the University to take over the funding. It was decided that the first one to be filled would be in the area of metabolic enzymology and be located in our Department. A nation-wide search was made for an outstanding person in this area; however, there was no acceptable applicant for the position, presumably because of the 10-year limit of the assured funding. To fill the position the search continued within the University for someone who already had tenure. This resulted in Paul Boyer being lured from the Department of Agricultural Biochemistry on the St. Paul campus to become a member of our Department in 1955.

Paul was born in Utah in 1918 and received a B.S. degree in 1939 at Brigham Young University. He went to the University of Wisconsin for graduate work in Biochemistry and received the Ph.D. degree in 1943. He then went to Stanford where he was as an Instructor, and in 1946 he joined the Department of Agricultural Biochemistry in St. Paul as an Assistant Professor. When he came to our Department in 1955 he was a full Professor. His research while at Minnesota was concerned mostly with the mechanism of enzyme action, especially the mechanism of oxidative phosphorylation. In 1955 he received the Paul Lewis Award in Enzyme Chemistry from the American

Chemical Society[12].

After the departure of Saul Cohen in 1956, it was necessary to fill the position in steroid biochemistry. After an extensive search, Frank Ungar came here in the spring of 1958 as Associate Professor of Physiological Chemistry. Frank was born in Cleveland, Ohio, in 1922 and did his undergraduate work at Ohio State University, receiving the B.A. degree in 1940. After being in the Armed Services during World War II, he did graduate work at Western Reserve University and Tufts Medical School. He received the M.S. degree at Western Reserve in 1948 and the Ph.D. degree at Tufts in 1952. He then worked at the Worcester Foundation for Experimental Biology in Shrewsbury, Massachusetts, until he came to Minnesota in 1958. His area of research is the regulation of the enzymes of steroid biosynthesis. In 1953 he had already co-authored with Ralph Dorfman a major reference book on this subject, and in 1965 these authors would publish the second edition on this subject[13].

While Frank was at the Worcester Foundation, he became Director of a Steroid Training Program in 1956 funded by the National Institutes of Health. When he came to Minnesota, a similar program was established here under his supervision. This would allow a large number of Ph.D. and M.D. post-doctoral students and clinical faculty members to obtain training in this new specialized field. (Again only at Utah in Leo Samuels' Biochemistry Department did such a program exist in a Medical School[14].) As an essential part of the Training Program, Frank would continue with the teaching of the graduate course in Endocrinology begun by Saul Cohen.

Frank's coming to Minnesota was not only fortunate for the Department but also turned out to be fortunate for me personally; he not only replaced Saul Cohen in his field of expertise, but in 1959 when Frank and his family moved to south Minneapolis, he replaced Saul as my car-pooling companion. We continued to car-pool for 25 years.

In 1958-59 David Glick took a sabbatical leave. One of his graduate students, Leonard Greenberg, who had just finished his Ph.D. degree, was put in charge of Glick's laboratory and given a temporary appointment as Assistant Professor.

In 1959 a student of Wallace Armstrong's, Curtis Carlson, finished his Ph.D. degree and was appointed Instructor. He continued to work in Wallace's laboratory, and in 1961 he obtained a Research Career Development Award and was promoted to Assistant Professor. Curtis had previously obtained the M.D. degree in 1957 at the University of Minnesota.

In 1960 there was a search for a Hill Professor in Basic Dental Investigation. The person chosen for this postion was Leon Singer of our Department. The only real change that occurred at this time was the

source of Leon's salary; he remained on our faculty in the same office and laboratory and had essentially the same responsibilities.

During this period of the 1950s there was the addition of several more joint appointees to the staff.

(1) In 1951 Ralph Holman came back from Texas to join the staff of the Hormel Research Institute, and he had a joint appointment in our Department. Ralph's research is mostly with the essential fatty acids, their metabolism and minimum requirements for adequate nutrition. He has also dealt with methods of lipid analysis and oxidative deterioration of fats. (See Appendix E).

Ralph T. Holman

Ralph spent one year on the Minneapolis campus in 1958-59 when Dave Glick was on sabbatical. To fill Dave's postition on the faculty, Ralph came up from Austin and became part of the on-campus faculty in addition to directing his research in Austin from 100 miles away.

(2) In 1952 Helmut Gutmann came to the Veterans Administration Hospital to conduct cancer research, and he was offered a joint appointment. Helmut was born in Strasbourg in 1911 and received the M.D. degree at the University of Gottingen in 1936. Before coming to Minneapolis he was a Research Associate at the University of Tennesee in 1948-50 and an Assistant Professor at the University of Florida in 1950-52.

(3) In 1954 Ivan Frantz came to the Department of Medicine as the Clark Research Professor, and he was also given a joint appointment in Physiological Chemistry. Ivan was born in 1916 in West Virginia and received the B.A. degree at Duke in 1937 and an M.D. at Harvard in 1941. He served in the Armed Forces in World War II, and then he was on the faculty at Harvard in the Department of Medicine until he came to Minnesota. Ivan's area of research is concerned mostly with the intermediary metabolism of cholesterol and the relationship of blood cholesterol levels to the development of atherosclerosis.

(4) In 1955 a former Ph.D. student of Dave Glick's, Richard Von Korff, returned from post-doctoral work at the Enzyme Institute at the University of Wisconsin to accept a research position in the Department of Pediatrics with a joint appointment in Physiological Chemistry. Dick was born in Davenport, Iowa, in 1916 and received the B.A. degree in 1947 and the Ph.D. degree in

1951 at the University of Minnesota. Dick's area of research was respiratory control in isolated mitochondria and interactions between cellular respiratory systems and the glycolytic route.

(5) A student of Wallace's, Quenton Smith, obtained a research position in the Department of Dermatology in 1959. It was also arranged that he would have a joint appointment as Assistant Professor in our Department. Quenton was born in Iowa in 1929 and received the B.S. degree in 1952 and the M.S. degree in 1953 at Iowa State University. In 1965 he would move to Oral Biology in the School of Dentistry, and his research there has dealt with the biochemistry of oral secretions and oral fluid composition in human pathology.

(6) Also in 1959, Ellis Benson, Professor and Head of Laboratory Medicine, was given a joint appointment. Ellis was born in Honan, China, in 1919, and he later came to this country where he obtained the B.A. degree at Augustanna College in 1941. He then received the M.D. degree at the University of Minnesota in 1945, and, after two years in the Armed Services, he joined the faculty of the Medical School here. In 1957 he spent a sabbatical year with Prof. Linderstrom-Lang at the Carlsberg Laboratory in Copenhagen. His field of research deals with the structure and function of muscle proteins and methods of clinical chemistry.

Thus at the beginning of 1960-61 our faculty now included: Armstrong, Barnum, Benson, Boyer, Carlson, Carr, Caster, Frantz, Glick, Gutmann, Holman, Singer, Smith, Sollner, Ungar, Van Pilsum, and Von Korff.

This period of 1946-1960 might be looked upon as a time in which the Department grew up or matured. The fledgling Department in 1946 began with a minimum of faculty and with facilities of a poor quality. That maturity had been reached in 1960 can be shown in at least three areas.

(1) A major increase in Departmental space was achieved. By means of an addition in the new Lyon Laboratories in 1954 and the remodeling of space in 1957-59 that was formerly occupied by the Bacteriology Department, our space increased from less than 10,000 square feet to somewhat more than 20,000 square feet. We now had a separate Departmental office of adequate size, most of the faculty had modern laboratory facilities, and our teaching laboratory was a newly remodeled facility that was much more convenient and somewhat larger than our old laboratory. The old one had been in use for 48 years without any remodeling. A more complete description of our space changes over the years is given in Chapter X.

(2) The teaching faculty for our courses for health science professional students increased from 6 to 14. The time required for these teaching responsibilities had now become optimal in the eyes of the faculty.

(3) There was an increase in the number of graduate faculty members from 7 to 15.

This was accompanied by an increase in research grants and the beginning of training grants for graduate students from the National Institutes of Health. These changes resulted in a considerable increase in the graduate program. For example, the number of Ph.D.s granted in 1956-60 was 11, and in 1961-66 it was 25. This latter rate, averaging about five per year, was to remain essentially constant up to 1988.

References

1. Wilson's History, p. 404

2. Burr, G.O. "The Use of Radioisotopes by the Hawaiian Sugar Plantations" J. Appl. Radiat. Isotopes 13 365 (1962); Kortschak, H.P., Hartt, C.E., and Burr, G.O. "Carbon Dioxide Fixation in Sugar Cane Leaves" Plant Physiol. 40 209 (1965)

3. Ref. No. 1, Chap. III

4. Ref. No. 23, Chap. III; Anon. "Harland Wood, Active Septuagenarian" Trends in Biochem. Sci. 2 N195 (1977)

5. Murray, J. "Dr. Nathan Lifson, Scientist, Scholar, Mentor" Univ. Minn. Med. Bull., Spring 1990, p. 6

6. ibid. "Claire Hemingway" Summer 1990

7. Sollner, K. Private Communication

8. Armstrong, W.D. "Modification of the Willard-Winter Method for Fluorine Determination" J. Am. Chem. Soc. 55 1741 (1933)

9. Ref. No. 36, Chap. III

10. Visscher, M.B., Varco, R.H., Carr, C.W., Dean, R.B., and Erickson "Sodium Ion Movement between the Intestinal Lumen and the Blood" Am. J. Physiol. 141 488 (1944); Visscher, M.B., Fetcher, E.S., Jr., Carr, C.W., Gregor, H.P. Gregor, Bushey, M.S., and Barker, D.E. "Isotopic Tracer Studies on the Movement of Water and Ions between Intestinal and Blood" ibid. 550 (1944)

11. Cohen, S.L. "Fifty Years of Estrogen Assays, or How I Learned to Love the 1,3,5(10)-Estratriene Nucleus" Modern Med. of Canada 34 1626 (1979)

12. Anon. "Paul D. Boyer, Paul-Lewis Laboratories Award in Enzyme Chemistry" Chem. Eng. News 33 1514 (1955)

13. Ungar, F., (with Dorfman, R.I.) "Metabolism of Steriod Hormones" 1st ed., Burgess Publ. Co., Minneapolis, 1953; ibid.. 2nd ed., Academic Press, New York, 716 pp., 1965

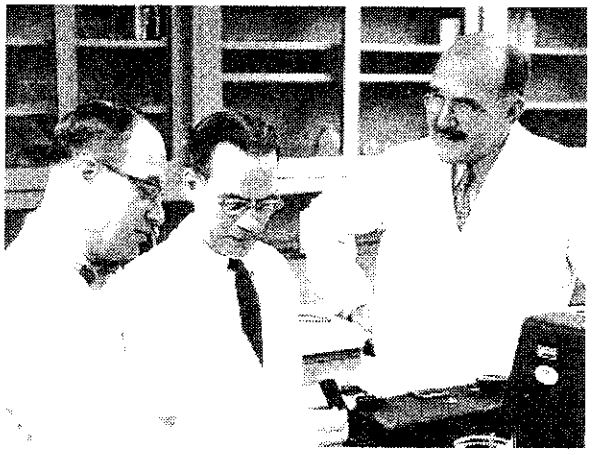
14. Ref. No. 21, Chap. III

Chapter V. Development of the Program - 1960-1974

The first few years of the nineteen sixties again saw a number of very significant changes in our faculty. As the fourth sign of our maturity, we began to lose faculty members to other schools where they were offered positions of Department Head or its equivalent. The first of these occurred in 1961 when Dave Glick was offered and accepted a very attractive position at Stanford. He became the Director of the Histochemistry Laboratory in the Pathology Department of the Medical School.

At Minnesota Dave had developed a major program in Quantitative Histochemistry, and he published more than one hundred papers on his research in this area while he was in the Department. By the time he left here his publications included 67 papers in a series entitled ``Histochemistry'' and another 22 papers in a series entitled ``Mucolytic Enzymes[1].'' He was also the advisor for five Ph.D. students and seven M.S. students.

In the early 1950s Dave obtained funds for the construction of a new laboratory in Lyon Laboratories of about 6000 square feet. In addition to establishing an extensive laboratory of histochemistry, he wrote a textbook on this subject which has been used world-wide[2], and he also started editing an annual review in this area called "Methods in Biochemical Analysis[3]." He continued to edit this series until he was eighty, finally stepping down from that with the publication of Vol. 33 in 1988.



David Glick, left, with John Bittner and Maurice Visscher in the new Lyon Laboratories Building. (Univ. Minn. Archives)

The position Dave Glick vacated was filled the following year when James Koerner came from the Massachusetts Institute of Technology where he had been doing post-doctoral work with Professor Buchanan. Jim was born in Iowa in 1929 and received both his undergraduate and graduate training at Iowa State University. He received the B.S. degree in 1950 and the Ph.D. degree in 1956. He went to MIT for post-doctoral work from 1956-61. His research area was concerned with the enzymes of DNA hydrolysis until 1975 at which time he changed fields to take up neurochemistry, especially the biochemistry of

of neurotransmitters and receptors.

In 1961 one of Paul Boyer's students, Mary Dempsey, finished her Ph.D., and she began post-doctoral work with Ivan Frantz. In 1962 she also received a joint appointment in the Department, and in 1965 she was appointed to a tenure-track position in the Department. Mary was born in St. Paul in 1928 and had her undergraduate training at St. Catherine's College in St. Paul, receiving the B.A. degree in 1950. She obtained an M.S. degree at Wayne State University in 1952. She then returned to the Twin Cities and worked as a Research Biochemist at the VA Hospital until 1956. She was an Instructor in Clinical Biochemistry in 1955-58, and then she began graduate work in our Department. Mary's research is in the field of lipid metabolism with special emphasis on the structure and function of lipoproteins and membrane-bound enzymes.

Also in 1961 it was decided that the Department should have a physical biochemist added to the staff. After a search was made, Donald Wetlaufer was hired and came here in 1962. Don was born in Wisconsin in 1925 and received both his undergraduate and graduate training at the University of Wisconsin. He received the B.S. degree in 1946, the M.S. degree in 1952, and the Ph.D. degree in 1954. He then spent two years at the Carlsberg Laboratories in Copenhagen in 1955-56 and then returned to this country where he was at Harvard for five years. He was then appointed as Assistant Professor at the University of Indiana in 1961-62. His research interest is on the structure, stability, and functions of biopolymers, especially proteins.

In 1962 another former student, Ernest Gray, returned to Minnesota after two years of post-doctoral work in Scotland and two years at Columbia University in New York City, to accept a research position in the Department of Pediatrics. He also received a joint appointment in our Department. Ernie was born in Winnipeg, Manitoba, in 1930. He received a B.S. degree in Pharmacy at the University of Manitoba in 1952 before coming here for graduate work in 1952. His area of research is nucleic acids, protein synthesis and cellular immunolgy.

In 1963 Robert Bernlohr was appointed Assistant Professor in the Department of Microbiology. He had a Ph.D. in biochemistry, and he was given a joint appointment in our Department in 1965. Bob was born in Columbus, Ohio, and he obtained the B.S. degree at Capitol University in Columbus in 1955 and the Ph.D. degree in biochemistry at Ohio State in 1958. He spent two years as a Fellow at Oak Ridge and two more years at Ohio State as an Assistant Professor before coming to Minnesota. Bob's research deals with microbial biochemistry.

Another event occurred at this time that did not involve faculty changes. At the graduate level in biochemistry there was a development of interest for a general course in biochemistry for students in chemistry and chemical engineering and also for doing some-

thing to improve the graduate program. In 1962 Dean Bryce Crawford of the Graduate School appointed an advisory committee to consider these problems[4]. It should also be pointed out that about this same time a new Department Head, LaVell Henderson, arrived on the St. Paul campus in the Department of Agricultural Biochemistry, and also that Department was about to be transferred from the College of Agriculture into the new College of Biological Sciences.

The results of most of the deliberations of the advisory committee will be described in some detail in Chapter VIII. One of the items that is of interest at this point was the consideration by the committee for a change in the name of the departments. It was the desire of the St. Paul Department to be ``Biochemistry,'' dropping the Agricultural. It was felt that the adjective somewhat limited the scope of the activities of the Department, and it was the aim of the Department to encompass all aspects of Biochemistry. When Wallace Armstrong heard of this proposal, he objected, for he felt this would make the St. Paul Department ``The Department of Biochemistry'' at the University and relegate the Minneapolis Department to secondary status. After further consideration, it was decided that both departments would be called Biochemistry. Thus the Department of Physiological Chemistry also had its name changed to Biochemistry. The only distinction that would be made was that the address of one would be St. Paul and be located in the College of Biological Sciences, and the address of the other would be Minneapolis and be located in the Medical School. The Board of Regents approved of this change on January 11, 1963.

In 1963 changes in the faculty continued to take place. After a period of 10 years during which time no new graduate students came to Karl Sollner's laboratory at the National Institutes of Health, it was decided that his graduate appointment in our Department would be terminated. During his association with the Department, he was advisor to six Ph.D. students and two M.S. students. The results of their thesis work was published in 25 papers, the work dealing with the basic physical chemistry of membranes[5]. He continued this line of research at NIH, and he pioneered the development of liquid membranes which have become so useful today, especially for ion-selective electrodes[6]. Dr. Sollner retired from the National Institutes of Health in 1973 but maintained an Emeritus status there until he died in 1986[7].

We suffered another loss of a distinguished faculty member when Paul Boyer left here to go to the University of California at Los Angeles where he was to become Director of the newly-established Molecular Biology Institute. At UCLA Paul continued to distin guish himself in the field of biochemistry. He has been elected to the National Academy of Sciences, he has received the William A. Rose Award in Biochemistry, and he served as President of the American Society of Biological Chemists in 1969-70.

Paul D. Boyer. (Univ. Minn. Archives)

During Paul's eight years in our Department, among other things, seven graduate students earned the Ph.D. degree in his laboratory, and at least a dozen post-doctoral fellows spent one year or more in his laboratory. He also taught a graduate course in Metabolic Enzymology. His publications while in our Department were nearly all on the mechanism of enzyme action and oxidative phosphorylation and numbered about forty[8]. In 1959 he joined Karl Myrback and Henry Lardy as co-editors of the second edition of ``The Enzymes,'' a two-volume treatise on the subject[9]. In 1970 he would become the sole editor for a 15-volume set that would be the third edition.

For several years Wallace tried to get a new position established so that we could teach a separate course for the medical technologists. Up to this time they had almost always been included in the course for the medical students, but this was never considered the best arrangement for either group of students. The medical technologists had prerequisite training of only two years in college-whereas the medical students had three to four years. In addition the standards of admission for the medical students were higher than for the medical technologists. As a result the two groups were graded with separate standards. Finally in 1963 we got the new position, and a search was made for an assistant professor.

The result of the search was that Ronald Edstrom joined the Department in 1964. Ron was born in 1936 in Oakland, California, and received the B.A. degree at the University of California, Berkeley, in 1958 and the Ph.D. degree at the University of California, Davis, in 1962. He then went to the University of Michigan for post-doctoral work with Professor Edward Heath in 1963, and when Prof. Heath moved to Johns Hopkins University, Ron went with him and stayed there until coming to Minnesota. His field of research is cellular biochemistry with special emphasis on calcium and cyclic nucleotide-dependent protein phosphorylations in the regulation of carbohydrate metabolism in muscle.

In 1964 Bill Caster accepted a position as Professor of Nutrition at the University of Georgia. Three years previously he had moved to the St. Paul campus in the College of Veterinary Medicine where he had the responsibility for the teaching of Physiological Chemistry to the first year students in Veterinary Medicine. During this time he maintained his appointment in our Department.

While in our Department, Bill was an

author of some 20 papers. In the project sponsored by the Atomic Energy Commission, his work was concerned mainly with the effect of radiation on biological tissues[10]. It was during this time in the 1950s that considerable concern developed over the fallout of strontium-90 from the atomic bomb tests, and Bill devoted some of his efforts to the study of the distribution of strontium in the biosphere and the effects of its radiation on human tissue. When he moved to the St. Paul campus, he collaborated with Ralph Holman in studies with lipids[11].

Also in 1964 Curtis Carlson left our Department to make a career change. He began a residency program in psychiatry at the VA Hospital and became a practicing psychiatrist. He died suddenly in 1987.

The next two years again saw some more very significant changes in our staff. In the first of these Joseph Larner was appointed to the Hill Professorship in Metabolic Enzymology. Dr. Larner was born in Brest-Litovsk, Poland, and later came the United States where he received the B.A. degree at the University of Michigan in 1942 and the M.D. degree at Columbia University in 1945. He then went on to get an M.S. degree at the University of Illinois and the Ph.D. degree at Washington University in St. Louis in 1951. He served as Instructor at Washington University in 1951-53, Assistant Professor at the University of Illinois in 1953-57 and Professor in the Pharmacology Department at the Case Western Reserve Medical School for seven years before coming to Minnesota in 1964. His research is concerned with intermediary metabolism, especially the genetic and hormonal control of glycogen metabolism.

The second change came about as the result of a real tragedy, the sudden death of Cy Barnum from a massive heart attack in the summer of 1965. He was teaching in our summer course, P. Chem.. 100-101, and he had given a lecture at eleven o'clock. During the noon hour, I talked with him about the upcoming exam in which we both had questions. Imagine my surprise when I heard at 2:30 that afternoon that he was dead! It was a great shock, and it was truly a great loss to the Department.

Cy was a wonderful teacher, not only in classroom lectures but also in the other aspects of teaching such as teaching in small groups (seminars, etc.), advising students, and examination preparation and grading. In recognition of his teaching abilities, a memorial fund has been established in the Department which honors the outstanding teaching assistant each year (the Barnum Distinguished Teaching Award).

Cy's research was very productive. In the early 1940s he collaborated with Wallace Armstrong in the use of radioactive phosphorus to study the turnover of phosphate in bone[12]. Shortly after that he began to use the radio-phosphate methodology in the field of nucleic acid chemistry; at that time nucleic acid chemistry was not in the mainstream of biochemical research. He stayed with it,

however, and in the 1950s it became one of the leading fields of interest.

In Cy's research work he introduced into the Department the use of differential centrifugation for the separation of the various types of cell particulates. His studies included nucleic acid metabolism in proliferating tissues such as regenerating liver and cancer, the effect of ionizing radiation on genetic material, and metabolic changes associated with diurnal cycles[13]. Sixteen graduate students earned the Ph.D. degree in his laboratory between 1950 and 1965, about one third of the total in the Department.

Cyrus P. Barnum, Jr. (Univ. Minn. Archives)

Cy also served for many years as *de facto* Associate Department Head, and he was Acting Head for six months in 1960-61 when Wallace took a leave to work in Sweden.

During the following year it was decided to try fill Cy's position with a highly competent person at the professorship level. The person chosen for this position was Finn Wold, who had been at the University of Illinois for several years. By everyone's assessment this turned out to be an excellent choice. Finn was born in Norway in 1928. He received the B.S. degree at the University of Oslo in 1950 and then came to this country. He received the M.S. degree at Oklahoma State University in 1953 and the Ph.D. degree at the University of California, Berkeley, in 1956. He was a Research Associate at Berkeley in 1957 and then joined the faculty at the University of Illinois where he remained until he came here. Finn's area of research is protein and enzyme chemistry with special emphasis on post-translational modification of proteins.

In 1965 the appointment of Dick Von Korff was switched from Pediatrics to our Department, and in 1966 he left to go to Maryland to become Director of Research for a program established by the Friends for Psychiatric Research at a Maryland State Hospital. He later went to the Dow Polymer Institute in Midland, Michigan, in a position from which he retired in 1984. While he was at Minnesota, he was the advisor for 2 students who received the Ph.D. degree and 5 students who received the M.S. degree.

A search to fill the vacated position led to James Bodley coming here as as Assistant Professor in January 1967. Jim was born in Oregon in 1937 and did his undergraduate work at Walla Walla College and received the B.S. degree in 1960. He then went to University of Hawaii where he received the

Ph.D. degree in 1964. He went from there to the University of Washington for post-doctoral work with Professor Earl Davie, and he came from there to Minnesota. His research is concerned with protein biosynthesis and RNA structure and function.

After the many changes of these last few years, there was a lull for the next two years with nary a move. In 1968 Venketaswarlu Pothapragada, a former student of Wallace Armstrong, came back to Minnesota after having been in India for six years. He joined Wallace's research group again, and he was appointed as Assistant Professor with some teaching responsibilities in the course for dental students. He left the Department in 1974 at the time of Wallace's retirement and joined the 3M Company where he is still employed.

As so often has been the case at the University of Minnesota, once a faculty member is established here as a very competent individual, offers of prestigious professorships come from other institutions. During this period of the 1960s with several highly competent faculty members leaving the Medical School, I was reminded by a colleague in another department that this was one of the functions of a large, first class state university, to be the training ground for some faculty to move to other institutions in positions of greater responsibility. And so it was that in 1969 our next change occurred when Joe Larner left to become Head of the Department of Pharmacology at the University of Virginia. Thus for the third time in this decade, we lost an extremely able faculty member to another school at a position of Department Chairman or its equivalent.

During the time that Prof. Larner was in the Department, he published about 20 papers, almost all of them dealing with the hormonal control of glycogen metabolism[14]. He also gave lectures in the course for medical students, taught the graduate course in Metabolic Enzymology, and was the advisor for 3 Ph.D. students and 2 M.S. students.

Also in 1969 the National Institutes of Health started its Physicians Augmentation Program (PAP) to encourage medical schools to increase their enrollments. Large grants to finance new buildings and new faculty were made, the amounts depending on the size of the increase in the entering classes. Our school decided to increase the size of the class from 165 to 225, a very large increase. This resulted in enough new funds for our Department to add two new assistant professors. In 1970 we began a search to fill these new positions, and in the summer of 1971 we had hired two assistant professors.

Robert Roon came from the University of California, Berkeley, where he had been doing post-doctoral work with Professor H. A. Barker. Bob was born in Michigan in 1943 and attended Calvin College in Michigan receiving the B.S. degree in 1965. He went to the University of Michigan for graduate work and obtained the M.S. degree in 1967 and the Ph.D. degree in 1968. His research

deals with metabolism of nitrogen compounds and the active transport of amino acids.

James Howard also came from the University of California, Berkeley, fresh from post-doctoral work with Professor Glaser. Jim was born in Indiana in 1943 and got his B.A. degree at De Pauw University in Indiana. For graduate work he went to the University of California at Los Angeles and got a Ph.D. in Biochemistry in 1968. Jim's area of research is concerned with protein chemistry and enzymology, especially post-translational modifications and iron-sulfur proteins.

In 1969 the Department of Obstetrics and Gynecology established a research position for a biochemist. Erlio Gurpide was hired for this position, and he had a joint appointment with us. He left the position in 1972, and William Kelley soon replaced him.

Also in 1969 Everett Short in the College of Veterinary Medicine was given a joint appointment because he was the course director and doing much of the teaching in the biochemistry course for the students in Veterinary Medicine. He had obtained the Ph.D. degree in our Department with Jim Koerner in 1968. In 1973 he became Associate Dean of Veterinary Medicine, and in 1978 he went to Oklahoma State University where he was named Head of Veterinary Sciences in the College of Veterinary Medicine.

During the period of the early seventies, several other joint appointments were also made. These included: Andreas Rosenberg of the Department of Laboratory Medicine and Pathology, Agnes Tan, Daniel Gilboe, and Govind Vatessary of the VA Hospital, Charles Blomquist from the Department of Obstetrics and Gynecology at St. Paul Ramsey Hospital, and Albert Notation of the Department of Obstetrics and Gynecology in the Medical School. There was also one loss of a joint appointee when Ellis Benson resigned from that appointment because of his responsibilities he had taken on as Head of the Department of Laboratory Medicine and Pathology. He had been the advisor for one Ph.D. student and one M.S. student in Biochemistry.

Thus at the end of 1973-74, our staff included: Armstrong, Blomquist, Bodley, Carr, Dempsey, Edstrom, Frantz, Gilboe, Gray, Gutmann, Holman, Howard, Kelley, Koerner, Notation, Roon, Rosenberg, Short, Singer, Smith, Tan, Ungar, Van Pilsum, Vatessary, Wetlaufer, and Wold.

References

1. e.g., Good, R.A., Kelley, V.C., Good, T.A., and Glick, D. ``Mucolytic Enzyme Systems. XX. Comparison of Mucoprotein and Hyaluronidase Inhibitor Concentrations in the Maternal and Infant Serums'' Peds. 575 (1953); Glick, D. and Greenberg, L.G. ``Quantitative Histological Distribution of the Succinic Dehydrogenase System in the Rat Adrenal and the Influence of Hypophysectomy, Adrenocorticotropin (ACTH), and Cortin'' Endocrin. 63 778 (1958); Glick, D. and Ferguson, R.B. ``Histochemistry. LXVII. Microscopic Microbiology Assay. Determination of Biotin to Gram'' Proc. Soc. Exptl. Biol. Med. 109 811 (1962)

2. Glick, D. ``Quantitative Chemical Techniques of Histo- and Cytochemistry'' Interscience Publishers, New York

   Vol. I. ``Histochemistry'' 1961

   Vol. II. ``Biological Chemistry, Laboratory Manual'' 1963

3. Glick, D., ed., ``Methods of Biochemical Analysis'' Vol. 33, John Wiley & Sons, 1988

4. Dept. of Biochemistry files, Letter to the Committee from Paul Boyer, Chairman

5. Sollner, K. ``Ion Exchange Membranes'' Ann. N.Y. Acad. Sci. 177 1953; ``The Electrochemistry of Porous Membranes,'' Chap. 4 in ``Electrochemistry in Biology and Medicine,'' T. Shedlovsky, ed., John Wiley, New York, 1955

6. Sollner, K. and Shean, G.M. ``Liquid Ion Exchange Membranes of Extreme Selectivity and High Permeability for Anions'' J. Am. Chem. Soc. 86 1901 (1964)

7. Anon. ``In Memoriam, Dr. Karl Sollner, 1903-1986'' The Record, National Institutes of Health, July 1986, p. 7

8. e.g., Boyer, P.D. ``Uses and Limitations of Measurements of Rates of Isotopic Exchange and Incorporation in Catalyzed Reactions'' Arch. Bioch. Biophys.82 387 (1959); Boyer, P.D. ``Mechanism of Enzyme Action'' Ann. Rev. Bioch. 29 15 (1960); Boyer, P.D. and Silverstein, E. ``Equilibrium Reaction Rates and Enzyme Mechanisms'' Acta Chem. Scand. 195 (1963); Boyer, P.D., Suelter, C.H., De Luca, M., Peter, J.B., and Dempsey, M.E. ``On the Nature of Intermediates in the Oxidative Phosphorylation Process'' Proc. 5th Intl. Cong. Bioch. 274 (1963)

9. ``The Enzymes'' Vols. I & II, Boyer, P.D., Myrback, K., and Lardy, H., eds., Academic Press, Inc., New York, 1959

10. e.g., Caster, W.O. and Armstrong, W.D. ``Electrolyte Metabolism after Total Body X-Irradiation'' Radiation Research 189 (1956); Caster, W.O. ``Strontium-90 Hazard: Relation between Maximum Permissible Concentrationand Population Mean'' Science 125 1291 (1957)

11. e.g., Caster, W.O. and Holman, R.T. ``Statistical Study of the Relation between Dietary Linoleate and the Fatty Acids of Heart and Blood Lipids'' J. Nutr. 73 337 (1961); Caster, W.O., Ahn, P., Mohrhauer, H., and Holman, R.T. ``Determination of Linoleate Requirement of Swine by a New Method of Estimating Nutritional Requirement'' J. Nutr. 78 147 (1963)

12. Barnum, C.P., Jr., and Armstrong, W.D. ``In Vivo and In Vitro Exchange of Phosphorus by Enamel and

Dentin'' Am. J. Physiol.135 478 (1942); ibid, ``The Use of Radioactive Calcium in the Study of Teeth and Bones'' J. Dental Res. 21 326 (1942)

13. e.g., Barnum, C.P., Jr., and Huseby, R.A. ``Some Quantitative Analyses of Particulate Fractions from Mouse Liver Cell Cytoplasm'' Arch. Bioch. Biophys. 9 17 (1948); Barnum, C.P., Jr. and Halberg, F. ``A 24-Hour Periodicity in Relative Specific Activity of Phosphorus Fractions from Liver Microsomes of Mice'' Metabolism, Vol. , No. 3, pp. 271-275 (1953); Jardetzky, C.D., Barnum, C.P., Jr., and Vermund, H. ``Deoxyribonucleic Acid and Phospholipid Metabolism in Regenerating Liver and the Effect of X-Radiation'' J. Biol. Chem. 222 421 (1956); Jardetzky, C.D. and Barnum, C.P., Jr. ``Metabolic Activity and Intracellular Distribution of Nucleic Acid Phosphorus in Regenerating Liver'' Arch. Biochem. Biophys. 6 350 (1957)

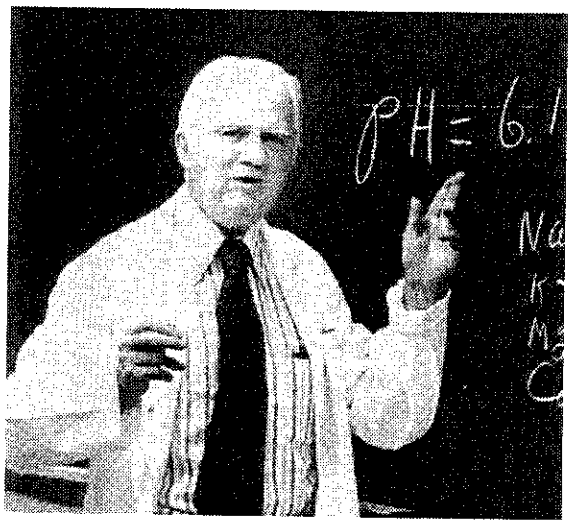
14. e.g., Larner, J.L. ``Hormonal and Non- hormonal Control of Glycogen Metabolism''Trans. N. Y. Acad. Sci. 29 192 (1966); Larner, J.L., Villar-Palasi, C. Goldberg, N.D., Bishop, J.S. Huijing, F., Wenger, J.I., Sasko, H., and Brown, N. ``Hormonal and Nonhormonal Control of Glycogen Synthesis. Control of Transferase Phosphatase and Transferase Kinase'' Adv. Enzyme Regul. 6409 (1968); Larner, J.L., Villar-Palasi, C., Goldberg, N.D., Bishop, J.S., Huijing, F., Wenger, J.I., Sasko, H., and Brown, N. ``Hormonal and Nonhormonal Control of Glycogen Synthesis - Control of Transfersase Phosphatase and Transferase I Kinase'' Prog. Endocrinol., Proc. Intl. Congr. Endocrinol., 3rd, 1968, (Publ. 1969) p. 137; Villar-Palasi, C. and Larner, J.L. ``Hormonal Regulation of Glycogen Metabolism in Muscle'' Vit. Horm. (N.Y.) 26 65 (1968)

Chapter VI. Development of the Program - 1974-1988

The next period of change begins with the retirement of Wallace Armstrong and the search for a new Department Head. In the early seventies the mandatory retirement age at the University was 68. (It has since been changed to 70 and will be eliminated entirely in 1994). This meant that Wallace would be required to retire on June 30, 1974. He did not feel ready for retirement, but he had no choice.

During his tenure as Department Head, Wallace directed an extensive and very productive research program concerned with calcium metabolism, the biochemistry of bones and teeth, and the effect of fluoride on various biological systems. He published more than 150 papers and was internationally recognized as an authority in these areas[1]. In his research he collaborated with many other individuals at the international, national, and local level, and he participated in many national and international conferences. He was a member of many scientific organizations, and he was elected president of the International Association for Dental Research in 1945-46[2,3]. As a result of his work, he received many honors and awards both in this country and abroad for his scientific contributions.

In 1966 he received the ``Biological Mineralization Award'' from the International Association for Dental Research for his work with fluoride, and he received their ``H. Trendley Dean Award'' in 1967. For his contribution to Dentistry he received a Doctorate of Odontology, Honoris Causa, from the University of Stockholm in 1955. He was elected to honorary membership in the American College of Dentistry in 1958 and in 1966 received the ``William John Gies Award'' for ``his leadership and meritorious service.'' Finally it should be emphasized that at the time of his retirement, the University bestowed on him the title of Regents Professor, its highest honor.



Wallace D. Armstrong, ca. 1970.

Wallace had great interest in teaching, and he put much effort into maintaining high standards for both the programs of the health science professional students and the graduate students. He set an example for his

colleagues by the quality of his own instruction and his interaction with students. He was the advisor for 13 students who received the Ph.D. degree; for 6 of these individuals, Leon Singer served as a co-advisor.

He also worked ceaselessly to improve the quality and quantity of the faculty and the facilities for research in the Department. In 28 years the faculty grew from 5 tenured positions to 12. He directed a major increase in departmental space in the period 1957-59 and later played a key role in the planning for the remodeling and increase in space that was completed in 1978. From the time the Department was formed until he retired, Wallace never took a full year's sabbatical leave. He did, however, take a six-month sabbatical in the winter and spring quarters of 1961 and a single quarter leave in the winter of 1973.

Wallace also had some unusual interests outside of his science. He was an avid student of the Civil War with particular interest in the health care given the Union and Confederate armies. Also, for many years he was a member of the ``Baker Street Irregulars,'' an international society of Sherlock Holmes fans. This society had been formed to study, discuss, and enjoy the work of the famous fictional detective, Sherlock Holmes[3].

When Wallace retired, he was fortunate in that he was offered the chance to be the Interim Director of Intramural Research at the National Institute for Dental Research, a position for which he was eminently qualified. He was reluctant to leave Minnesota, but he finally accepted this position, and he and his wife, Mary, left Minnesota for Washington in August, 1974.

After two very productive years in Washington, Wallace returned to the University. As Regents' Professor Emeritus he continued his research on fluoride until his death in 1984. In his honor a memorial fund has been established from which awards are made each year to the outstanding medical student and outstanding dental student in their first year biochemistry courses.

In the fall of 1973, anticipating Wallace's retirement, Dean Gault appointed a search committee for Wallace's successor. It was decided by the Medical School Administration that the new Head should be recruited from outside the University. It was also agreed that $100,000 would be added to the Department's budget for three new positions at the assistant professor level, and that $100,000 would also be available on a one-time basis for the new Head to use as necessary for his or her own laboratory and for equipment for the three new staff members. These were considered to be inducements to help attract a very capable person for this position. I should mention at this point that the Dean had assured us that he would not appoint anyone to this position until he had consulted with us concerning our opinions of the person being considered. As the reader will see, this turned out to be

very important for us.

The committee went to work, and in December it presented a list of six possible candidates to the Dean. The Dean soon found out that five of them, for one reason or another, were not interested in the position. The Dean then invited the remaining candidate for a visit at the end of January. The candidate was here for two days, looking over the facilities and talking with all parties concerned including the faculty. The day after the visit (Friday) our faculty had an informal meeting in the Campus Club, and it was unanimously agreed that this individual was not suitable. (This was quite unusual for the members of an academic department to be in complete agreement on such an important subject!) Three of us were directed to draft a letter to the Dean outlining our objections. The letter was written over the week-end, everyone signed it on Monday, and it was delivered to the Dean immediately. The outcome of the search was that this person was dropped from further consideration.

The search committee went back to work to come up with some more possible candidates, and two individuals were invited here in April and early May. The result of these two visits was that we liked one candidate very much, Daniel Lane, and did not care for the other one at all. The Dean then invited Dan for a second visit. It turned out that because of earlier commitments, Dan could not return for a second visit until September. At this point it was clear that we would not have a Department Head on July 1, and the Dean asked me if I would serve as Acting Head until he could persuade Dan to take over. Having served in this capacity for one quarter when Wallace was on leave in 1973, I agreed to this, for it appeared to be for a period of not more than six months. A system of Departmental committees was already in place to deal with much of the administrative decisions and planning for the interim.

It should also be pointed out here that another big change in our faculty occurred. One year earlier LaVell Henderson, Head of the Department of Biochemistry in the College of Biological Sciences, announced that he would step down from his position as Department Head on June 30, 1974, coincident with Wallace's retirement. This would allow the possibility for the University Administration to join the two departments into one at a relatively convenient time if it so wished. However, this was not seriously considered, and both departments were thus conducting searches for new Heads at the same time.

The St. Paul Department was no more successful than the Minneapolis Department in attracting an outsider, and in March 1974 they persuaded Finn Wold of our Department to become their new Head on July 1. He accepted this appointment with the proviso that it be for five years only. What was our loss was St. Paul's gain, for if

an internal appointment for Department Head had been considered in 1975 for our Department, Finn would have been essentially a unanimous choice with the faculty.

While Finn was in our Department, he published a considerable amount of work dealing primarily with enzyme inhibitors and the chemical modification of enzymes plus a textbook, ``Macromolecules, Structure and Function[4].'' He also gave lectures in many of our courses, and he was the advisor for 5 Ph.D. students and 1 M.S. student.

Thus at the beginning of the 1974-75 academic year, we not only were without Wallace, we no longer had Finn; in addition, Frank Ungar was to be on sabbatical leave for the year. To make up this depletion in our graduate program, planning was begun in the summer of 1974 for a major symposium on a current biochemical topic to be held in the spring of 1975. It worked out so well that this event would be continued for several more years. (See Appendix G).

In September 1974 Dan Lane came for a second visit, and he was given the royal treatment with the hope that he would accept our position. Somewhat to our surprise and greatly to our disappointment, in early October he finally said he preferred to stay at Johns Hopkins. So, once more the search started from scratch, and we continued with our short-handed staff. During the winter more candiates appeared, and one, John Law, was considered to be very desirable by us. He came back for a second visit, was offered the position, and again we were rejected. Thus in March, 1975, it was clear that we were going into the 1975-76 academic year without a new Head.

Another search was begun in the spring, and two more candidates came for visits. Again, one of them, William Lands, was considered to be desirable. (It seemed that if their names began with La, we would like them!) In the late summer Dr. Lands came back for a second visit and was offered the position. Once more at the end of September, we were turned down.

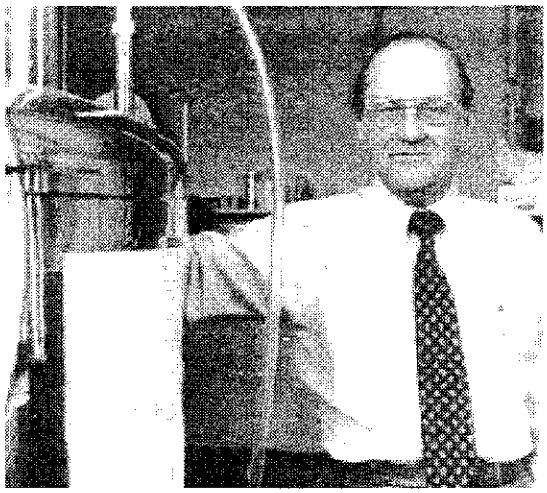
At this point I should mention another loss in the Department that occurred in the spring of 1975. In May Don Wetlaufer was offered and accepted the position of Dupont Professor and Head of the Department of Chemistry of the University of Delaware. While Don was in the Department his research dealt mostly with the physical chemistry of proteins, and he published many papers on this subject[5]. He also took part in the teaching of several courses, and he was the advisor for 9 Ph.D. students and 3 M.S. students.

Thus going into the academic year 1975-76, we would be without one more professor. This brought to three the number of full professorships that had been vacated in one year's time. After the turn-down by Bill Lands in the fall of 1975, the search committee went back to work. In December we had visits by five more prospective candidates, and after these visits the search

committee sent the names of two of them whom they wished the the Dean to consider further. We also told the Dean that of the two, we had a very definite preference for one, Harry Hogenkamp, of the Biochemistry Department at the University of Iowa. Harry came for a second visit, and our preference for him was strongly solidified. The Dean then offered him the position, and luckily for us he accepted. He would become the Head of the Department on September 1, 1976.

Harry was born in Doesburg, The Netherlands, in 1925. At the end of World War II he served in the Dutch Army for three years, spending most of this time in Indonesia. After getting out of the Army, he went to Calgary, Alberta, and worked for a year. During this time his supervisor suggested that he should go to college. He and his wife, Lieke, went to Vancouver where Harry attended the University of British Columbia. He got a B.S. degree in 1957 and an M.S. degree in 1958. Then he went to the University of California, Berkeley, for more graduate work and received a Ph.D. in Biochemistry in 1962, working with Professor H. A. Barker. He then worked for one year for the Fisheries Research Board in Canada, and in 1963 he joined the Department of Biochemistry at the University of Iowa as an Assistant Professor. He became a full Professor in 1972.

Harry's research interests include the biochemistry and mechanism of action of the cobamide enzymes and characterization of thioredoxins and ribonucleotide reductases. He also wanted to use nuclear magnetic resonance to study molecular structure, and he was the prime mover in getting the first equipment for this kind of research in the Medical School. A 250 megahertz unit was obtained in 1980, and larger 500 megahertz unit in 1988.



Harry Hogenkamp

Although Harry was not picked until the fifth round of the search, I feel that we were lucky. It is like the fellow seeking a wife who is turned down by the first three girls whom he would have liked to marry. Then the fourth one accepts him, they are married, and it turns out that she was better for him than any one of the first three.

Two changes in our joint appointees occurred in 1974-75. Bob Bernlohr left the University to become Head of the Department of Microbiology, Biochemistry, and Biophysics at Penn State University. Bob was the advisor for 4 students who received the

Ph.D. in Biochemistry. It is also interesting to note here that Bob's son, David, is now an Associate Professor in the Department of Biochemistry on the St. Paul campus.

Also during the 1974-75 academic year the Department of Orthopedic Surgery under the leadership of their new Head, Roby Thompson, added a research biochemist to their staff, Theodore Oegema. Ted had been hired by Dr. Thompson in consultation with our faculty. Thus we were ready to accept Ted as a joint appointee our faculty. Ted was born in 1945 and went to Hope College in Michigan where he received the B.A. degree in 1967. He then went to the University of Michigan for graduate work. He received the Ph.D. degree in Biochemistry in 1972 and continued with post-doctoral work there until 1974, at which time he came to Minnesota. Ted's field of research includes proteoglycan and complex carbohydrate chemistry and matrix biochemistry.

In November of 1975 we had anticipated that there would be a permanent Department Head going into 1976-77, if not from outside the University, then from the inside. Thus we requested from Dean Gault the opportunity to begin the search for new assistant professors. We felt that we could do the initial screening, and that by the time a new Head was selected, that person could be involved in the final selection process. This way, instead of waiting for a new Head to be on board, we could get our first new appointees a year earlier. The Dean agreed with this, and a search committee was set up with Jim Koerner as chairman and Frank Ungar and Bob Roon as the other members. By the time the committee was ready to process the approximately 250 applications, Harry had agreed to be our new Head, and, as had been anticipated, he was involved in the search almost from the beginning.

In the spring and early summer of 1976 several applicants were interviewed, and the consensus choices of the faculty were offered positions in August. As a result of this search, the three individuals who accepted our offers were Nancy Martin, John Lipscomb, and Dennis Livingston. John came to the Department in March 1977, Nancy in June, and Dennis in September.

John Lipscomb was born in Delaware in 1947 and received his B.A. degree at Amherst College in 1969. For graduate work he went to the University of Illinois and obtained an M.S. degree in 1971 and the Ph.D. degree in 1974. He then came to the Gray Freshwater Biological Institute at Navarre, Minnesota, where he carried out post-doctoral work until 1977, at which time he joined our staff. John's research is concerned with oxygenase mechanisms, biodegradation, and metallo-proteins.

Nancy Martin was born in Illinois in 1948 and received her undergraduate education at Pritzer College in Claremont, California where she obtained the B.A. degree in 1970. She then went to Harvard where she obtained the M.S. degree in 1973 and the Ph.D.

degree in 1975. For the next two years she did post-doctoral work at the University of Chicago, and she came to Minnesota in 1977. Nancy's area of research is with yeast genetics, dealing particularly with mitochondrial DNA and RNA.

Dennis Livingston was born in California in 1946 and attended the University of California, Davis, receiving the B.A. degree in 1968. He then went to Harvard where he received the Ph.D. degree in 1974. In 1974 he went to the University of Washington for post-doctoral work and stayed there until he came to Minnesota in 1977. His area of research is the biochemistry of genetic recombination.

In June of 1976 a very tragic event occurred when Bill Kelley died unexpectedly. Bill, a member of the Obstetrics and Gynecology Department, had been a joint appointee only a short time, and he was very much interested in the affairs of the Department. From the time he first met Harry, he had been a very enthusiastic supporter of Harry's candidacy for Department Head.

Also at this time another joint appointee from the Department of Obstetrics and Gynecology, Albert Notation, accepted a position as Professor of Chemistry at Quinnipiac College in Connecticut. Albert had originally come into the Department on the Steroid Training program, and later was appointed Assistant Professor.

At the end of 1976-77 our staff was now: Blomquist, Bodley, Carr, Dempsey, Edstrom, Frantz, Gilboe, Gray, Gutmann, Hogenkamp, Holman, Howard, Koerner, Lipscomb, Livingston, Martin, Oegema, Roon, Rosenberg, Singer, Smith, Tan, Ungar, Van Pilsum, and Vatessary.

We still had two unfilled positions, and another search was started. From this search we obtained one new faculty member, Kenneth Adolph, who joined us in November 1978. One of the other candidates was a woman to whom we made an offer, and she did not come because we could not arrange a position for her husband, who was an astrophysicist. She eventually went to Massachusetts Institute of Technology.

Ken Adolph was born in 1944 in Oldham, England, and after coming to this country, attended the University of Wisconsin, receiving the B.S. degree in 1966 and the M.S. in 1967. He then went to the University of Chicago where he obtained the Ph.D. degree in 1972. He spent two years doing post-doctoral work with Prof. Aaron Klug at the Laboratory of Molecular Biology in Cambridge, England, in 1973-74, and then came back to this country for a year at the Rosenstiel Basic Medical Science Center at Brandeis University. The next two years were spent at Princeton University prior to his coming to Minnesota. Ken's research deals with chromosome structure and non-histone proteins.

In 1979 Nancy Martin resigned from the Department to take a similar position at the

University of Texas in Dallas where her husband-to-be had accepted a position. He was unable to get a suitable position at Minnesota. Thus when a new search was initiated, we would be looking for two assistant professors, for we were still lacking one in the three new positions that had been established by the Dean. This time two of our top candidates accepted our offers, David Thomas and Howard Towle.

Howard Towle was born in Pennsylvania in 1947 and received the B.S. degree in 1971 and the Ph.D. degree in 1974, both at Michigan State University. He spent two years as a post-doctoral fellow with Prof. Bert O'Malley at the Baylor College of Medicine, 1974-76. He then came to the University of Minnesota to carry out research work in the Endocrinology Section of the Department of Medicine. He remained there until he joined our Department in 1979. His research specialty is hormonal and nutritional regulation of gene expression.

David Thomas was born in Michigan in 1949 and did both his undergraduate and graduate work at Stanford, getting the B.S. degree in 1971 and the Ph.D. degree in 1976. He carried out post-doctoral work at Harvard in 1977 and returned to Stanford as a Helen Hay Whitney Fellow for two years before coming to Minnesota. Dave's field of research is the molecular dynamics and structure of muscle and membranes using EPR, fluorescence and phosphorescence spectroscopy.

A change in our joint appointees also occurred in 1979 when Govind Vatessary at the VA Medical Center decided not to continue with us.

In 1979 another change also occurred at the VA, for Helmut Gutmann had reached the mandatory retirement age of the University, now 70 years. As a cancer research specialist, Helmut carried out research for many years on the metabolism of carcinogenic fluorene derivatives, and he published many papers on this subject[6]. He also was the major advisor for 3 students who obtained the Ph.D degree, and he participated in the teaching of some of our courses for the health science students.

In 1982 another position became available in the Department when Dave Thomas received a Research Career Development Award from NIH. This award would support Dave for five years, freeing up his departmental salary for someone else during this time. Because I would reach mandatory retirement by the end of that period, it would be possible for us to bring in another faculty member five years before I retired. As a result another search was carried out, and in September 1983 David LaPorte joined the faculty.

David LaPorte was born in 1951 and attended the University of Wisconsin at Oshkosh, receiving the B.S. degree in 1976. He then went to the University of Illinois and obtained the Ph.D. degree in 1980. After three years of post-doctoral work in Prof.

Daniel Koshland's laboratory at the University of California, Berkeley, he came here in 1983. David carries out research on the regulation of cellular differentiation and on the structure and function of key regulatory proteins

In the spring of 1984 I decided to retire. Although I was four years from the mandatory age, I felt that this was the right time for me to do so. After being in Millard Hall for 45 years, it was not easy for me to quit just like that, but the Department made it easier by allowing me to have a small laboratory for two years and an office for a longer period. I have been able to come to the campus about three days a week, have lunch with some of my faculty member friends, and carry out a few projects of my choice, including the writing of this history.

After I retired, during the next four years leading up to the end of the first century of the Medical School, there has continued to be change.

In 1984-85 the Medical School established the Institute of Human Genetics, and in 1985-86 the Institute carried out a search for an outstanding person in the field of biochemical genetics. The individual chosen for this position was Brian Van Ness from the Department of Biochemistry at the University of Iowa. Brian had received his Ph.D. degree with Jim Bodley in our Department in 1980, and six years later he had already established an excellent record of research. Brian's academic appointment is in the Department of Biochemistry. His field of research is eukaryotic gene regulation and rearrangements and expression of immunoglobulin genes.

In 1985-86 the Endocrinology Division of the Department of Medicine appointed an Assistant Professor who is a biochemist, Dr. Michel Sanders. In the negotiations involving her appointment, it was decided that the Department of Biochemistry would be responsible for one-third of her salary. Dean Brown assured the Department that new funds would be available for this appointment. Michel was born in 1953 and attended Macalester College in St. Paul receiving the B.A. degree in 1976. She then went to the University of Michigan where she obtained the Ph.D. degree in 1981. After a year of post-doctoral work at the University of Washington, she came to the Department of Medicine at this Medical School. Michel's research is concerned with steroid and peptide hormone regulation of gene expression.

Also in 1985-86 the Chemistry Department recruited a distinguished biochemist from the California Institute of Technology, Michael Raftery. When he came, he had a joint appointment in our Department, and in 1988 he had his appointment transferred to the St. Paul Department. Professor Raftery is especially noted for his pioneering work with the acetyl choline receptor.

In 1986 Ivan Frantz became 70 and had to retire; however, he continued to keep his

laboratory in operation. During his tenure with the joint appointment in Biochemistry he taught a graduate course in Lipids for many years on an alternate year basis. He also was the advisor for 7 Ph.D. students and 7 M.S. students.

Much of Ivan's research was concerned with the intermediary metabolism of cholesterol[7]. He has also conducted epidemiological studies on certain populations concerning blood cholesterol levels and has worked with certain groups to determine what factors might lead to the lowering of blood levels of cholesterol[8].

In the academic year of 1986-87 Harry Hogenkamp took a sabbatical leave, spending the time in Germany. Jim Bodley was appointed the Interim Head, and he did an excellent job in this position. There were a number of problems that he had to deal with, and he handled them very well. These included overseeing the realignment of the office and laboratory suites for several faculty members, discussions with other department heads concerning the location of a new endowed chair, and the transfer of a faculty member from another department to ours.

The transfer of a faculty member to our Department in 1986-87 came about without our looking for it. Professor Nelson Goldberg of the Pharmacology Department, a biochemist by training and expertise, was permitted, by mutual agreement with his departmental colleagues and Dean Brown, to transfer his departmental status to the Department of Biochemistry.

Nelson was born in Cleveland in 1931 and attended the University of Toledo, receiving the B.S. degree in 1953. He later went to the University of Wisconsin where he received the Ph.D. degree in 1963. He carried out post-doctoral work with Prof. Lowry at Washington University at St. Louis for two years and then joined the Pharmacology Department at the University of Minnesota in 1964. His research specialty is biochemical mechanisms of cellular regulation, dealing especially with cyclic nucleotides.

In 1986-87 Agnes Tan decided to make a career change and has entered the University of Minnesota School of Management. She no longer has her position in the Division of Endocrinology and Metabolic Diseases at the VA Medical Center. Agnes' research there was concerned with the enzymes of glycogen metabolism[9]. She taught in one of our courses and consistently received very high teaching evaluations from students in her classes.

In June 1988 Leon Singer retired. As previously indicated, Leon had a long association with the Department and had very distinguished career, making many important contributions to the program of Biochemistry. His tenure as a member of the Department was 39 years, 1949-1988. Nearly every year since Leon came here, he was in charge of the course for Dental students. He always gave the bulk of the lectures, and one year,

1950-1951, he gave all 90 of them. During this whole time the course has run very smoothly, and it has had the fewest criticisms from the students of any of our health sciences courses.

For many years Leon spear-headed the implementation of a summer research program for dental students whereby interested students could work in selected research laboratories. Many worthwhile projects have been carried out, and several students have received national awards in this program.

In his own research Leon was associated with Wallace Armstrong, working in the area of fluoride metabolism and other aspects of the biochemistry of calcified tissues[1,10]. When Wallace retired in 1974, Leon continued to work in this area, and several more significant contributions resulted[11]. An especially important work showed that the fluoride content of commercially prepared infant foods was dependent on the fluoride content of the water used in their processing. These foods when mixed with fluoridated water in the home would sometimes result in too large an intake of fluoride in infants[12]. This study along with some later ones led to decisions by manufacturers to reduce the fluoride content of their baby foods.

Leon was also the advisor for 14 students who received the Ph.D. degree; for 6 of these individuals he was the co-advisor along with Wallace Armstrong.

As had Wallace Armstrong, Leon also appeared before many governmental bodies supporting the fluoridation of municipal water supplies. In 1975 he was elected a Fellow of the American Association for the Advancement of Science, he received the H. Trendley Dean Award from the International Association for Dental Research in 1986, and in 1987 he was made an Honorary Fellow in the American Academy of Dentistry. A scholarship fund in his honor has been established in the College of Dentistry. Tragically, Leon died of coronary disease in September, 1988, two months after he retired.

With all these changes in the past four years, the faculty roster beginning in 1988-89 includes Blomquist, Bodley, Dempsey, Edstrom, Gilboe, Goldberg, Gray, Hogenkamp, Holman, Howard, Koerner, Laporte, Lipscomb, Livingston, Oegema, Roon, Rosenberg, Sanders, Smith, Thomas, Towle, Ungar, Van Ness, and Van Pilsum.

On the occasion of the 42nd anniversary of the Department and the 100th anniversary of the Medical School, the Department can look forward to more exciting changes in the future. For example, in 1985 the University appointed a new President, Kenneth Keller, and he initiated a major fund-raising compaign. The Minnesota Campaign, as it was called, was to be a three-year effort to raise $300,000,000 from private sources. It was planned that, among other things, the money would be used to fund up to 100 endowed chairs and in other ways to strengthen

specific programs. One of the programs with high priority was the biological sciences. When the campaign came to an end, more than 300 million dollars had been pledged, and there are to be at least 100 new endowed chairs established. This is the largest amount ever obtained in such a drive by a public university.

One of the gifts in this campaign was donated by William F. Dietrich, who requested that the money be used for a chair in ``fundamental molecular and cell biology'' in the Medical School[13]. After more than a year of meetings and discussion, it was finally agreed that the specific individual should be an expert in the field of structural studies using X-ray techniques, and the position would be located in the Biochemistry Department. Research space for this position would become available in the Department because at this same time hands-on teaching of the biochemistry laboratory to health science students would be phased out completely. (See Chapter VIII). The teaching laboratories would be remodeled to provide space for this new program. In the fall of 1987 a search was started to find an individual to fill this new position, and as the program in Biochemistry began it second century, it would have its first professor with a permanently endowed chair.

References

1. e.g., Armstrong, W.D. ``Composition and Crystal Structure of the Bone Salt'' Conference on Metabolic Interrelations, E.C. Reifenstein, ed., Josiah Macy, Jr., Foundation, New York 1950, p. 11-13; Hayes, D.K., Singer, L., and Armstrong, W.D. ``Calcium Homeostatic Mechanisms and Uptake of Isotopes in the Lobster'' Am. J. Physiol. 202 383 (1962); Armstrong, W.D., Singer, L., and Makowski, E.L. ``Placental Transfer of Fluoride and Calcium'' Am. J. Obs. Gyn. 107 432 (1970); Armstrong, W.D. and Singer, L. ``Fluoride Tissue Distribution: Intracellular Fluoride Concentrations'' Proc. Soc. Exptl. Biol. Med. 164 500 (1980)

2. Patterson, T. ``Wallace Armstrong, Ph.D., M.D., A Tribute on His Retirement'' Univ. Minn. Med. Bull., Summer 1974

3. Anon. ``Wallace Armstrong Named University of Minnesota Regents' Professor'' Northwest Dentistry, July-August p. 222, 1974

4. e.g., Wold, F. and Cardenas, J.M. ``Comparitive Studies of the Structural and Catalytic Properties of Enolase'' Arch. Biochem. Biophys. 144 663 (1971); Spring, T.G. and Wold, F.``Two High-Affinity Enolase Inhibitors. Chemical Characterization'' Biochemistry 10 4649 (1971); Brown, W.E. and Wold, F. ``Alkyl Isocyanates As Active Specific-Site Inhibitors of Chymotrypsin and Elastase'' Science 174 608 (1971); Wold, F.``Bifunctional Reagents'' Methods Enzymol. 25 (Pt. B) 623 (1972); *ibid.* ``Chemical Modification of Enzymes'' Birth Defects, Orig. Art. Ser. 9 46 (1973)

5. e.g., Balasubramanian, D. and Wetlaufer, D.B. ``Optical Properties of Cyclic Peptides. Prototype Helix Systems'' Conform. Biopolym., Pap. Int. Symp., Madras, 1 147 (1967); Wetlaufer, D.B. and Saxena, V.P. ``Formation of Three-Dimensional Structure in Proteins. I. Rapid Nonenzymic Reactivation of Reduced Lysozyme'' Biochemistry 9 5015 (1970); ; Wetlaufer, D.B. and Ristow, S. ``Acquisition of Three-Dimensional Structure in Proteins'' Ann. Rev. Biochem. 42 35 (1973)

6. e.g., Gutmann, H.R., Galitski, S.B. and Foley, W.A. ``The Carcinogenicity of the O-Methoxy Derivatives of N-2- Fluorenylacetamide and of Related Compounds in the Rat'' Cancer Res. 28 234 (1968); Gutmann, H.R. and Kaplan, E. ``Separation and Identification of Metabolites of the Arylamide, N-3-Fluorenylacetamide, by High Pressure Liquid Chromatography'' J. Chromatogr. 144 136 (1977); Chow, Y.M., Gutmann, H.R., and Kaplan, E. ``Effect of the Structural Isomer N-3-Fluorenylacetamide on Microsomal Binding and Hydroxlyation of the Carcinogen N-2-Fluorenylacetamide'' Biochem. Pharmacol. 30 1253 (1981)

7. e.g., Frantz, I.D. Jr., Sanghvi, A., and Schroepfer, G.J., Jr. ``Irreversibility of the Biogenetic Sequence from 7-Cholesten-3-beta-ol through 5,7 cholestadien-3-beta-ol to Cholesterol'' J. Biol. Chem. 239 1007 (1964); Frantz, I.D., Jr., Scallen, T.J., Nelson, A.N., and Schroepfer, G.J., Jr. ``Cholesta-7,24-dien-3-beta-ol, A Probable Intemediate in Cholesterol Synthesis'' J. Biol. Chem. 241 3818 (1966); Frantz, I.D., Jr. ``Sterol Biosynthesis'' Ann. Rev. Biochem. 36 691 (1967)

8. e.g., Heiss, G., Tamir, I., Davis, C.E., Tyrroler, H.A. Rifkind, B.M., Schonfield, G., Jacobs, D., and Frantz, I.D., Jr., ``Lipoprotein Cholesterol Distributions in Selected North American Populations: The Lipid Research Clinics Program Prevalence Study'' Circulation 61 302 (1980); Jacobs, D.R., Jr., Hunninghake, D.B., Dempsey, M.E., Taylor, H.L., Kuba, K., Luepker, R.V., Dawson, E.A., Frantz, I.D., Jr., and Hannan, P. ``Blood Lipids and Lipoproteins in a Minnesota Urban Population'' J. Chronic Dis. 33 395 (1980); Frantz, I.D., Jr. ``Lipids and Atherosclerosis'' Cancer Res. 41 3718 (1981)

9. e.g., Tan, A. and Nuttall, F.Q. "Evidence of the Non-Identity of Proteins having Synthase Phosphatase, Phosphorylase Phosphatase, and Histone Phosphatase Activity in Rat Liver" Biochem. Biophys. Acta 522 139 (1978); Tan, A. "Glycogen Synthase R in Livers of Starved Rats and Starved Rats Given Glucose" J. Biol. Chem. 257 5004 (1982)

10. e.g., Singer, L. and Armstrong, W.D. ``Regulation of Human Plasma Fluoride Concentration'' J. App. Physiol. 15 508 (1960); Singer, L. and Armstrong, W.D. ``Determination of Fluoride in Bone with the Fluoride Electrode'' Anal. Chem. 40 613 (1968)

11. e.g., Singer, L., and Ophaug, R. ``Ionic and Non-ionic Fluoride in Plasma (or Serum)'' CRC Crit. Rev. Clin. Lab. Sci. 8 111 (1982)

12. Singer, L., Ophaug, R.O., and Harland, B.F. ``Estimated Fluoride Intake of 6-Month Old Infants in Four Dietary Regions of the United States'' Am. J. Clin. Nutr. 33 (2) 324 (1980); Singer, L. and Ophaug, R.O. ``The Determination of Fluoride in Foods'' J. Agric. Food Chem. 34 511 (1986); Shafer. M. "Research, Leon Singer" Health Sciences Magazine, Winter 1985, p. 5

13. Minn. Med. School Bull., Spring, 1987, p. 13

Chapter VII. The Graduate Program in Biochemistry

Graduate studies in Biochemistry at the University of Minnesota began in the period 1910-15. In the colleges of Agriculture and Medicine, graduate programs were begun which were directly related to the professional roles of the two colleges. This is reflected in the actual names of the programs at that time, Agricultural Chemistry in the College of Agriculture and Physiological Chemistry in the Medical School. For both of these programs, the first descriptions that appear in Graduate School bulletins occurred in the bulletin for 1911-12.

Although the original curricula were somewhat different and the research work was considerably different, these ``different" disciplines became much more alike over the years. In 1963 the graduate programs were merged into one, and it was given the most appropriate name for the time, Biochemistry. I will first outline the development of the two programs separately as it occurred up to 1963 and then outline the development of the combined program. Because I am mainly concerned with the Minneapolis program in this history and know more about it, there will be considerably more emphasis on its development than on the St. Paul program.

A. Agricultural Biochemistry

From the earliest days of the College of Agriculture, there was a Division of Agricultural Chemistry. In the Graduate School bulletin for 1911-12 a program in Agricultural Chemistry is listed with two instructors, Ralph Hoaglund and Cornelia Kennedy, and there were two courses, Advanced Agricultural Analysis and Soil Research. In 1912-13 there were four instructors listed, Rodney West and Clyde Bailey along with Hoaglund and Kennedy, and five graduate courses were offered. In 1914 is the first time that a course entitled "Biochemistry" appears in the bulletin along with one in Biochemical Laboratory Methods. Also in 1914 an M.S. degree in Agricultural Chemistry was awarded to George Koch.

The bulletins show that it was in 1915 that the name of the program was changed to Agricultural Biochemistry. At that time Professor Roscoe Thatcher, who had come to the College of Agriculture in the Division of Agricultural Chemistry in 1913, became the Head of the newly named Division of Agricultural Biochemistry. The first Ph.D. degree in this program was granted in 1915, the recipient being Morris Blish, and his major advisor was Prof. Thatcher.

In 1914 Ross Gortner came to the College of Agriculture as Associate Professor of Soils Chemistry in the Division of Agricultural Chemistry. In 1916 he became Associate Professor of Agricultural Biochemistry, and in 1917 he was named Professor of

Agricultural Biochemistry and Head of the Division when Prof. Thatcher became Dean of the College of Agriculture. Prof. Gortner was born in 1885 in Nebraska, the son of a missionary[1]. He received the B.S. degree at Nebraska Weslayan College in 1907, an M.S. degree at the University of Toronto, and a Ph.D. at Columbia University, majoring in organic chemistry under Marston Taylor Bogert.

Prof. Gortner was an active researcher; the Publications of the Faculty indicate that in 1915 he published 5 papers in that one year. When Prof. Gortner became Head of the Division, there were three graduate faculty members, Gortner, Clyde H. Bailey, and John J. Willamen, and by 1919-20 there were three more, Clarence A. Morrow, R. A. Dutcher, and Leroy S. Palmer.

In the next 20 years under Gortner's leadership, the Department developed one of the outstanding programs in the country, and it attracted many graduate students. Between 1921 and 1942, when Professor Gortner died suddenly, there were 106 Ph.D. degrees awarded in the program. In addition to carrying out research, the faculty organized and taught advanced courses in biochemical topics, not only for their own students but also graduate students in related departments. These topics included Proteins, Carbohydrates, Enzymes, Colloids, Lipids, and Nutrition. In 1929 Prof. Gortner published the first edition of his textbook, ``Outlines of Biochemistry," which became one of the leading texts in the field. A second edition came out in 1938[2].

Ross A. Gortner. (Univ. Minn. Archives)

In 1940 there were 70 graduate students enrolled in the program, with 44 of these students already having obtained the M.S. degree. And 11 Ph.D. degrees had been awarded in just the previous year! It was also indicated that these 70 students came from 22 different states and provinces[3]. At this time there were just seven graduate faculty members, Gortner, Bailey, Palmer, David Briggs, William Geddes, Cornelia Kennedy, and W. Martin Sandstrom.

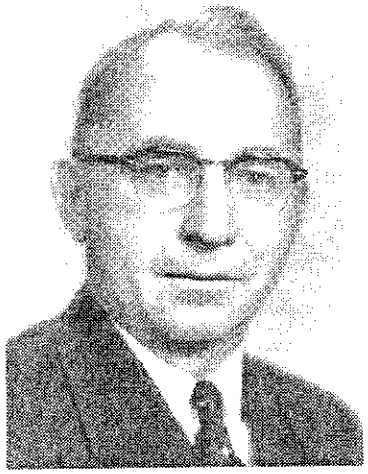
Gortner's primary research interest was in the field of colloid chemistry[4]. His studies were wide-ranging, dealing mostly with electrokinetic phenomena[5], the nature of proteins as colloids[6], and water relationships with the biocolloids and the concept of ``bound water[7]." He wrote and lectured extensively on the subject of colloids. In the second edition of ``Outlines of Biochemistry" more

than one third of the book is devoted to "The Colloidal State of Matter." In 1935-36 he held the Baker Non-Resident Lectureship in Chemistry at Cornell University, and his lectures were published as ``Selected Topics in Colloid Chemistry[8]." Partly through his influence, the University of Minnesota by 1940 had assembled a considerable number of first-class colloid chemists on its faculty, located in four different departments. (See Appendix H).

In addition to heading a large academic program in biochemistry and being the author of an outstanding textbook, Gortner was also one of the co-founders of the journal, Archives of Biochemistry. Tragically, he died suddenly in 1942, and his obituary appears in Volume 1 of that journal[9].

After the death of Gortner in 1942, which occurred during World War II, a new Head was chosen from within the Department, Professor Leroy S. Palmer. The Department's bad fortune continued, for in 1944 Professor Palmer also died. At that time Professor Geddes was named Department Head.

William Geddes was born in Canada in 1896 and received the B.A. degree at the University of Toronto in 1918. He later came to Minnesota for graduate work and obtained an M.A. degree in 1924, an M.S. degree in 1927, and a Ph.D. in 1929, all in the Department of Agricultural Biochemistry. His Ph.D. advisor was Prof. C. H. Bailey, whose specialty was cereal chemistry. In 1929 he returned to his native Canada and held several positions there until 1938 at which time he came back to Minnesota as Professor of Agricultural Biochemistry.



William F. Geddes. (Univ. Minn. Archives)

At the end of World War II new additions were made to the staff which included Robert Jenness, Fred Smith, Max Schultze, and Paul Boyer. Later additions were made that included Irvin Liener in 1949 and Samuel Kirkwood and Robert Glass in 1956. With this faculty the graduate program continued to prosper, for in the period 1946-1960, 103 Ph.D. degrees were awarded. In 1958 Professor Geddes died, and Professor David Briggs served as Head until 1962 when Professor LaVell Henderson from Oklahoma State University was named Head.

Prof. Henderson was born in Utah in 1917 and received the B.S. degree at Utah State University in 1939. He did graduate work at the University of Wisconsin, getting

LaVell M. Henderson

an M.S. degree in 1941 and a Ph.D. in 1947, majoring in Biochemistry. He was on the faculty at the University of Illinois from 1948-57 and Head of the Department of Biochemistry at Oklahoma State University from 1957 until he came to Minnesota in 1962. His research interests are involved with the metabolism of amino acids and vitamins, including tryptophan, hydroxylysine, niacin, and cobalamin. As was described in Chapter V, it was after the coming of Prof. Henderson that the names of the two departments were both changed to "Biochemistry." In addition another outcome of the deliberations of the Advisory Committee on Biochemistry was the merger of the two separate graduate programs into one. *vide infra.*

B. Physiological Chemistry

For the program in Physiological Chemistry, the first indication of any kind of graduate studies is given in the Medical School bulletin of 1895-97. In the Physiology section under Graduate Courses it is stated that "opportunity will be afforded, in the laboratories of physiology and physiological chemistry, for the pursuance of special courses of study, in both experimental and chemical physiology under the direction of the chair."

The bulletin also states that the Medical School would offer a series of graduate level courses in several fields and will be inaugurated in November, 1896, each course running for six weeks. One of the courses listed is "Physiological Chemistry of Fluids of the Body," with Professor Beard as the instructor. Also at this time, Hubert C. Carel is listed as a candidate for the M.S. degree with a major in Chemistry and Physiology, *vide supra.* Although Carel continued to teach courses until 1908, eventually becoming Professor of Chemistry, there is no record of his ever having completed an advanced degree, and there is no record of any published research.

Although the Graduate School was started in 1888, the first Graduate School bulletin was published for 1896-97, and the first Dean of the Graduate School was appointed in 1905. The first indication of graduate work in Physiological Chemistry given in the Graduate School bulletin is in 1911-12 where

five advanced courses were listed. These courses were The Material Bases of the Animal Body, The Physiologic Chemistry of Digestion, The Chemistry of Respiration, The Physiologic Chemistry of the Urine, and Studies in Metabolism and Nutrition. The instructors for these courses were Professors Scott and Gibson; however, Gibson left the University in 1913, and Scott was no longer associated with Physiological Chemistry after 1914.

As already indicated in Chapter I, the real beginning of a faculty and curriculum for this subject was in 1914 when 3 new faculty members had been added to the Physiology Department specifically in the area of Physiological Chemistry. Also the Graduate School bulletin states for the first time that a graduate degree in Physiological Chemistry could be obtained, and there were several new advanced courses being offered.

A graduate student in this program, Frederick Schlutz, is listed in directories from 1912 to 1915, but it appears that he never obtained a graduate degree. He already had an M.D. degree, and as indicated in Chapter I, he became a full-time professor in the Pediatrics Department in 1915. Also in the directory for 1912, John Handy in listed as a candidate for the M.S. degree, but there is no record of his having obtained the degree.

The graduate program in Physiological Chemistry really got under way at the end of World War I in association with the faculty of the Mayo Clinic. A few years earlier the faculty at Mayo had approached the University regarding the possibility of offering advanced academic degrees through the University for their post-graduate physicians. There was a lot of opposition to this in the Medical School faculty in Minneapolis, primarily because Mayo was a profit-making clinic. However, President Vincent and Dean Lyon were strongly in favor of it, and a tentative agreement was finally reached in 1915 which became permanent in 1917. The agreement allowed the Mayo post-graduate students to obtain M.S. and Ph.D. degrees through the Graduate School in both clinical and basic sciences[10]. In spite of the early opposition to the affiliation, years later it was generally accepted as a very worthwhile venture for the Medical School[11].

One aspect of the cooperative nature of this arrangement was that every Ph.D. examination committee, both preliminary and final, for every student, both Minneapolis and Rochester, had two members from the Mayo faculty. The Master's oral examination committee also had one Mayo faculty member. This added considerable difficulty in arranging the times for these examinations; however, it allowed for a considerable amount of interaction between the faculty of the two groups. In fact, for many years there was at least as much if not more interaction between the Minneapolis faculty and the Mayo faculty than there was between the Minneapolis faculty and the St.

Paul faculty.

In 1920 the only graduate faculty member at Mayo was Professor Edward C. Kendall. (See Chapter II). In 1928 the faculty there included in addition to Kendall, Edgar Witzemann, and Arnold Osterberg, Kendall's first Ph.D. student. By 1937 there were six faculty members, Kendall, Osterberg, Walter Boothby, Harold Mason, Marschelle Power, and Ancel Keys.

The graduate faculty members in Physiological Chemistry on the Minneapolis Campus in 1920 were Professors McLendon, Pettibone and Kingsbury. From this time until 1939 when Prof. McClendon left the University, there were 15 Ph.D. degrees granted in Physiological Chemistry with McClendon being the advisor for 10 and Kendall the advisor for 5. There were also 13 M.S. degrees obtained, with McClendon being the advisor for 12 and Kendall the advisor for 1.

During the period 1920-1940 the Medical School of the University of Minnesota developed into one of the outstanding medical research and teaching institutions in the country, to be rated equally with Harvard and Johns Hopkins. In his history of the first one hundred years of the University of Minnesota, James Gray had this to say about this period:

"In the early 1930s there began in the Medical School one of those periods when every participant in a cooperative enterprise seems to be surcharged with creative energy. Whatever may be the subtle influence that enters a community of minds and touches them all with distinction, its power moved illuminatingly through this group of men..... It is often made to seem like a kind of miracle when the rule of rarity that governs the distribution of high talent is set aside and all the neighbors in a small group emerge as men of conspicuous intellectual worth. The truth probably is that such a time is the culmination of a long period of preparation. Brilliant work is done when men have beent rained through many years to exact good work of themselves in each days effort[12]."

' There was a whole group of top-rated medical scientists, both clinical and basic, who had contributed to this stature of the school. Wangensteen (Surgery), Fahr, Myers, and Watson (Medicine), Jackson, Downey, Rasmussen (Anatomy), Bell (Pathology), McQuarrie (Pediatrics), Henrici, Larson, Green (Bacteriology), Hirschfelder (Pharmacology), and Rigler (Radiology) were among the individuals who were primarily responsible for this high ranking of the school.

Physiological Chemistry was only a program in the Department of Physiology during this time, and, other than for McClendon, its faculty members were not known for carrying out significant research As was pointed out in Chapter II, compared to the other graduate programs in the Medical School, Physiological Chemistry was considered to be mediocre at best. At this time, if a student came to the University of Minnesota seeking graduate study in Biochemistry/Physiological

Chemistry, that student would most likely go to the Department of Agricultural Biochemistry on the St. Paul Campus, which, as already indicated, had a high national reputation under the leadership of Ross Gortner. This is shown by the fact that between 1920 and 1940 there were 106 Ph.D. degrees awarded in Agricultural Biochemistry compared with the 15 in Physiological Chemistry, 5 of which were at the Mayo Clinic. Also students majoring in Chemistry or Bacteriology who chose a Minor in Biochemistry always took it in Agricultural Biochemistry. About the only graduate students earning Ph.D. degrees on the Minneapolis Campus were those who were hired as teaching assistants. For a retrospective on this time, however, see Appendix C.

After Maurice Visscher became the Head of the Physiology Department in 1936, he began to build up the research expertise of the program in Physiological Chemistry.

In 1937 Leo Samuels, whose research was in the newly developing field of steroid biochemistry, was appointed as Assistant Professor. As indicated in Chapter III, the appointment of Samuels was the beginning of a unique tradition at Minnesota, having the teaching and basic research in Endocrinology located in the Physiological Chemistry/ Biochemistry program of the medical school.

At this time there were many Jewish refugee scientists arriving in this country from Germany, and two of them became associated with the Physiology Department.

Herbert Freundlich

One of these was Herbert Freundlich, generally known as the "father of colloid chemistry," a branch of chemistry closely allied to biochemistry[13]. (See Appendix H).

Professor Freundlich was named a Distinguished University Professor without departmental assignment, but he interacted with faculty and students primarily in three Departments, Chemistry, Agricultural Biochemistry, and Physiology. He gave lectures to the medical students on colloids in biology and medicine, he participated in the Physiology seminar program, and he was a consultant in several of the research programs of the Department. He also initiated two graduate courses in the field of colloid chemistry, (1) A General Survey of Colloid Chemistry and (2) Colloids in Biology and Medicine.

The other refugee appointment was Karl Sollner, who had worked with Freundlich for several years in the Kaiser Wilhelm Research Institute in Berlin[14]. His area of research

was the physical chemistry of membranes, and he was appointed specifically to work with Dr. Visscher on membrane problems.

In addition to the newcomers listed above, there were now two "home grown" staff members who were beginning to make their mark as very competent researchers. They were Wallace Armstrong and L.Earle Arnow, both of whom had earned the Ph.D. and M.D. degrees in the decade past. Thus at the beginning of the forties decade, with George Burr now the Director of the newly established Division, the program in Physiological Chemistry on the Minneapolis Campus now had a graduate faculty of a high degree of research competence.

As indicated in Chapter III, some of these faculty members soon left, but other very competent individuals joined the faculty. The improvement in the graduate program was marked by, among other things, the fact that from 1940 through 1946 there were 18 Ph.D. degrees awarded with seven different advisors as compared with 10 Ph.D. degrees from 1920 through 1939 with one advisor. The research accomplishments of the faculty during this time were detailed in Chapter III.

During this period, which included World War II, the only course that all of the students were required to take was Physiological Chemistry 100-101, the course that was given for the medical students. Most of those majoring in Physiological Chemistry also took the course in Physiology which was given for medical students. In addition there were the six one-quarter courses offered by the faculty in Agricultural Biochemistry, and the Minneapolis students would usually take one or more of these. There were also two weekly seminars which all students were expected to attend. One was the combined Physiology-Pharmacology seminar usually presented by one of the staff members of those two departments or sometimes another Medical School faculty member. The other seminar was a student seminar in Physiological Chemistry in which the presentations were made by the students. The remaining credits required for the degree were made up by research credits.

As has already been documented, at the end of World War II and with the formation of a new department, major changes in the Graduate Faculty took place. Of the Graduate Faculty in the period 1940-45, those who were no longer at Minnesota in the fall of 1946 included Arnow, Barnes, Burr, Freundlich, Hemingway, Samuels, Utter, and Wood. In the fall of 1946 the Graduate Faculty in the new Department consisted of Armstrong, Barnum, Cohen, Frame, Glick, Lundberg, and Sollner, with Sollner in Washington at NIH and Lundberg at the Hormel Research Institute in Austin.

In 1946-47 there was also nearly a complete turnover in the graduate student population. Those who had been there during the war managed to finish their work and leave, and the new students all started from scratch, coming from some other war-time

experience. There were only 6 Ph.D. degrees awarded between 1946 and 1950, with 3 of them in 1950.

Under the leadership of Wallace Armstrong, the graduate program began to come back in the late 1940s and early 1950s. In 1947 a series of advanced courses for graduate students was started. There were six of these, one given each quarter on an alternate year basis, and they were chosen to complement the advanced courses given by the St. Paul Department. These courses included Histochemistry, Endocrinology, Advanced Intermediary Metabolism, Nitrogen Metabolism, Ionic Equilibria and Mineral Metabolism, and Advanced Laboratory Techniques. Thus our students had about 10-12 such courses to choose from for their major studies.

There was also a growth in the number of graduate students; faculty members began to have adequate grant money to support some students with research assistantships. Up to this time about the only support had been the five or six teaching assistantships. Thus between 1951 and 1960 there were 26 Ph.D. degrees awarded.

The graduate faculty also had some turnover with a net addition of 6 during that period. Additions to the regular staff were Paul Boyer, Charles Carr, Leon Singer, Frank Ungar and Jack Van Pilsum, and four joint appointees were Ivan Frantz, Ralph Holman, Helmut Guttman, and Richard Von Korff. Walter Lundberg transferred his faculty appointment to the St. Paul department, Elizabeth Frame went to the National Institutes of Health, and Saul Cohen left because of illness.

By 1960 a stimulation of the graduate program occurred when the National Institutes of Health began to support graduate education in the biomedical sciences with training grants for graduate students. Along with most other good biochemistry departments, we were able to get one of these grants which enabled us to support about 10-15 students per year. Jack Van Pilsum was named Director of this grant, and he would serve in this capacity until 1975 when training grants in Biochemistry were discontinued. This grant, along with increasing numbers of research assistantships being available, led to almost a doubling of our graduate student enrollment during the early 1960s. As was pointed out in Chapter IV, the graduate student enrollment since then has remained essentially constant up to 1988.

One event in the 1950s, especially, involved both the Departments, when the faculty from both Departments took part in the arrangements for a major symposium that was held here in 1951[15]. The local section of the American Chemical Society had been sponsoring symposia for some time, and the fifth annual symposium was on the subject "The Chemistry and Functions of Proteins." It was also the occasion for the Centennial Celebration of the University of Minnesota

and the year of the 75th Anniversary of the American Chemical Society.

Paul Boyer, then of the St. Paul Department, was the General Chairman, and other biochemists associated with the arrangements were David Briggs, W. M. Sandstrom, Robert Jeness, and Irving Liener of the St. Paul Department and Cy Barnum of the Minneapolis Department. All of the speakers for the symposium were from out of the state and included John Edsall, Irving Klotz, Felix Haurowitz, Joseph Fruton, Frank Putnam, Henry Bull, Sidney Fox, John W. Williams, Theodore Winnick, and Paul Cannon. All of the sessions were held in the lecture auditorium of Owre Hall. The Symposium continued for three days, and all of the sessions were well-attended.

References

1. Lind, S.C. "Ross Aiken Gortner" Proc. Natl. Acad. Sci., Biograph. Mem. 23 149 (1945)

2. Gortner, R.A. "Outlines of Biochemistry" John Wiley & Sons, New York, 1st ed. 1929, 2nd ed. 1938, 953 pp.

3. Letter from Prof. Gortner to President Ford, Oct. 1940, Univ. Minn. Arch.

4. e.g., Gortner, R.A. "The Application of Colloid Chemistry to Some Agricultural Problems" First National Symposium on Colloid Chemistry, J.H. Matthew, ed., Univ. of Wisconsin, 1924, p. 392

5. e.g., Bull, H.B. and Gortner, R.A. "Studies on Electrokinetic Potentials. XI. Effect of Sodium Soaps on the Electric Moment of the Double Layer at the Aqueous-Cellulose Interface" Physics 2 21 (1932).

6. e.g., Gortner, R.A. "Physico-Chemical Studies of Proteins. I. The Prolamines - Their Chemical Composition in Relation to Acid and Alkali Binding" Second National Symposium on Colloid Chemistry, H.N. Holmes, ed., The Chemical Catalog Co., New York, 1925, p. 209-359

7. Mann, F.D. "Ross Aiken Gortner and Bound Water, The Water of Life" Perspect. Biol. Med. 20 142 (1976)

8. Gortner, R.A. "Selected Topics in Colloid Chemistry with Especial Reference to Biochemical Problems" Cornell Univ. Press, 1937

9. Palmer, L.S. "Ross Aiken Gortner, 1885-1942" Arch. Bioch. 1 165 (1942); See also Bailey, C.H. "Ross Aiken Gortner, 1885-1942" Science 96 395 (1942) and Ref. No. 1

10. Wilson's History, pp. 159-212

11. e.g., Visscher, M.B. "Fifty Years of Medical Education at the University of Minnesota" Minn. Med. 22 719 (1939)

12. Gray, J. "The University of Minnesota, 1851-1951" Univ. of Minnesota Press, 1951, p. 505

13. See Ref. No. 24, Chap. III

14. See Ref. No. 25, Chap. III

15. Department of Biochemistry Files, Copy of Symposium Program

Chapter VIII. The Joint Graduate Program

It has already been pointed out in Chapter V that the two Departments agreed to change their names to Biochemistry in 1963. It was also indicated there that Dean Crawford of the Graduate School had appointed an Advisory Committee on Biochemistry to look at several aspects of the graduate program[1]. The committee members were David Briggs and Fred Smith of the St. Paul Department, Wallace Armstrong, Cyrus Barnum, and Paul Boyer of the Minneapolis Department, and Stuart Fenton and Rufus Lumry of the Chemistry Department.

One of the Committee's major items dealt with the existence of two separate graduate programs in Biochemistry in one university. To outside applicants there was some confusion with two separate departments, and within the university there was some competition for students and funds. The outcome of the deliberations of the Committee was the establishment of a single graduate program in Biochemistry with two major centers on two campuses five miles apart.

The first step in implementing the union was the appointment of a Biochemistry Coordinating Committee by Dean Crawford. It consisted of five members, two from the St. Paul Department, two from the Minneapolis Department, and a ``neutral" chairman, Stuart Fenton, from the Chemistry Department. The first question for this Committee to deal with was the organization of a general biochemistry course that all first year students would take. It would not only be required of all biochemistry majors but also would be suitable for graduate students from other departments such as Chemistry, Chemical Engineering, and the other Biological Sciences. It would be a three quarter course, taught by members of both Departments and be given on one campus one quarter and on the other the next quarter.

After several meetings of the Committee and feedback from the two faculties, the new course was first given in 1965-66. At first there was not complete agreement, for the fall and winter courses were given jointly, but in the spring quarter the Departments gave separate courses. It was not until 1969 that the spring quarter course also became a joint offering. Also for several years the two Departments offered different laboratory courses for the first year students.

At the same time that the new course was being organized, plans were also being made to put the admission of new students on a coordinated basis. An Admissions Committee was appointed, consisting of two members from each Department, with the chairmanship rotating between the Departments every two years. (I was chairman of the first committee because Wallace Armstrong told me that he would agree to a joint admissions

committee only if I would agree to be chairman).

The function of the Committee was (1) to review the applications and make recommendations for admission or rejection to the Graduate Dean of Admissions, and (2) to recommend to the respective Department Heads whether or not offers of financial support should be given. At this time the two Departments were still autonomous with regard to their funds for graduate student assistance. Thus at the time of admission, the students who were offered assistantships or traineeships had to decide in which Department they wished to work. This may seem somewhat awkward, but it apparently was satisfactory, for in 12 years not more than 2 or 3 students (out of 200) opted to change Departments after entering the program.

The Committee began its work with the new applicants who began their studies in 1965-66, and, with many changes of committee members, it has continued to operate in much the same way ever since. It is interesting to note that, although initially there may have been some concern about equitable distribution of students, in the 20 years, 1966-1985, the average number of students in each of the two departments was about the same, and the number of Ph.D.s granted by the two Departments was 100 by St. Paul and 101 by Minneapolis.

In the late 1970s one change in the admissions policy was made when it was decided to admit the students to the Program without commitment to either campus. The students were now being supported by a common Training Grant and other Departmental funds. During their first year in residence the students would select an advisor and in the succeeding years would most often be supported by the advisor's research grant, and would be working on the campus on which their advisor was located.

During the years following the initial joint first year course offering and joint admissions, other aspects of the program were incorporated into the overall combined effort. Many of the stated course requirements for the M.S. and Ph.D. degrees were the same in the two Departments, although several differences remained for a while. Gradually nearly all of the differences have been removed.

Until 1975 the laboratory course work for graduate students was handled separately in the two Departments, each one offering a somewhat different type of course. In 1976 it was decided to have a unified type of laboratory experience when the idea of laboratory rotation was adopted[2]. At the beginning of the fall quarter the entering students would have an opportunity to meet each of the graduate faculty members from both Departments and learn of the kinds of research that they did. Then they would select three professors and spend one quarter in each of the three laboratories during their first year. This laboratory rotation plan

would allow the student to have hands-on experience of three different kinds before choosing a major advisor. This kind of laboratory experience is still in effect for the entering students.

Another change came in 1977-78 when for the first time all students in the program were required to take the same written preliminary examination. There were some individual concerns, especially with the mechanism, but with well-placed efforts, it seems to have worked out fairly well, for many years later the same general format is still in use. An added benefit of the joint written preliminary examination is that the combined faculty takes part in the discussions concerning the on-going status of all students.

During the first ten years of the joint program, the faculty and leadership remained largely unchanged. Since 1974, however, there have been two new Department Heads in each Department and many changes in the faculty. The new additions to the faculty have come about through replacement of faculty who have left the University or retired and through the addition of new staff positions. In 1988 there were 12 new faculty in St. Paul and 12 new ones in Minneapolis. In spite of all these changes, the joint graduate program has continued to operate in the same general manner, and the number of students has remained almost constant.

In 1985 a change was made in the graduate curriculum that allows students to choose one of four sub-fields for their major. For the minor, another one of the sub-fields could be chosen; however, the option for a minor in a field other than biochemistry or the supporting program is still retained. The four sub-fields are Enzymology, Physiological Chemistry*, Physical Biochemistry, and the Biochemical Aspects of Molecular Biology. This development is a reflection of the very rapid growth of knowledge within biochemistry that has occurred since the Department was organized. A discipline that did not become an academic department until 1946, by 1985 has become one in which four different sub-fields are each considered sufficiently large to encompass the study for a Ph.D. degree.

It has been indicated earlier in Chapter VII that the graduate faculty in Biochemistry was not limited to the two Departments on the Twin Cities campus. Almost from the very beginning the Mayo Clinic group has been associated with the program right up until 1982 when the Mayo Undergraduate and Graduate School of Medicine elected to become independent of the University of Minnesota.

The location of graduate faculty at other off-campus sites began to proliferate after 1940. In 1942 the Hormel Institute was

*It is interesting to note that Physiological Chemistry is now considered by the faculty to be a sub-field of Biochemistry, whereas for many years the terms were considered to be synonymous.

founded as a unit of the University of Minnesota Graduate School, and ever since several of its staff members have held graduate faculty appointments in Biochemistry. A few students have taken advantage of this, taking their course work and examinations in the Twin Cities and doing their thesis work in Austin.

In 1946 when Karl Sollner went to the National Institutes of Health, he retained his graduate faculty appointment. During the next ten years 3 students did their thesis work at NIH.

In 1952 when Helmut Gutmann came to the Veterans Administration Hospital to carry out cancer research, he had a graduate faculty appointment with the Minneapolis Department, and he has had 3 Ph.D. students do their Ph.D. thesis work in his laboratory. Two other individuals at the VA Hospital have also had graduate faculty status in Biochemistry.

In 1972 the Freshwater Biological Laboratory was established at Navarre on Lake Minnetonka, and its staff members were given faculty appointments in departments of the College of Biological Sciences. Several of their staff have been on the graduate faculty in Biochemistry, and some students have elected to do their thesis work there.

In 1974 a branch of the University of Minnesota Medical School was established at the University of Minnesota at Duluth, with the first two years of the curriculum being given there. A Biochemistry Department was included in the Medical School, and in 1979 their faculty of five members was included in the combined graduate program in Biochemistry. Thus in 1980, the graduate faculty in Biochemistry included more than 60 members on its roster, and, in addition to the Twin Cities campus, they were located in Austin, Duluth, Navarre, Rochester, and the VA Hospital! In 1982 the Mayo group left the program, and the total graduate faculty is now somewhat less than 60.

As it approaches 80 years of existence, the graduate program in Biochemistry is in a very lively condition. The joint program in two different colleges on two different campuses has functioned almost better than could be expected for more than 20 years. In spite of the efforts of some individuals working to form one Department of Biochemistry operating on one campus, the prospects for such a development are such that it is not very likely to occur in this century.

At the present time the University is trying to implement its ``Committment to Focus" and to put the school's rank in the top five percent of the public institutions of the country[3]. Biochemistry, along with many other programs, is trying to improve its overall standing. Several new faculty members are currently being added, with some being young, with lots of promise, and others already well-established, top-ranking bio-

chemists. Some new programs are already in place that include front-running biochemical expertise, and some others are still in the process of being organized. As might be expected, there are also problems ahead. The commitment of state support is always tenuous, and not expected to be generous. More importantly, the supply of graduate students is diminishing, for the number of individuals in that age range is dropping, and the competition from other top-ranking programs is very stiff. Nevertheless, the prospects for the future are bright, even if the program does not become ranked in the top five per cent in the country.

References

1. See Ref. No. 4, Chap. V
2. Minutes of Staff Meeting, Department of Biochemistry, Minneapolis, June 1975
3. See Ref. No. 13, Chap. VI

Chapter IX. The Teaching of Health Science Professionals

A. The Course for Medical Students, Physiological Chemistry 100-101

From the very beginning of the Medical School there has been biochemical subject matter included in the curriculum. In the three-year course of 1888 there were courses in urinalysis and toxicology (medical chemmistry) plus subject matter which included digestion, nutrition, and blood chemistry in the physiology course. As described in Chapter I, in 1893 the course materials were taken directly from the courses taught at the Laboratory of Physiological Chemistry at Yale, the foremost center for the subject in the country[1]. By 1895-96 the medical course was four years in length, and there was not only the aforementioned urinalysis and toxicology, but it is stated in the bulletin that in the physiology course, three hours per week were devoted to physiological chemistry.

In 1900 the medical course was six years in length, and physiology was taught in both the third and fourth years. As part of the physiology sequence of courses, a course called ``Physiologic Chemistry and Microscopy" was now given in the third year. A description of the course is as follows:

``Laboratory work and demonstrations. A practical study of the several classes of proteids; of carbohydrates, fat, muscle and bone; of gastric juice, saliva, pancreatic juice and bile in their respective digestions; of glucogen and of blood, lymph, chyle, and milk. Microscopic study of the carbohydrates in vegetable and animal forms; of the physiologic emulsions of fat; of the crystalline waste products, and of the physiologic conditions of the blood cells and of the blood crystals. Practical instruction is given during this course in the enumeration of the blood cells, in the estimation of hemoglobin and of the corpuscles in mass, in the spectroscopic examination of the blood, in the determination of blood tests, etc. Twelve hours a week, first half of the first semester, fourth year. Open to those who have completed the courses in General Physiology and Systemic Physiology."

The situation continued this way until 1910 when, in addition to the physiology courses, courses in metabolism and nutrition were given. In 1914, after the coming of three new faculty members, a separate course for medical students called ``Physiological Chemistry" appears in the bulletin; it was finally separated from the physiology course.

The textbooks used in this country in the 1890s were mostly English translations of books originally written in German, the first American text not being published until 1915[2]. At Minnesota in the 1890s the text for Physiology (including Physiological Chemistry) was ``Textbook of Physiology" by M. Foster[3], a book of about 1000 pages.

Considerable portions of it dealt with Carbohydrates, Fats, Proteids, and Nuclein, and also with Metabolism and Nutrition. In 1905 the ``Textbook of Physiological Chemistry'' was used, an English translation of a book originally written in German by a Swedish biochemist, Hammersten[4]. Later when Physiological Chemistry was separated from Physiology, the ``Textbook of Physiological Chemistry'' by Abderhalden, a German physiological chemist was being used[5].

The books of that time had just as many pages as the books of today, in spite of the fact that so much of modern biochemistry has become known only after the beginning of this century. While knowledge of biochemistry was much less at that time, the authors wrote much more about what was known. For example, a book would have 20 or 30 pages on salivary digestion, whereas a textbook today will not have more than a half page on that subject.

It was right after World War I, 1919-20, that for the first time the course in Physiological Chemistry in the medical curriculum was given in two quarters, and the numbers for the courses were 100 and 101. It was 6 credits each quarter with 2 credits per quarter devoted to the laboratory. There were 4 lectures per week, and 2 three-hour laboratory sessions per week. The prerequisites for the course, taken during the premedical years, were analytical chemistry, organic chemistry, and physics. It should also be pointed out here that physical chemistry was a part of the medical curriculum and was taken in the first year of medical school before physiological chemistry.

There was little change until 1937-38 at which time physical chemistry was no longer a part of the medical school curriculum but had been added to the premedical requirements. Also the physiological chemistry course was increased to seven credits in the first quarter, with six credits still in the second quarter. At this time there were always a number of non-medical students who also took this course, these being mostly graduate students and medical technologists with now and then a senior undergraduate or adult special student. During the fall and winter quarters the enrollment was about 145-155 with medical students accounting for about 100.

The course was also repeated during the summer session with the pace of presentation being doubled, i.e., there were two lectures per day five days a week and one laboratory session four days per week over the 10-week period of the summer session. This was given primarily for medical students who had to repeat the course before beginning their second year, not only for Minnesota students but students from other medical schools. In addition there were usually some graduate students and repeaters from the medical technology and dental curriculums. The enrollment was always considerably smaller in the summer than in the fall and winter

quarters. There were about 30 in the class when I took it in the summer of 1940. We continued with the course every summer until 1969 when our Medical School converted to a year-round curriculum.

During the years of World War II, 1941-1946, the medical curriculum was accelerated with a new class beginning every three quarters. Thus when I became an Instructor in the the Department in the fall of 1946, the first year medical students were already in their second quarter taking the 101 course. The number of medical students during the war years had been somewhat less than usual, there being 70 in the fall of 1946 along with 28 other students. The next Medical class started in the spring of 1947 and was now back to 100, being filled mostly with returning veterans. The total enrollment in the course in the spring of 1947 was 120.

After the summer of 1947 the accelerated curriculum was stopped, and a new class started on a regular schedule in the fall of 1947. To take into account the large number of returning veterans, the medical class size was increased to 120. (There were a couple of thousand applications!) There were also 30 other students in the class for a total enrollment of 150. This level of enrollment for the course remained much like this for the next several years.

In 1949 it was decided, in view of our heavy teaching load, to teach the medical students and the dental students together. There was no lecture room in the medical sciences complex that was large enough to hold a class of nearly 300 students, and it was necessary to use the auditorium in the Physics building which was about two blocks on the other side of Washington Avenue. Because the dental students had less rigorous pre-professional requirements, it was clear that the two groups had to be graded separately. After one year of this experiment, it was abandoned, because (1) the far-removed classroom was inconvenient, (2) it was more difficult lecturing to such a large class with somewhat different educational goals, and (3) the difference in performance on examinations by the two groups indicated that it was not pedagogically sound to have them in the same class.

In the 1950s the medical class was increased to 150 students. Also in 1952 a small change was made in the course to take into account the rapidly increasing knowledge in the field; the number of credits in the second quarter was increased to 7 with the addition of a fifth lecture per week. Between 1952 and 1962 there were minor changes in content to keep up with the developing knowledge. These changes included revision of lecture material and, more often, changes in the laboratory experiments. For example, during this time experiments were introduced that involved paper chromatography and paper electrophoresis, and in 1962 we also had available for the first time a double-beam UV spectrophotometer.

In the 1955-56 school year a unique

experiment was carried out by the first year medical school class. Just a few years earlier the association of blood cholesterol levels with heart disease had first been shown to be significant. Then followed the finding of the apparent relationship of the dietary unsaturated fatty acids to the levels of blood cholesterol. As something that would be very interesting for the students to do in their laboratory work, it was suggested that this latter relationship might be tested on the students.

An experiment was set up in which students would supplement their diet for a short period of time with fats of varying amounts of unsaturation and then determine whether or not their blood cholesterol levels changed appreciably. With a considerable amount of help from individuals outside the Department, four different ``milk shakes'' were prepared, with the only variable being the type of fat used in the recipe. The four fats were cream, olive oil, corn oil, and safflower seed oil. 159 students volunteered to participate, and they each consumed one pint of the ``milk shake'' at noon instead of their regular lunch for a period of nine days. Blood samples were drawn before and just after the completion of the regimen, and the cholesterol concentrations were determined by the students and independently in the Laboratory of Physiological Hygiene that had regularly been making blood cholesterol determinations. The students also participated in the statistical analysis of the data.

The results of this experiment showed significant differences between the various fats. Those students on the corn oil and safflower seed oil ``shakes'' had lowered their blood cholesterols on the average of 11.2% and 8.9% respectively. Those taking the olive oil ``shake'' had values that averaged 5.4% lower, while those with the cream ``shake'' had no significant change. The corn oil and safflower seed oil had the most polyunsaturated fatty acids, the olive oil less, and the cream the least. Thus in this relatively crude experiment, it was shown that blood cholesterol levels could be lowered significantly, at least over a short period of time, by making a considerable change in the type of fat included in the diet. These data were considered to be of enough significance so that a paper describing the work was prepared and eventually published[6].

In the period following World War II several new and revised textbooks appeared on the market, and we had a difficult time agreeing on one that would be the most suitable. The result was that between 1946 and 1956 the recommended text was changed at least four times. For the laboratory work in 1946 we were using a mimeographed set of directions that had been put together by the faculty over the past many years. During the next few years I made several additions and revisions, and in 1950 Dr. Armstrong and I agreed to have it published by a company in Minneapolis that

specialized in laboratory manuals[7]. This manual was revised in 1957 and again in 1963, and in 1969 we stopped using it altogether. ***vide infra.***

A considerable addition to the lecture content of the medical course was made in 1962, a change that came about because of a change in medical school prerequisites. Because there was a dearth of medical school applicants in the late 1950s, all other schools had dropped the physical chemistry premedical requirement. After considerable study and debate, Minnesota became the last school to drop this requirement. The only valid reason for doing it at that time was that it would improve our chances of getting more of the better students. Hindsight now indicates that it would have been dropped within ten years for other reasons.

Although physical chemistry was not a prerequisite for 100-101, many physico-chemical topics were not covered because nearly all of the students had had physical chemistry. In order to teach the entering class in 1962, many of which now had not had physical chemistry, the Department was allotted more time for lectures which dealt explicitly with physico-chemical topics which we deemed to be essential. To include these topics we were given one more lecture per week, increasing to 8 the number of credits per quarter. This meant six lectures per week, so we now gave a lecture every Saturday morning. During the next 7 years, because of the pressure for more time for other topics, the time devoted to physical chemistry gradually dropped to where it became very little.

In 1968 the Medical School followed the lead of many of the other medical schools in the country in curriculum review, and, after a year's study and planning, made a major change in the total curriculum. A major goal of the new curriculum was to present a shortened version of the basic sciences in the first year. In order to do this, even on a much reduced basis, it was necessary to lengthen the school year to 11 months. Then in the second year some 15 units of clinical specialties would be covered in another year of 11 months of school time. The teaching in each of these units was to be done by teams with the relevant basic science being taught by the appropriate basic science faculty. The final two years would consist of clerkships in the various disciplines, not much different from the old curriculum. This revised curriculum went into effect in the fall of 1969.

The change in biochemistry was considerable, for the total credits of our first year course was dropped from 16 to 10. In the first phases of the planning, it was to be only 8 credits, but 2 credits were added when the Department of Physiology indicated that we should continue to teach the more ``physiological" topics of blood chemistry, endocrinology, and nutrition. The net effect was that we had 50 lectures and 10 laboratory periods in the first term of Year I (6 credits) and 30 lectures and 8 laboratory periods in the

second term (4 credits). To substitute for the reduced teaching time in Year I, we were to have lectures in many of the courses in Year II. The first year after the adoption of the new curriculum, we did have about 12 lectures in four different courses, but this gradually eroded such that in 1988 we have 2 lectures in one course.

With the reduction of lectures from about 115 to 80, we were pressed to make judicious changes so that we still covered essentially the same material. This was accomplished in a fairly satisfactory manner as far as the faculty was concerned. Because some of the more elementary material was omitted, it did make it more difficult for the students, especially for those whose background in basic science was minimal.

Another change in the lecture part of the course was made in 1982-83. The number of regular lectures was reduced from 80 to 70 because at this time many of the students were now coming into Medical School who had already taken one or more courses in biochemistry. Thus some more of the elementary material could be eliminated. For those students who felt that their basic science preparation was minimal, there was offered a series of 20 supplementary lectures. In the first year of this approach these lectures were attended by about 10% to 30 % of the class. This format was well-received, and it has been continued up to the present.

It should also be mentioned that in 1969-70, the University changed its course numbering system from 3 digits to 4 digits because there were now so many more courses. Thus at this time our course had a 5 added as the first digit. The 5 indicated that it was a course for upper division undergraduates and for first year graduate students. The Department could choose whatever it wished for the remaining 3 digits, so we decided to let the 100, 101 remain unchanged.

The change in the laboratory teaching at the time of the curriculum change was quite drastic, not only because of the time reduction, (one-half), but also because of a change in the students' previous preparation and also a change in their attitude about laboratory that occurred in the late 1960s. The laboratory manual that had been used, with continuing revision, for more than 30 years was scrapped. A new set of experiments was devised that allowed students to do some ``research type" experiments, and also they were introduced to some of the newer research techniques and equipment. This necessarily required the participation of more of the faculty for laboratory teaching than had been necessary in the past.

In spite of the considerable effort that went into the completely revised laboratory teaching, it was never received very well by the bulk of the students. During this period most of the students were <u>not</u> at all interested in basic sciences but only in ``real" medicine. This illustrated by the fact that in

the 1960s we had about a dozen students who completed both the M.D. degree and the Ph.D. degree in Biochemistry, whereas, in spite of considerably larger class size, only one student did this in the 1970s.

Although the students were less than enthusiastic about the laboratory work, we continued to include it because we have always been convinced that the carrying out of selected experiments and the collection and analysis of data are essential to the understanding of the discipline of biochemistry. Many medical schools had eliminated the laboratory work in biochemistry; however, biochemistry faculty members from these schools occasionally applauded us and encouraged us to keep on with it. A laboratory manual edited by Jack Van Pilsum and Robert Roon was used for many years during this period[8].

In 1981 an experiment in laboratory teaching was instituted which involved cooperative learning in small groups. In this approach the students were divided into small learning groups, with the grade for each student being dependent on the single grade given to the total small group's work. After the first year it was felt that the results were positive with repect to the students' taking part in group problem solving and in helping them to understand the relevance of the biochemistry laboratory[9]. In the following years this approach was expanded and somewhat modified. Nevertheless the negative trend in medical education concerning laboratory work has continued, and in 1987-88 the hands-on laboratory in biochemistry at Minnesota was dropped entirely. In its place are laboratory lecture-demonstrations which cover much of the same material. Thus the personal participation of the students in laboratory work which was so strongly emphasized in 1888, has disappeared in 1988, not only in biochemistry but in some of the other basic sciences as well.

B. Courses for the Other Health Science Professionals

In addition to teaching biochemistry to medical students, the program has also had the responsibility for teaching students in the other health sciences - medical technology, dentistry, nursing, and veterinary medicine. Because these students come into their programs with widely varying backgrounds and have different curricular needs, the nature of the courses in biochemistry for these groups must necessarily be different. Thus, we have nearly always offered courses for each of these groups separately. The differences are in the level at which the course is taught, in the quantity of material that is presented (credit hours), and to a limited extent in the emphasis on certain topics, depending on the particular curriculum of the students. In a few instances over the years we have combined two groups in a single course, but we have generally felt that this is not a satisfactory arrangement.

(1) Medical Technology

In 1922 a four-year course in Medical Technology was instituted in the Medical School. The science prerequisites to be taken in college were the same as for medical students except for the lack of a requirement for physical chemistry. The students, in their third year in college and first year in Medical Technology, were thus put in with the medical students in Physiological Chemistry 100-101. Although they were graded separately from the medical students, they continued to take this course for many years.

As described in Chapter V, it was not until 1964 that the Department received a teaching position specifically for a separate course for the Medical Technologists. This new course was Physiological Chemistry 106,107, a two quarter course of 4 credits per quarter. Because these students received so much laboratory training in their fourth year, their laboratory work in Physiological Chemistry in their third year was discontinued. In 1970 the course number was changed to 5-300, 5-301, and these students continued to take this course until 1986. In the 1980s the enrollment in Medical Technology dropped considerably, and it finally became apparent that a separate course no longer seemed feasible. Thus in 1986 these students were once more included in the course for the medical students.

(2) School of Dentistry.

(a) Dental Students

The Dental School at the University of Minnesota had its beginning at the same time as the Medical School. In fact, Perry Millard was the Dean of both programs. The Dental course was three years in length, and in the first semester the students had a chemistry course, and in the second semester they had their physiology course. The physiology course included physiological chemistry, just as it had for the medical students. A single course in physiology and physiological chemistry continued until 1916 at which time a course in physiological chemistry specifically for dental students first appears in the bulletin, Physiological Chemistry 6, 3 credits, in the first year and Physiological Chemistry 7, 2 credits, in the second year, with general chemistry as the prerequisite. The course number was changed to 56, a single course of 5 credits in 1921, and it was changed again in 1923 to 57, 4 credits, the way it remained until 1939. In 1929 organic chemistry also became a prerequisite for the course.

In 1939-40, a two quarter sequence was instituted, 56, 57 for 9 credits. One quarter of laboratory work was introduced at this time, accounting for 2 of the 9 credits. In 1949-50 the course numbers were changed to 104, 105, indicating that it now was a senior and first year graduate level course. The credits were 10 at this time, changed to 11 in 1952-54, and to 12 in 1967. The

numbers were changed to 5-200, 5-201 in 1970 at the time all course numbers were changed throughout the University.

In 1974 a major change was made in the dental curriculum, and this included quite a change in biochemistry. The course in the first term became Biochemistry 5-202, an 8 credit course taught in a term of 14 weeks, beginning the day after Labor Day and ending with the Christmas break. This covered all of the material in general biochemistry. Then in the final year of the new curriculum, Biochemistry 5-203 was given, a 2 credit course called Topics in Dental Biochemistry. This is still the arrangement for biochemistry in the dental curriculum except that the laboratory in the first term has been discontinued, and 5-203 is now given in the second year.

As pointed out in Chapter I, the course in biochemistry in the dental curriculum was under the supervision of Dr. Leon Singer from 1949 to 1988. He was primarily responsible for the design of 5-202, 5-203 that was made in 1974, and he taught most of 5-203 until he retired.

(b) Dental Hygiene

In 1919 the Dental School began a program of training in dental hygiene, a non-degree program of two years for students with a high school education. Because they would receive instruction in all of the basic sciences, physiology, including physiological chemistry, would be one of the first courses they would take. These students were included in a course already in place, Physiology 4, which was being taught to the degree students in Nursing. This course was of 4 credits, and had a prerequisite of either high school or college general chemistry. A single course in physiology and physiological chemistry was continued until 1929, when for the first time a separate course in physiological chemistry for these students in listed in the bulletin, Physiological Chemistry 1, for 2 credits.

In the middle 1930s some Twin City hospitals had their non-degree nursing students come to the University to take their basic science courses through the Extension Division. Physiological Chemistry 1 was changed to a course without a chemistry prerequisite, and it was given to the Extension students and the students in Dental Hygiene. A new course, Physiological Chemistry 50, 4 credits, with a general chemistry prerequisite was begun for the degree students in Nursing and for students in Physical Education.

Shortly after World War II the hospital nursing students no longer came to the University, and the the Dental Hygiene students became the main group of students taking Physiological Chemistry 1. In the 1950s high school chemistry again became a prerequisite, and the course number was changed to 30. These students still take this course, the only change being that its number was changed to 1-030 in 1970.

(3) School of Nursing

In 1909 a three-year degree program in Nursing was begun, and the first six months was devoted to the basic sciences. A physiology course, which included physiological chemistry, contained such topics as the composition and analysis of water, milk, urine, and blood. As indicated in the last section, this single course in physiology and physiological chemistry was continued until 1929, when for the first time a separate course in physiological chemistry for students of nursing was instituted. In the middle 1930s these students were put into the new course, Physiological Chemistry 50, 4 credits, with a general chemistry prerequisite, and it also included students in Physical Education. The degree students in Nursing have continued over the years to take this same course, the only change being that the number was changed to 3-050 in 1970.

(4) Veterinary Medicine

After World War II the University organized a College of Veterinary Medicine, and it was located on the St. Paul campus. Its curriculum was to be very similar to that of the Medical School. The students would be admitted to the College after two or more years of undergraduate work and then pursue a four-year curriculum to complete the degree, Doctor of Veterinary Medicine (D.V.M.). The curriculum had basic science courses in the first two years, Anatomy, Biochemistry, Microbiology, Pharmacology, Pathology, and Physiology. In 1947 our Department agreed to take on the teaching of Biochemistry to the first year students in Veterinary Medicine, with the idea that the new College would eventually have their own faculty to do this teaching. In the meantime they would transfer funds from their budget to our budget for this increase in our teaching responsibilities.

We began this course in the winter and spring quarters of 1948, the courses being numbered 102-103, 6 credits each quarter. There were four hours of lecture per week and two 3-hour laboratory periods per week. Two of the lectures were given on the Minneapolis campus on the two days in which the students had their laboratory work. The other two lectures were given on the St. Paul campus in one 2-hour session each week.

In 1961 William Caster, who had been working on a grant from the Atomic Energy Commission with Dr. Armstrong in our Department, was relocated on the St. Paul Campus in the College of Veterinary Medicine. He was given the responsibility for teaching this course, and it would be taught entirely in St. Paul.

In 1964 Dr. Caster went to the University of Georgia, and the teaching of this course was then taken over by Dr. Everett Short, who had the D.V.M degree and was completing the Ph.D. degree in our Department. He was on the faculty of the College of Veterinary Medicine, and he had a joint appointment in our department. He was soon

joined in the teaching of this course by Dr. Sally Jorgensen who had also just completed the Ph.D. degree in our department and had become a member of the faculty of Veterinary Medicine. Dr. Armstrong monitored the course for several years, but by the end of the 1960s, our responsibility was essentially ended. In 1970 the course number was changed to MdBc 5-200, 5-201, and in 1975 it finally became listed as Veterinary Biology 5-200, 5-201.

References

1. See Ref. No. 8, Chap. I

2. Matthews, A.P. ``Physiological Chemistry'' William Wood Co., N.Y., 1st ed., 1915

3. Foster, M.F. ``Textbook of Physiology'' Lea Bros., Phila., 4th American ed., 1891

4. Hammarsten, O. ``Textbook of Physiological Chemistry'' (Authorized Translation by John Mandell) John Wiley & Sons, New York, 1893

5. Abderhalden, E. ``Textbook of Physiological Chemistry'' Trans. by Hall, W.T. and Defren, G., John Wiley & Sons, New York, 1908, pp. 272

6. Armstrong, W.D., Van Pilsum, J., Keys, A., Grande, F., Anderson, J.T., and Tobian, L. ``Alteration of Serum Cholesterol by Dietary Fats'' Proc. Soc. Exptl. Biol. Med. 96 302 (1957)

7. Armstrong, W.D. and Carr, C.W. ``Physiological Chemistry, Laboratory Manual'' Burgess Publ. Co., Minneapolis, 1951, 1957, 1963

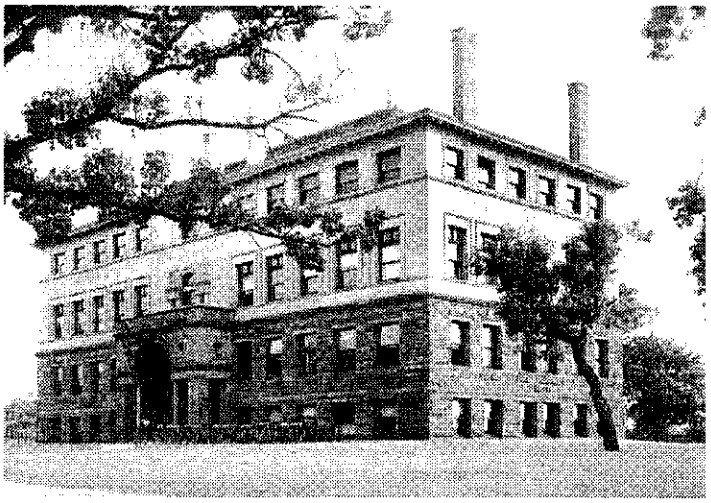
8. Van Pilsum, J. and Roon, R. ``Medical Biochemistry; Principles and Experiments'' Univ. Minn. Press, 1986

9. Roon, R., Van Pilsum, J., Harris, I. Rosenberg, P., Johnson, R., Liaw, C., and Rosenthal, L. ``The Experimental Use of Cooperation Learning Groups in a Biochemistry Laboratory for First Year Medical Students'' J. Biochem. Educ. 11 1 (1983)

Chapter X. Program Space

When the Medical School began in 1888, there was to be special emphasis on laboratory work. The building where the classes were held was one which had most recently been used for the Minneapolis College of Medicine, and it is not very likely that laboratories of any sort were used in this proprietary school. The new school did have a small chemistry laboratory which appears to have been a space that was formerly a drug storeroom[1,2].

In 1892 when the Medical School moved onto the campus of the University of Minnesota, there was one new building for its use, Medical Hall (now Wulling Hall).



Medical Hall. (Univ. Minn. Archives)

For the building of Medical Hall, Dean Millard had put in $20,000 of his own money as an interest-free loan in anticipation of a legislative appropriation[1,3].

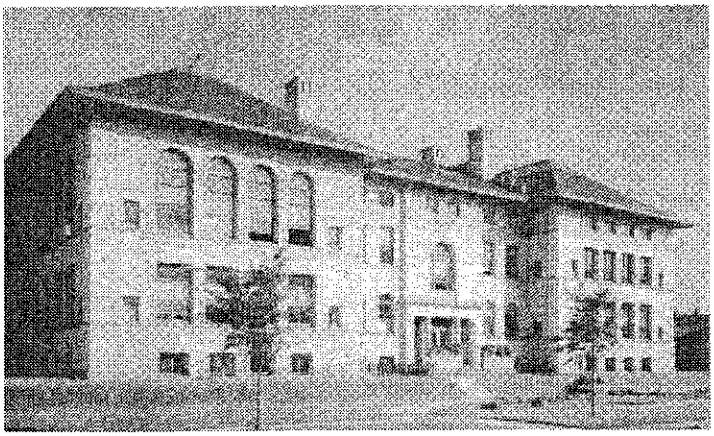
Medical Chemistry or the "Bowling Alley." (Univ. Minn. Archives)

In 1893 another building was ready for use, the Medical Chemistry building, occupying the the site where Johnston Hall is now located. It was a one-story brick and frame building, built for the cost of about $6,500. It was long and narrow, and it had laboratories for Physiological Chemistry and Histology and an amphitheater for lectures. Because of its shape, it was frequently referred to as the ``bowling alley[4]." It was razed in 1924.

In 1896 a third building was completed, Medical Sciences, and the Physiology Department was now located in this building and the Medical Chemistry building. The following is a description of this space taken from the bulletin of 1896:

``The chair of physiology occupies a suite of rooms in the laboratory of medical sciences, including a general laboratory of physiological chemistry and physiology, a demonstration room for experimental work and the library and office of the professor of this branch. Class work in physiological chemistry is conducted in the laboratory of chemistry, occupying the adjoining building (Medical Chemistry Building).

In the basement of medical sciences, the chair maintains a spacious and comfortably equipped animal room, which is furnished with a large aquarium, frog tanks, rabbit and guinea pig enclosures, breeding cages, and dog and cat kennels."



Medical Sciences, later renamed Wesbrook Hall. (Univ. Minn. Archives)

In 1908 it was decided to begin a new medical campus to the south next to the Mississippi River. Three buildings were built in 1911, Elliot Memorial Hospital, new Millard Hall, and the Anatomy Building (now Jackson Hall). The total cost for the Anatomy Building and Millard was $636,000.

Millard Hall was built primarily to house the Physiology and Pharmacology Department. (Pharmacology became a separate department in 1913). The exterior of the building was Bedford stone and Danville brick, the interior was of brick, concrete, and tile construction, and it had 82,455 square feet of floor space. It had both AC and DC electrical circuits and high pressure steam and compressed air lines[5]. In addition to space for the Physiology and Pharmacology Department, it included the offices for the Dean and for the Heads of four clinical departments and space for a Medical School library. A description of this space, taken from the Medical School bulletin for 1912-13 follows:

``The Department of Physiology and Pharmacology will occupy its permanent quarters, during the summer of 1912 in the new Millard Hall which is now approaching completion upon the new medical campus. This department will enjoy about three fifths of the space provided in the building. In addition to the lecture amphitheaters shared with other departments, it will equip a large students' laboratory of experimental physiology, two laboratories of physiological chemistry, an equally spacious laboratory of experimental pharmacology, demonstration rooms, a number of small apartments for the secluded study of special sense phenomena, a laboratory of materia medica, the offices and private laboratories of the individual members of the staff, and special laboratories for post graduate study.

The basement of the new Millard Hall will be

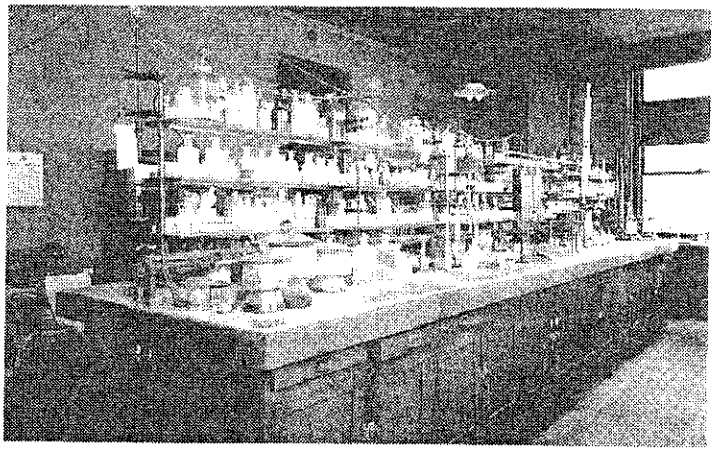
provided with a diet kitchen, motor and still rooms, an insulated chamber for electro-cardiograph-galvanometer, combustion rooms, and ample work-shops and storerooms. In the roof house will be placed animal enclosures of thoroughly modern and sanitary equipment, as well as small laboratories for experimental studies along special lines."

Thus just at the time of the real beginning of the program in Physiological Chemistry, there were new facilities available.

These new buildings were very well constructed. Over the years Millard Hall has undergone several remodelings as the result of different programs coming and going and the development of needs for different kinds of space. Nevertheless, 80 years later the basic structure is still the same. The tile flooring in the hallways looks about as good as ever, and so do the stair wells and stairs. The student laboratories and research laboratories also stood up very well. When I first came to Millard Hall in 1939, the original laboratory benches were still in use, and in pretty good shape. In fact the benches in the student laboratory were to be used until 1959. The bench tops were of a gray tile that was just about impervious to any kind of chemical, and, except for a few of the tiles being cracked, they showed essentially no wear. The shelves for chemicals in the middle of the benches were something else. There was a one-half inch pipe framework which held shelves made of plate glass. Needless to say, over the years many of these were broken.

In 1931-32 a new building was constructed primarily to house the Dental School and also to provide administrative offices for the School of Nursing and the Medical School. This building was called Medical Sciences when it was built, and some time after World War II the name was

Millard Hall, ca. 1920. (Univ. Minn. Archives)

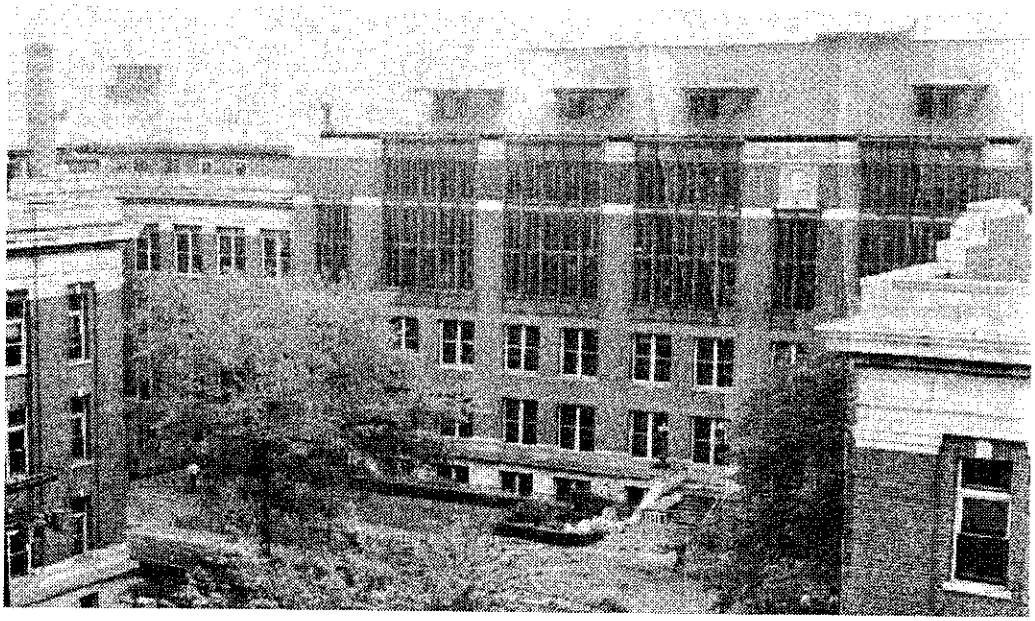


Laboratory Bench in Millard Hall. (Univ. Minn. Archives)

changed to Owre Hall in honor of Alfred Owre, who served as an excellent Dean of the Dental School during 1905-1927. Prior to the construction of this building, the Dental School had occupied Wesbrook Hall (old Medical Sciences) ever since the Medical school left in 1912.

Owre Hall joined Millard Hall at the southwest corner and extended to the west at right angles to Millard. In fact, the stockroom of the student laboratory of Physiological Chemistry on the fifth floor extended several feet into Owre Hall. In the late thirties other parts of this building would provide research laboratory space for Phyiological Chemistry, and today more than one third of the Department's space is in this building.

During the period of 1912-1935, it is apparent that the laboratory and office space for faculty members in Physiological Chemistry was quite adequate. In the late 1930s with the coming of Maurice Visscher as the Department Head of Physiology, there was an increased emphasis on research. Dr. Visscher obtained a large grant from the Rockefeller Foundation to study intestinal absorbtion in 1937, Dr. Armstrong returned



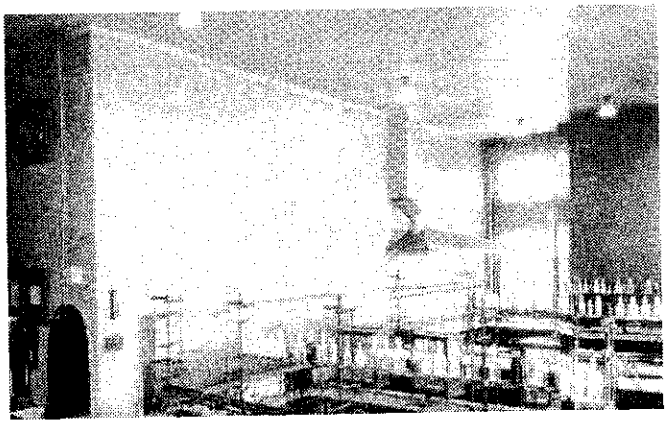
Medical Sciences, later renamed Owre Hall. (Univ. Minn. Archives)

from a year of study in Europe in 1939 ready to begin a major program in calcified tissue research, and Dr. Burr became the Director of the Division of Physiological Chemistry in 1940. These three events especially, increased the space utilization to the maximum. However, because of the advent of World War II, no space remodeling or additions would be made at this time.

In 1946 when the Department of Physiological Chemistry was formed, many personnel changes were made (already documented), and the Department had five and one half funded positions. Wallace Armstrong had office and laboratory space in the second floor of Owre Hall. (It is now the animal room for the Pharmacology Department). His office had not more that 300 square feet of space. It also had to serve as the Departmental office, so he had to make room for the desk of the departmental secretary! His laboratory space in this area was about 800 square feet.

Cy Barnum's office and laboratory were in the southeast corner of the fourth floor of Millard Hall where our departmental office is now located. His space was about 1000 square feet, quite adequate for that time. Saul Cohen also had his office and laboratory on the fourth floor of Millard Hall, his laboratory being that which is now occupied by Frank Ungar, about 600 square feet. His office was just across the hall. David Glick also was on the fourth floor, his office and laboratory occupying the space in Owre Hall that is now our departmental library. Elizabeth Frame had her office and laboratory in Owre Hall next to Dave Glick.

Our teaching laboratory was on the fifth floor, in the southeast corner of Millard Hall in space now occupied by the Physiology Department. It was about 2500 square feet, and with 90-100 students in there at one time it was quite crowded. My office and laboratory was next to the teaching lab, and it was about 450 square feet.



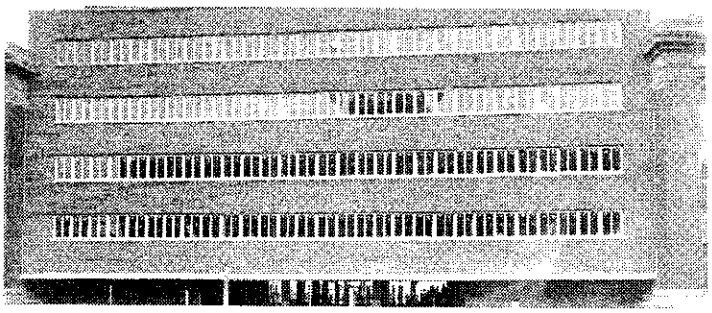
Teaching Laboratory for Physiological Chemistry in Millard Hall. Picture taken in 1926; it looked the same in 1959. (Univ. Minn. Archives)

There were also some auxilliary spaces: (1) We had some rooms for small animals on the sixth floor of Millard Hall. (2 The stockroom for the teaching lab was so large that about 400 square feet of it was made available as common research space. (3) Some attic-like space on the seventh floor of Owre Hall was make available to Wallace Armstrong where he carried out some of his high-level radioactive experiments.

The total space in 1946 was somewhat less than 10,000 square feet and about 2,000 square feet less than the space occupied by physiological chemists in 1940-46. When Wood, Utter, and Sollner left in 1946, their space reverted to the Physiology Department. The space with which we started as deparment in 1946 had three serious shortcomings. While in square feet it was almost adequate for the staff at that time, it was very old, it had a vertical profile with space on the second, fourth, fifth, sixth, and seventh floor on the south side of the Millard-Owre complex, and it had essentially no space for a departmental office.

Needless to say, this fledgling Department was soon in a position where it was crowded, for each of the research laboratories was expanding with new research grants followed by new personnel. At this time the whole Medical School was also in the need of space, and plans were under way for a new building. The plans were for a 22-story tower, but by the time the money was raised, inflation had taken its toll, and the building was reduced to 14 stories[6]. The Mayo Building, as it was called, was finally finished in 1954, and in a secondary manner we gained a lot of space after its construction.

Dave Glick had obtained money for the construction of a histochemistry laboratory, and in the original plans of the Mayo Building he would have had one floor. When the plans were changed, Dave ended up getting one floor in a new addition of four floors that joined the north wings of Millard and Jackson Halls, a space that was named Lyon Laboratories. (It was named for Elias P. Lyon, who was the third Dean of the Medical School). This addition, finished in 1954, increased our space by about 6000 square feet. We also relinquished about 1500 square feet, the former laboratories of Drs. Glick and Frame, which were returned to the Dental School.



Lyon Laboratories. (Univ. Minn. Archives)

When the Mayo Building was completed, the Bacteriology (Microbiology) Department moved out of Millard Hall into two floors of the new building. We "inherited" all of the space that they vacated on the fourth floor of Millard and also much of what they had in the basement (second floor). We could not make much use of it right away because it needed considerable remodeling and modernization, and the money for this was not immediately available. For a period of about five years, we did make use of some of this space on a makeshift basis.

By 1957 money was obtained from NIH along with matching funds from the state legislature for this remodeling project. We

designed our new laboratories and offices, construction began, and the "new" space was ready in the summer of 1959. At this time we gave up some space, our teaching laboratory on the fifth floor, for we had constructed a new teaching laboratory in the northwest wing of the fourth floor in the space that was formerly the teaching laboratory for the Department of Bacteriology.

Another part of this remodeling project that benefited the Department, was the construction of new animal quarters for the three basic science departments quartered in Millard Hall. The old animal space on the top floor of Millard Hall was completely demolished and reconstructed into new office and laboratory space for the Physiology Department. The new animal space was put below ground level underneath Lyon Laboratories. It was a tremendous improvement over what we had before, and we gained about 500 square feet of additional space. The net gain in space for the Department from the 1957-59 remodeling project was about 6000-7000 square feet.

The culmination of this project resulted in a major change for the Department. For the time being there was adequate space for everyone, even though we had added four more faculty members. The remodeling included a new and comparitively spacious Departmental office, which was located in the northeast corner of the fourth floor. The teaching laboratory was not much larger than the old one, but it was new and in many ways more convenient both for the students and for the staff. Also we gained the walk-in cold room that had belonged to the Department of Bacteriology. It was not in very good condition, but it was much better than we had before, which was nothing. Finally, we were now more cohesive, i.e., we had a more horizontal profile, being entirely on the second and fourth floors.

During the 1960s each research laboratory was growing because research grants came relatively easy, and we also added three more staff members. Once more by 1966 we were pressed for space. In the meantime the Medical School as a whole was again looking at expansion. Thus, our second major remodeling and increase in space came about as a result of the expansion in facilities for the teaching of medical and dental students that occurred in the late 1960s. However, from the time we realized that we needed more space until it became available would take twelve years.

Along with most other universities that had major health science programs, Minnesota began to make plans for their expansion in the early 1960s. After studies of the medical and dental manpower needs in the state and proposals from the University administration, the legislature in its 1967 session appropriated planning money for some new buildings. In 1969 they implemented the plans by appropriating enough money for the first of several new buildings[7]. This building was to accommodate the

entire Dental School, plus teaching laboratories for the basic science departments, and some space for the School of Public Health. In addition to getting this new teaching laboratory space, we would also get considerable space for remodeling in the space vacated by the Dental School in Owre Hall. It was planned that the new building (Unit A, now Moos Health Science Tower) would be finished for classes in the fall of 1973, and the remodeling in Owre Hall would be finished by 1975.

We were able to use the laboratories in Unit A for our classes in the fall of 1973, the students entering the unfinished building through a special walk-way. This was was made possible largely through the special efforts of Gerald Bratt, assistant administrator in the Department. We now had about as modern and spacious teaching laboratory as we could wish for. At this time, however, the rest of the building schedule was postponed. By the time the legislature was asked to appropriate money for the second building, there had developed reservations about proceeding further with construction[7]. The money for our remodeling had to come after the money for Unit BC (Phillips-Wangensteen Building), and the BC money did not come until 1974. It was then anticipated that the legislature would appropriate funds for the Owre Hall remodeling in 1975.

This vacated space in Owre Hall was to be converted into expansion space for all the basic science departments in Millard and Jackson Halls. These departments included Anatomy, Biochemistry, Laboratory Medicine and Pathology, Pharmacology, and Physiology. To make use of this space, it was first necessary to decide how it was to be divided among these Departments, and the Heads of these Departments began to plan this distribution in 1973. A tentative plan would be proposed and brought to the respective faculties for discussion. This resulted in several revisions, and it was not until March, 1974, that a plan was reached that appeared to have gained general consensus. The Department of Biochemistry fared quite well in this distribution because it had been recognized that we had been shortchanged in space ever since becoming a department. However, in the spring of 1975 the legislature turned down the University's request for remodeling Owre Hall, and things looked pretty dark for our long-awaited additional space.

In the meantime, with the completion of the new teaching laboratories in the new building, our Department made plans to convert the vacated teaching laboratory in Millard Hall into office and research space for our staff, the money coming from internally generated funds. This project was begun immediately after the last class was held there in March 1973, and it resulted in a new office and research laboratory for both Mary Dempsey and Jim Bodley. Up until this time Mary had a small laboratory in Lyon Labs, and Jim had a small laboratory in

the basement (second floor) of Millard.

In the building of Moos Tower the Dental School incorporated considerable space for basic science research, and much of this would be occupied by individuals who had joint appointments in the Basic Science Departments of the Medical School. Thus in 1974, shortly after the retirement of Wallace Armstrong, Leon Singer moved the calcified tissue research group into very spacious quarters on the eighteenth floor of the new building (about 4000 square feet). The space which they vacated in Millard-Owre became available to our Department.

In November 1975 the Department Heads of the basic science departments were getting concerned about the lack of progress with the major remodeling of the Jackson-Owre-Millard-Lyon complex, and they arranged to meet with Health Sciences Vice President French to discuss the situation. It had been determined earlier that the amount needed for the complete remodeling would be 15 million dollars. It was found out at this meeting that it had apparently also been decided that it would be best to ask for this money in small increments. This meant that there would be a request made to the legislature in the spring of 1976 for 3 million dollars, and that a similar request would be made every two years for 10 years. What a dismal prospect!

Miracles do happen. In December 1975 Dean Gault of the Medical School heard that there was some surplus NIH funds for building that involved medical education, and that application for such funds must be made as soon as possible. In a hurry-up manner a small group of individuals put together an application for 2.5 million dollars for the remodeling of 81,000 square feet of Jackson-Owre-Millard. This was not the entire project, but it was as much as the Medical School could ask for. In addition it would have to be matched by twice that much locally. This application was put together with not a lot of hope that it would be approved, but it was better than doing nothing. Not only was it approved, but because the University had this money in hand, the legislature agreed to put in the necessary 5 million dollars of matching funds. Thus we now had funds to complete a major part of the remodeling, not a piddling 20%.

In 1974-75 the Department had spent quite a bit of time in making plans for this project, and when the money became available, we had our plans ready. The construction started in the beginning of 1977 and was completed at the end of 1978. The net result was to increase our space from somewhat less than 25,000 square feet to a little more than 40,000 square feet. In more detail the results were the following:

(1) Two air-conditioning towers were built on the south side of the complex so that the entire 81,000 square feet of the remodeled space could be centrally air-conditioned.

(2) We had a completely new Departmental office built in the southeast corner

of Millard Hall on the fourth floor. It was quite spacious and had everything arranged about as conveniently as possible within the limits of the outside walls.

(3) Next to the office on the west side in Owre Hall there was a Departmental reading room of adequate size, and across the hall was a combined seminar-conference room. In 1979 the reading room was dedicated as the Jesse F. McClendon Reading Room.

(4) On the fourth floor of Millard Hall next to the office was an office-laboratory suite for the Department Head.

(5) On the fifth floor of Owre where the old Dental Clinic was located, there were now seven new office-laboratory suites for individual staff members.

(6) In addition to the seven laboratories for faculty members on the fifth floor, there were two more laboratories for graduate students, space which was not assigned to any specific faculty member.

(7) Three new walk-in cold rooms were built, which when added to the three already in place, meant that we now had six such rooms for a senior faculty of 15 persons.

(8) Two common rooms for large equipment and two rooms for dishwashing were also built on the fifth floor of Owre.

Thus in 1979 eleven of the fifteen senior faculty members had newly remodeled space of sufficient size. The other faculty members had quite adequate space in square footage, but it was old and not-so-well arranged for present-day research. At this time, however, there was not enough money to complete the job for the space at the north end of the fourth floor of Millard, the Lyon Lab space, and the space on the second floor. It was hoped that a Phase II would be funded in the near future, but ten years later that was still only a hope. Nevertheless, at the end of this Phase I remodeling, when compared with the past, the Department was in very good condition with respect to space.

In 1975 the planning had been to have space that would be adequate at least till about 1985. As most always happens in a major university, space that is adequate at a given time, can become inadequate in ten years. That is exactly what happened here, and in 1985 the Department began making rearrangements of space and looking for more.

References

1. Beard, R.O. "The Medical School of Minnesota" J. Lancet 51 73 (1931)
2. Wilson's History, p. 48
3. *ibid.*, p. 50
4. Beard, R.O. "The Past of the Medical School of the University of Minnesota" J. Lancet 41 155 (1921)
5. Minn. Alumni Weekly Suppl. "University Directory" Nov. 1913
6. Wilson's History, pp. 426-443
7. *ibid.* pp. 545-554

Chapter XI. Student Records

A. Ph.D. Recipients

The following is a list in chronological order of those students who have received the Ph.D. degree in Physiological Chemistry/Biochemistry through the Department in the Medical School. It includes the year in which the degree was granted, the major adviser, and the thesis title. It also includes the most recent position and current address for as many of the individuals as I have been able to ascertain. In this chapter, where I am aware of it, the data have been made current, i.e., June 30, 1994. The two-digit number in parenthesis indicates the latest year for which I have information.

Of the 208 individuals listed up to 1988, there are only 4 for whom I have no knowledge of their whereabouts since getting their degrees. There are also 16 for whom I have listed information about earlier positions, but for whom I do not know their recent whereabouts. This information has been obtained from inquiries of major advisors, records in the Departmental office, the use of the directories of American Men and Women in Science and of the Federated Amercan Societies of Experimental Biology, and personal knowledge.

1. Osterberg, Arnold (ret.) M.S. 1921, Ph.D. 1925
   Advisor: Kendall
   Thesis: ``Chemical Nature and Physiologic Significance of Thyroxin and Related Compounds"
   Positions: Professor, Physiological Chemistry, Mayo Clinic, 1924-44; Associate Chemist, Abbott Laboratories, 1944-59; Head, Drug Contol Section, Clinical Branch, National Cancer Institute, 1958-70. (86)
   Address: 1316 Second St., N.W.
   Rochester MN 55901

2. Mulder, Arthur (ret.) Ph.D. 1926
   Advisor: McClendon
   Thesis: ``The Physiologic Chemistry of Fluorine"
   Positions: Professor, Physiology, University of Tennessee, 1927-47; Professor, Physiology, Stritch Medical School, Loyola University, Chicago, Illinois,1947-53. (54)
   Address: See above

3. Gregory, Raymond L. (dec.) Ph.D. 1927, (M.D. 1929)
   Advisor: McClendon
   Thesis: ``A Study of the Quantitative Determination of Bile Salts"
   Position: Professor and Head, Internal Medicine, University Medical Branch, Houston, 1940-68.

4. Remington, Roe (ret.) Ph.D. 1928
Advisor: McClendon
Thesis: ``Electrical Conductivity as a Measure of the Permeability of Cells of the Beet Root''
Positions: Professor of Nutrition and Director, Food Research Laboratory, Medical College of Georgia, 1928-45; Department of Physiology, Medical College of Georgia, 1945-52. (60)
Address: See above

5. Simonsen, Daisy (ret.) Ph.D. 1932
Advisor: Kendall
Thesis: ``The Biological and Chemical Study of Cysteine and Cystine with Special Reference to Their Oxidation Reactions''
Positions: Biochemist, Department of Medicine, University of Southern California Medical School, 1941-53; Biochemist, City of Hope National Medical Center, 1955-74. (74)

6. Armstrong, Wallace D. (dec.) Ph.D. 1932 (M.D. 1937)
Advisor: McClendon
Thesis: ``Studies on Fluorine Analysis''
Positions: Professor and Head, Department of Biochemistry Medical School, 1946-74; Acting Director, Intramural Program, National Institute of Dental Research, 1974-76; Regents Professor Emeritus, University of Minnesota, 1974-84.

7. Myers, Charles S. (ret.) Ph.D. 1932
Advisor: Kendall
Thesis: ``Derivatives of Diiodotyrosine and Thyroxine''
Positions: Research Biochemist, Federal Drug Administration, 1936-49; Chief, Chemical Laboratories, Bureau of Sanitation and Engineering, Pennsylvania State Department of Health, Harrisburg, Pennsylvania, 1949-64. (65)

8. Hamilton, Robert H. (ret.) Ph.D. 1933 (M.D. 1935)
Advisor: McClendon
Thesis: ``Some Studies on Carbohydrate Metabolism''
Position: Professor and Head, Department of Biochemistry, Temple Medical School, 1944-71. (93)
Address: 6900 Wayne Ave., Philadelphia PA 19119

9. Arnow, L. Earle (ret.) Ph.D. 1934 (M.D. 1940)
Advisor: McClendon/Stenstrom
Thesis: ``Physico-Chemical Effects Produced by the Irradiation of Crystalline Egg Albumin with Alpha Particles''
Positions: Director of Research, Merck, Sharpe, and Dohme, 1942-58; President, Warner-Lambert Research Institute, 1958-65; Senior Scientific Consultant, 1965-74. (94)
Address: 14 Fairfield Drive
Convent Station NJ 07961

10. Allers, William D. Ph.D. 1935 (M.D. 1939 Northwestern)
Advisor: Kendall
Thesis: ``The Influence of Diet and Mineral Metabolism on Dogs after Suprarenalectomy"
Positions: Instructor, Physiology and Pharmacology, Northwestern University and Chemical Research Assistant, Armour & Co., 1935-39; Director, Allers Industries, 1947- ; Practicing Physician, 1947- , Chicago, Ill. (55)

11. Lundgren, Harold P. (ret.) Ph.D. 1935
Advisor: McClendon
Thesis: ``A New Chronometric Micro Method for Determination of Iodine Based on Its Catalytic Effect on an Oxidation-Reduction Reaction"
Postions: Head, Protein Section, U.S. Department of Agriculture, Western Regional Laboratories, 1953-57; Chief, Wool and Mohair Laboratory, USDA, 1957-74; Acting Chairman, Division of Textiles and Clothing, University of California, Davis, 1974-78. (86)
Address: 92 Kingston Road, Kensington CA 94707

12. Flock, Eunice V. (dec.) Ph.D. 1935
Advisor: Kendall
Thesis: ``A Study of the Phosphorus Compounds in the Liver of the Dog"
Positions: Professor of Biochemistry, Mayo Graduate School of Medicine,1935-71; Visiting Scientist, Clinical Research Section, Phoenix Indian Medical Center, NIAMD, 1971-80.

13. Street, Harold R. Ph.D. 1936
Advisor: McClendon
Thesis: ``A Study of Some Physiological Effects of Vitamin G Deficiency"
Positions: Vitamin Research Fellow, Yale University, 1936-39; Biochemist, Research Laboratories, Winthrop Chemical Co., 1938-42; Sanitary Corps, U.S. Army, 1942- (44)
Address: Unknown

14. Bernhart, Finn W. M.S. 1934, Ph.D. 1938
Advisor: McClendon
Thesis: ``The Chemical Effects of the Ultra-Violet Irradiation of Crystalline Egg Albumin"
Positions: Head, Nutrition-Endocrine Research and Development, Wyeth Laboratories, 1956-70; Pediatric Research Department, Philadelphia General Hospital, 1970- (71)
Address: See above

15. Stone, William E. Ph.D. 1939
Advisor: McClendon
Thesis: ``Intermediary Carbohydrate Metabolism of the Brain: Quantitative Studies of Lactic Acid and Some Carbonyl Compounds"
Position: Professor Emeritus, Department of Physiology, University of Wisconsin (88)
Address: Department of Physiology, University of Wisconsin
Madison WI 53706

16. Barnes, Richard H. (dec.) Ph.D. 1940
Advisor: Burr/Visscher
Thesis: ``Fat Transport"
Positions: Director, Biochemical Research, Merck, Sharpe, and Dohme, 1944-56; Jamieson Professor of Nutrition and Dean, Graduate School of Nutrition, Cornell University, Ithaca, New York, 1956-80.

17. Barnum, Cyrus, P. (dec.) Ph.D. 1940
Advisor: Kolthoff/Visscher
Thesis: ``Polarographic Investigations of the Cystine-Cysteine System"
Position: Professor of Physiological Chemistry, University of Minnesota Medical School, 1942-65.

18. Loeb, Harold G. (ret.) Ph.D. 1940
Advisor: Burr
Thesis: ``The Composition of Rats Maintained of Diets High in Carbohydrate and Saturated Fat but Devoid of Unsaturated Fatty Acids, with Emphasis on the Lipid Component"
Position: Manager, Clinical Chemistry, Abbott Scientific Products Division, Pasadena, California (86)
Address: 4478 Via Marina, Marina Del Rey CA 90291

19. Wells, Benjamin B. Ph.D. 1941 (M.D. 1935 Baylor)
Advisor: Kendall
Thesis: ``The Biochemical and Physiologic Properties of Compounds Separated from the Adrenal Cortex"
Positions: Assistant to Vice President, Medical Center, University of Alabama, 1967-69; Deputy Chief Medical Director, Veterans Administration, Washington, D.C., 1969- (69)
Address: U.S. Veterans Administration, 810 Vermont Ave. N.W.
Washington D.C. 20420

20. Berryman, George H. Ph.D. 1941 (M.D. 1950 Chicago)
Advisor: Bollman
Thesis: ``Studies on the Role of the Liver in the Formation of the Plasma Proteins"
Position: Vice President, Medical Affairs, Department of Medicine, Abbott Laboratories, 1970- ; Associate Professor of Medicine, Stanford University, 1970- (70)
Address: 281 East Hamilton Ave., Campbell CA 95008

21. Swendseid, Marian E. (ret.) Ph.D. 1941
Advisor: Hemingway
Thesis: ``The Use of A Stable Isotope of Heavy Carbon in the Study of Intermediary Metabolism"
Position: Professor and Head, Division of Nutritional Science, UCLA School of Public Health (94)
Address: Division of Nutritional Science, UCLA School of Public Health
Los Angeles CA 90024

22. Szego (Roberts) Clara M. (ret.) Ph.D. 1942 (M.S. 1939)
Advisor: Samuels
Thesis: ``Studies on Methods of Chemical Assay of Estrogenic Substances and the Physiological Problem of Steroid Metabolism"
Position: Professor, Department of Biology, University of California, Los Angeles, 1957-85; Professor Emeritus, 1985- (94)
Address: 405 Hilgard Ave., Los Angeles CA 90024

23. Olsen, Norman S. (dec.) Ph.D. 1942
Advisor: Hemingway
Thesis: ``The Synthesis and Metabolism of Glycine"
Positions: Assistant Professor, Biological Chemistry, University of Michigan Medical School, 1943-47; Assistant Professor, Biological Chemistry, Washington University, St. Louis, 1947- 50; Chief Biochemist, Division of Medicine, Research Units, Veterans Hospital, Nashville, Tennessee, 1950-61.

24. Abrams, Irving M. (ret.) Ph.D. 1942
Advisor: Sollner/Visscher
Thesis: ``Studies on Model Membranes with Particular Reference to Anomalous Osmosis"
Position: Manager, Technical Division, Duolite International Inc.,Subsidiary, Diamond-Shamrock Corp. (82)
Address: P.O. Box 829, Redwood City CA 94064

25. Eckles, Nylene E. (ret.) Ph.D. 1943 (M.D. 1945)
Advisor: Evans/Burr
Thesis: ``Studies on Intravenous Administration of Emulsified Fat"
Position: Professor Emeritus, University of Texas Cancer Center, Houston, Texas (86)
Address: 4055 Tartan Lane, Houston TX 77025

26. Roberts, Sidney Ph.D. 1943 (M.S. 1942)
Advisor: Samuels
Thesis: ``The Influence of Previous Diet on the Preferential Utilization of Foodstuffs"
Position: Professor of Biological Chemistry, Department of Biological Chemistry, UCLA Medical School (94)
Address: Department of Biological Chemistry, University of California at Los Angeles
Los Angeles CA 90024

27. Rusoff, Irving (ret.) Ph.D. 1943
Advisor: Burr
Thesis: ``Infrared Analysis of Corticosteroidyl C21-glucuronosides"
Position: Director of Science, Nabisco, 1971-84, Nutrionist (ret.) (94)
Address: 65 Central Boulevard
Brick NJ 08724

28. Greenberg, Robert Goodwin (ret.) Ph.D 1944 (M.S. 1942)
Advisor: Arnow/Burr
Thesis: "An Ultraviolet Spectroscopic Study of the Structure of Amino Acids and Proteins"
Position: Professor of Biological Chemistry, University of Michigan, 1954- (94)
Address: Box 134, Dept. of Biological Chemistry, University of Michigan Medical School
Ann Arbor MI 48109

29. Holman, Ralph T. (ret.) Ph.D. 1944
Advisor: Burr
Thesis: ``Studies on the Autooxidation of Lipids"
Positions: Professor of Biochemistry, Hormel Research Institute and University of Minnesota Medical School, 1952- ; Associate Director, Hormel Research Institute, 1952-76; Director, Hormel Research Institute, 1976-85. (94)
Address: Hormel Research Institute, Austin MN 55912

30. Ackerman, Elizabeth M. (dec.) Ph.D. 1945
Advisor: Barnum/Burr
Thesis: ``An Enzymatic Study of the Submicroscopic Particles of Cytoplasm"

31. Garst, Josephine B. (ret.) Ph.D. 1945
Advisor: Evans/Burr
Thesis: ``Clinical Studies of Sex Sterols"
Position: Research Biochemist, VA Hospital, Cleveland, Ohio, 1957-74 (88)
Address: 409 South Orange Grove Ave., Los Angeles CA 90036

32. Lerner, Aaron B. Ph.D. 1945 (M.D. 1945)
Advisor: Arnow/Barnum
Thesis: ``Studies on Plasma Proteins. I. The Nature and Significance of Turbidity. II. The Ultraviolet Absorbtion of Plasma Proteins"
Position: Professor and Head of Dermatology, Yale University Medical School, 1957- (94)
Address: Division of Dermatology, Yale University Medical School
New Haven CT 06510

33. Kretchmer, Norman Ph.D. 1946 (M.D. 1952, Cornell)
Advisor: Barnum
Thesis: ``A Serial Study of the Chemistry and Histology of the Mouse Liver Cytoplasm during Carbon Tetrachloride Induction of Hepatoma"
Positions: Director, National Institute of Child Health and Development, 1974-81; Professor, Nutritional Science, Pediatrics, and Obstetrics, Department of Nutritional Science, University of California, Berkeley, 1981-86; Chairman, Department of Nutritional Science, 1986- (94)
Address: Department of Nutritional Science, University of California, Berkeley
Berkeley CA 94720

34. Caster, William O. (ret.) Ph.D. 1948
Advisor: Mickelsen/Keys
Thesis: ``The Excretion of Thiamine and Its Degradation Products"
Positions: Professor of Nutrition, University of Georgia, 1970-86; Professor Emeritus, University of Georgia, 1986- (94)
Address: 208 John Paul Avenue, Statesboro GA 30458-5593

35. Tsuboi, Kenneth K. (ret.) Ph.D. 1948
Advisor: Barnum
Thesis: ``A Chemical and Enzymatic Study of Pentose Nucleic Acids and Their Hydrolysis of Cytoplasmic Fractions of Liver Tissue"
Position: Research Professor, Dept. of Pediatrics, Stanford University Medical School (94)
Address: Dept. of Pediatrics, Stanford University Medical School, Palo Alto CA 94304

36. Lindenbaum, Arthur (ret.) Ph.D. 1948)
Advisor: Armstrong
Thesis: ``Investigations with Radioactive Isotopes"
Position: Biochemist, Division of Biological and Chemical Research, Argonne National Laboratories (76)
Address: Division of Biological and Medical Research, Argonne National Laboratories
Argonne IL 60439

37. Bitman, Joel Ph.D. 1950 (M.S. 1948)
Advisor: Cohen
Thesis: ``A Study of the Acetate Buffer Hydrolysis of the Conjugated 17-Ketosteroids of Normal Male Urine"
Position: Chemist, Milk Secretion and Mastitis Laboratory, Animal Science Institute, U. S. Department of Agriculture (94)
Address: Animal Science Institute, Agricultural Research Center, USDA, Beltsville MD 20705

38. Grim, Eugene D. (ret.) Ph.D. 1950
Advisor: Sollner/Armstrong
Thesis: ``An Experimental Study of Anomalous Osmosis with Particular Reference to Its Pos sible Physiological Significance"
Position: Professor of Physiology, University of Minnesota Medical School, 1957- ; Head of Department, 1968-86 (94)
Address: Department of Physiology, University of Minnesota Medical School
Minneapolis MN 55455

39. Neihof, Rex A. (ret.) Ph.D. 1950
Advisor: Sollner/Armstrong
Thesis: ``An Experimental Study of Mosaic Membranes Which Are Composed of Selectively Anion and Selectively Cation Permeable Parts"
Position: Research Chemist, Marine Biology and Biochemistry Branch, U. S. Naval Research Laboratory (94)
Address: U. S. Naval Research Laboratory, Washington DC 20375

40. Malmstrom, Bo G. Ph.D. 1951
Advisor: Glick
Thesis: ``A Quantitative Histochemical Method for the Determination Zinc and Its Appli- cation to Studies on the Gastric Mucosa"
Position: Professor of Biochemistry and Biophysics, Chalmers University of Technology and Goteborg University; Chairman, Nobel Committee for Chemistry (94)
Address: Department of Biochemistry and Biophysics, Goteborg University, S-412 96
Goteborg, Sweden

41. Nygaard, Oddvar F. Ph.D. 1951
Advisor: Barnum
Thesis: ``Studies on the Kinetics of Acid Hydrolysis of Pentose Nucleic Acid Derivatives"
Position: Professor of Radiology, Case Western Reserve Medical School, 1975- ; Director, Division of Radiation Biology, 1976- (93)
Address: Division of Radiation Biology, Case Western Reserve Medical School
Cleveland OH 44106

42. Oneson, Irving B. Ph.D. 1951
Advisor: Cohen
Thesis: ``Studies on the Conjugated Steroids of Human Urine"
Position: Senior Biochemist, Ethicon Inc., 1959- (65)
Address: Ethicon Inc., Somerville NJ 08876

43. Savchuk, William B. Ph.D. 1951 (DDS 1948)
Advisor: Armstrong
Thesis: ``Fluoride Analytical Studies and Turnover in the Human Skeleton"
Position: Scientist Administrator, Pathology Study Section, Division of Research Grants, NIH, 1965- (79)
Address: 608 Rockford Road, Silver Spring MD 20902

44. Von Korff, Richard W. (ret.) Ph.D. 1951
Advisor: Glick
Thesis: ``Studies on Gastric Urease Employing Isotopic Urea"
Position: Dow Polymer Institute (94)
Address: 15 Rosemary Court, Midland MI 48640

45. Cohen, William D. (ret.) Ph.D. 1952 (M.S. 1950)
Advisor: Frame
Thesis: ``Hormonal Influences on the Carbohydrate Metabolism of Isolated Muscle"
Position: Chief Biochemist, St. John's General Hospital Laboratories, 1970- ; Clinical Associate Professor, Memorial University, 1971- (93)
Address: R.R. No. 1, Orangedale
Nova Scotia, Canada BOE 2KO

46. Norcia, Leornard N. (ret.) Ph.D. 1952
Advisor: Lundberg
Thesis: ``The Use of Synthetic, Simple, Pure Triglycerides in a Study Relating to Fat Metabolism"
Position: Emeritus Professor, Department of Biochemistry, Temple Medical School (86)
Address: Department of Biochemistry, Temple Medical School, Philadelphia PA 19140

47. Towey, John P. (dec.) Ph.D. 1952
Advisor: Armstrong
Thesis: ``Influence of Some Nutritional Factors on the Ash Content, Breaking Stress, and Elasticity of Rat Bones"

48. Hamilton, James G. (ret.) Ph.D. 1953
Advisor: Holman/Armstrong
Thesis: ``Displacement Separation of Lipids"
Position: Group Chief, Department of Biochemical Nutrition, Hoffman-La Roche, Inc. (94)
Address: 2976 Heather Bow, Sarasota FL 34235

49. McGuckin, Warren F. (dec.) Ph.D. 1953
Advisor: Kendall/Armstrong
Thesis: ``The Partial Synthesis and Physiologic Study of Some Analogs of Adrenal Hor mones"
Position: Owner-Director, Chelmo Research Laboratories

50. Nayyar, Som N. Ph.D. 1953 (M.D. 1955)
Advisor: Glick
Thesis: ``Quantitative Histological Distribution of Beta-Glucuronidase in the Adrenal Gland in Various Physiological States"
Position: Private practice (93)
Address: 1127 Wilshire Blvd. 1100, Los Angeles CA 90017

51. Dray, Sheldon Ph.D. 1954 (M.D. 1946 Chicago)
Advisor: Sollner/Armstrong
Thesis: ``A Quantitative Theory of Dynamic Polyionic Potentials Across Membranes of Ideal Ionic Selectivity in Terms of Transference Numbers and Its Experimental Test with Permselective Membranes"
Position: Professor of Microbiology, University of Illinois Medical Center, Chicago, 1972- ; Head of the Department, 1972-84 (94)
Address: Department of Microbiology and Immunology,
University of Illinois Medical Center, P.O. Box 6998, Chicago IL 60680

52. Clausen, Donald F. Ph.D. 1955 (M.S. 1950)
Advisor: Lifson/Barnum
Thesis: ``Studies on the Determination of Inulin and Evans Blue in Blood and Tissues"
Position: Acting Vice President (65)
Address: Stout State, University of Wisconsin, Menomonie WI

53. Drakakis (Jardetzky) Christine Ph.D. 1955
Advisor: Barnum
Thesis: ``Kinetic Studies on the Nucleic Acids of Regenerating Mouse Liver"
Position: Adjunct Associate Professor of Chemistry, Tufts University, 1970- (70)
Address: 13 University Drive, Natick MA 01760

54. Peters, John H. (ret.) Ph.D. 1955
Advisor: Gutmann
Thesis: ``Studies on the Metabolism of Carcinogenic Fluorene Derivatives"
Position: Director, Biochemistry and Pharmacology Program, Stanford Research Institute International, Life Sciences Division (94)
Address: 11087 Linda Vista Dr., Cupertino CA 95014-4751

55. Woods, Kenneth R. Ph.D. 1955
Advisor: Armstrong
Thesis: ``Magnesium Metabolism Studies"
Position: Director, New York Blood Center; Adjunct Associate Professor, Cornell University Medical Center (85)
Address: New York Blood Center, 310 East 6th Street, New York NY 10021

56. Simmons, Noel (dec.) Ph.D. 1956
Advisor: Barnum
Thesis: ``Studies on Glycine 2-C-14 Incorporation into Mouse Liver Constituents"
Position: Professor, Biochemistry Department, State University of New York, Buffalo

57. Mizuno, Nobuko (ret.) Ph.D. 1956
Advisor: Schultze/Armstrong
Thesis: ``Biochemical Studies on an Experimentally Induced Hypoplastic Anemia in Calves"
Position: Research Biochemist, Department of Experimental Surgery, Veterans Administration Hospital, Minneapolis, 1956-78 (94)
Address: 3628 Loma Way, San Diego CA 92106

58. Bollum, Frederick Ph.D. 1957
Advisor: Barnum
Thesis: ``The Effect of Glutathione on the X-ray Inhibition of P-32 Incorporation into Deoxyribonucleic Acid of a Mouse Mammary Cancer"
Positions: Professor, Biochemistry, University of Kentucky Medical School, 1965-77; Professor, Biochemistry, Uniformed Services University of Health Sciences, 1977- , Chairman of Department, 1977-81; CEO, Supertechs, Inc. (94)
Address: Supertechs, Inc., 9620 Medical Circle Dr.
Rockville MD 20850

59. Gray, Ernest D. Ph.D. 1958
Advisor: Barnum
Thesis: ``Kinetic Studies Of Metabolic Interactions among Mono- and Polynucleotides of Mouse Liver"
Position: Professor, Pediatrics and Biochemistry, Univ. of Minn. Medical School (94)
Address: Dept. Pediatrics, Univ. Minn. Medical School, Minneapolis MN 55455

60. Greenberg, Leonard J. Ph.D. 1958
Advisor: Glick
Thesis: ``Quantitative Histochemical Distribution of Co-enzyme A and Certain Phosphorus Compounds in the Rat Adrenal Gland in Various Functional States"
Position: Prof. of Laboratory Medicine and Pathology, Univ. of Minn. Medical School (94)
Address: Dept. of Laboratory Medicine and Pathology, Univ of Minn. Medical School
Minneapolis MN 55455

61. Nelson, Walter L. Ph.D. 1958 (M.S. 1956)
Advisor: Barnum
Thesis: ``The Effect of Diisopropylfluorophosphate Administration on the Phosphorus Metabolism of Rat Brain"
Position: Administrative Scientist, Department of Laboratory Medicine and Pathology, University of Minnesota Medical School (83)
Address: Dept. of Laboratory Medicine and Pathology, Univ. of Minn. Medical School
Minneapolis MN 55455

62. Carlson, Curtis H. (dec.) Ph.D. 1959 (M.D. 1956)
Advisor: Armstrong/Singer
Thesis: ``Retention, Distribution, and Excretion of Radiofluoride"
Position: Clinical Assistant Professor of Psychiatry, Veterans Hospital and private practice

63. Smith, Quenton T. Ph.D. 1959
Advisor: Armstrong/Singer
Thesis: ``*In vivo* Effects of Certain Hormonal Variations on Collagen Metabolism"
Position: Professor, Department of Oral Biology, University of Minnesota Dental School and Adjunct Professor, Department of Biochemistry, University of Minnesota Medical School (94)
Address: Department of Oral Biology, Univ. of Minn. Dental School, Minneapolis MN 55455

64. Ives, David H. Ph.D. 1960
Advisor: Barnum
Thesis: ``A Kinetic Evaluation, Employing Radiophosphorus, of the Synthesis and Metabolic Stability of DNA in Regenerating Rat Liver"
Position: Professor, Department of Biochemistry, Ohio State University (94)
Address: Department of Biochemistry, Ohio State University
Columbus OH 43210

65. Reynard, Alan M. Ph.D. 1960
Advisor: Boyer
Thesis: ``The Mechanism of Enzymatic Phosphate Transfer Reactions"
Position: Professor, Department of Pharmacology and Therapeutics, Medical School, State University of New York, Buffalo (88)
Address: Department of Pharmacology and Therapeutics, SUNY Medical School
Buffalo NY 14214

66. Parekh, Amritlal C. Ph.D. 1960 (M.D. 1963)
Advisor: Glick
Thesis: Quantitative Cytochemical Studies of the Mast Cell"
Position: Medical Center, University of California, San Fransisco, San Fransisco CA (77)
Address: See above

67. Chang, Kim Yong Ph.D. 1961 (M.D. Seoul Univ. 1955)
Advisor: Carr
Thesis: ``Studies on the Fine Structure of Nucleic Acids and Nucleoproteins by Ion Binding Techniques"
Position: Department of Pharmacology, McGill University, Montreal, 1966-72 (72)
Address: Unknown

68. Dahle, Leland K. Ph.D. 1961
Advisor: Holman
Thesis: ``Effects of Protein and Unsaturated Fatty Acids in Autooxidation Phenomena"
Position: Division Head, Cereal Science, Campbell Institute for Food Research (92)
Address: 215 Garfield Ave., Cherry Hill NJ 08034-1519

69. Dempsey, Mary E. Ph.D. 1961
Advisor: Boyer
Thesis: ``Studies on the Possible Occurrence of Unrecognized Phosphate Compounds Related to Muscle Contraction and Oxidative Phosphorylation"
Postion: Professor, Department of Biochemistry, University of Minnesota Medical School (94)
Address: Dept. of Biochemistry, Univ. of Minn. Medical School, Minneapolis MN 55455

70. Hayes, Dora (Holly) K. Ph.D. 1961
Advisor: Armstrong/Singer
Thesis: ``Body Fluid and Skeletal Tissue Interrelations in the American Lobster"
Position: Research Chemist and Laboratory Chief, Livestock Insects Laboratory, United States Department of Agriculture (94)
Address: Livestock Insects Laboratory, S & E Room 120, Bldg. 120
BARC, USDA, Beltsville MD 20705

71. Schroepfer, George J. Ph.D. 1961 (M.D. 1957)
Advisor: Frantz
Thesis: ``Studies on the Conversion of Zymosterol to Cholesterol in the Rat"
Positions: Professor of Biochemistry and Organic Chemistry, University of Illinois, Urbana, 1967-72, Director, School of Basic Medical Sciences, 1968-70; Professor, Department of Biochemistry, Rice University, 1972- , Chairman of the Department, 1972-84 (94)
Address: Department of Biochemistry, Rice University, Houston TX

72. Lewbart, Marvin L. Ph.D. 1961
Advisor: Mattox/Ungar
Thesis: ``Formation and Reactions of Steroidal Glyoxals: I. Reactions of Alpha-Ketolic Steroids with Methanolic Cupric Acetate; II. The Mechanism of the Porter-Silber Reaction"
Position: Clinical Assoc. Prof. of Medicine, Steroid Lab., Hahnemann Medical College (92)
Address: 81 Great Valley Pkwy., Suite 700, Malvern PA 19355

73. King, Charles M. Ph.D. 1962
Advisor: Gutmann
Thesis: ``Studies on the Interaction of Oxidative Metabolites of the Carcinogen 2-Acetoaminofluorene with Protein"
Position: Chairman, Dept. of Chemical Carcinogenesis, Michigan Cancer Foundation (94)
Address: Michigan Cancer Foundation, 110 E. Warren Avenue, Detroit MI 48201

74. Pothapragada, Venketaswarlu Ph.D. 1962
Advisor: Armstrong/Singer
Thesis: ``Studies on Fluoride Metabolism and Transport"
Position: Chemist, Commercial Chemical Division, 3M Center (94)
Address: Commercial Chemical Division, 3M Center, St. Paul MN 55144

75. Deluca, Marlene A. (dec.) Ph.D. 1963
Advisor: Boyer
Thesis: ``Studies of the Rapid Uptake of Inorganic Phosphorus P-32 by Mitochondria as Related to Oxidative Phosphorylation"
Position: Professor, Department of Chemistry, University of California, San Diego, 1978-87; Director, Division of Biochemistry, 1985-87

76. Oleson, Arland E. Ph.D. 1963
Advisor: Koerner
Thesis: ``A Newly Formed Deoxyribonuclease from Cells of *Escherichia coli* Infected with T2 Bacteriophage"
Position: Professor of Biochemistry, North Dakota State University; Head of Department, 1988- (94)
Address: Department of Biochemistry, North Dakota State University
Fargo ND 58105

77. Peterson, William J. Ph.D. 1963
Advisor: Carr
Thesis: ``Studies on the Structure of the Red Cell Membrane"
Position: Founder and President, Peninsula Laboratories, 1969- (94)
Address: Peninsula Laboratories, Inc., 611 Taylor Way, Belmont CA 94002

78. Pollara, Bernard Ph.D. 1963 (MD. 1963)
Advisor: Von Korff
Thesis: ``Studies on the Nature of Cryofibrinogens"
Position: Professor of Pediatrics, Albany Medical College, 1969-, Chairman of the Department, 1979- ; Director, Kidney Disease Institute, N. Y. State Department of Health, 1969-79 (94)
Address: Department of Pediatrics, Albany Medical College, Albany NY 12208

79. Silverstein, Emanuel Ph.D. 1963 (M.D. 1954 SUNY Downstate)
Advisor: Boyer
Thesis: ``Equilibrium Reaction Rates and Enzyme Mechanism. I. Beef Heart and Rabbit Muscle Lactate Dehydrogenase. II. Liver and Alcohol Dehydrogenase. III. Yeast Hexokinase"
Position: Professor, Biochemistry Program, Department of Medicine, School of Graduate Studies, State University of New York Health Sciences Center (94)
Address: Dept. of Medicine, Box 112, SUNY Health Sciences Center, 450 Clarkson Ave. Brooklyn NY 11203-2098

80. Rahm, Joseph J. Ph.D. 1963
Advisor: Holman
Thesis: ``The Effects of Dietary Fatty Acids upon Lipids of Subcellular Particles"
Position: Boise-Cascade Paper Group (85)
Address: Boise-Cascade Paper Group, 907 West 7th Street, Vancouver, WA 98660

81. Peter, James B. Ph.D. 1964 (M.D. 1958 St. Louis U.)
Advisor: Boyer
Thesis: ``Studies of Bound Phosphohistidine and Its Possible Precursor in Mitochondria and in Soluble Enzyme Systems"
Position: President, Specialty Laboratories, Inc. (94)
Address: Specialty Laboratories, 2211 Michigan Avenue, Santa Monica CA 90404

82. Blomquist, Charles H. Ph.D. 1964
Advisor: Armstrong
Thesis: ``Studies of Embryonic Chick Heart Cells in Tissue Culture"
Position: Adjunct Associate Professor, Department of Obstetrics and Gynecology, St. Paul Ramsey Medical Center (94)
Address: Department of Obstetrics and Gynecology St. Paul Ramsey Medical Center, St. Paul MN 55101

83. Joos, Richard W. (ret.) Ph.D. 1964
Advisor: Carr
Thesis: ``Calcium Binding to Phospholipids and Phospholipid-Protein Complexes"
Position: Research Specialist, Dental Products Research, 3M Company (94)
Address: 3934 Denmark Ave., Eagan, MN 55123

84. Kvistberg, David R. Ph.D. 1964 (M.D. 1965)
Advisor: Barnum
Thesis: ``Model Studies on the Staining Reaction of Beta Cells of the Islets of Langerhans by Aldehyde Fuchsin"
Position: Unknown

85. Niehaus, Walter Ph.D. 1964
Advisor: Barnum
Thesis: ``Characterization of Nuclei from Regenerating Rat Liver on the Basis of Incorporation of Radioisotope *In Vivo*"
Position: Professor of Biochemistry, Virginia Polytechnic University (94)
Address: Dept. of Biochemistry, Virginia Polytechnic University, Blacksburg VA 24061

86. Scallen, Terrance Ph.D. 1965 (M.D. 1961)
Advisor: Frantz
Thesis: ``Chemical Synthesis of Cholestra-4,7,24-Trien-3Beta-ol and Demonstration of Its Conversion to Cholesterol in the Rat"
Position: Professor of Biochemistry, New Mexico University Medical School (94)
Address: Department of Biochemistry, New Mexico University Medical School
Albuquerque NM 87131

87. Choi, Yong Sung Ph.D. 1965 (M.S. 1963, M.D. Korea 1962)
Advisor: Carr
Thesis: ``Magnesium Binding Studies of Ribosomes"
Position: Director, Immunology, Sloan-Kettering Cancer Research Institute, 1973-85; Director, Immunology Laboratory, Ochsner Medical Research Foundation and Professor of Medicine, Tulane University Medical School, 1985- (94)
Address: Ochsner Medical Research Foundation, 1516 Jefferson Highway
New Orleans LA 70121

88. Cost, Helen Ph. D. 1965
Advisor: Barnum
Thesis: ``Studies on the Incorporation of Radioactive Phosphate into Ribonucleic Acid and Other Cell Components during the Formation of Bacteriochlorophyll in *Rhodospirillum rubrum*"
Position: Senior Engineer, Interior Systems Engineering, Chrysler Corporation (88)
Address: 3614 Dukeshire, Royal Oaks MI 48072

89. Mobberly, Mary Lou Ph.D. 1965
Advisor: Frantz
Thesis: ``Evidence for the Existence of Multiple Pools of Late Cholesterol Intermediates in the Rat"
Position: Unknown (86)
Address: 14 Ridgewood Drive, Roseburg OR 97470

90. Linn, Tracy C. Ph.D. 1965
Advisor: Frantz
Thesis: ``Beta-Hydroxy-Beta-Methylglutaryl-CoA Reduction By an Enzyme from Rat Liver Microsomes"
Position: Biochemist and Asst. Prof, Health Science Center, VA Hospital, Univ. of Texas (86)
Address: VA Hospital, Health Science Center, University of Texas, Dallas TX 75216

91. Yarbro, John W. Ph.D. 1965 (M.D. 1960)
Advisor: Barnum
Thesis: ``Hydroxyurea and Mithramycin Inhibition of Nucleic Acid Synthesis in Mouse Ascites Tumor as Measured by Radiophosphorus Incorporation"
Position: Prof., Dept. of Medicine, University of Missouri Medical School (92)
Address: Department of Medicine, University of Missouri Medical School
Columbia MO 65212

92. Simon, Gerald Ph.D. 1965
Advisor: Barnum
Thesis: ``Glutamate Oxidation in Guinea Pig Cerebral Cortex Slices *in vitro*"
Position: Department of Pathology, Scripps Memorial Hospital (81)
Address: Department of Pathology, Scripps Memorial Hospital, La Jolla CA 92037

93. Jorgenson, Sally Ph.D. 1966 (M.S. 1964)
Advisor: Koener
Thesis: ``Separation and Characterization of a New Deoxyribonuclease from *Escherichia coli*"
Position: Associate Professor and Associate Dean, College of Veterinary Medicine, University of Minnesota (94)
Address: College of Veterinary Medicine, University of Minnesota
St. Paul MN 55108

94. Johnson, Arthur Ph.D. 1966 (D.D.S. 1962)
Advisor: Armstrong/Singer
Thesis: "The Relationship of Calcium and Strontium in Mineralized Tissues of the Rat; Replacement and Exchange of These Elements *In Vivo* and *InVitro*"
Position: Private practice (88)
Address: 1025 Le May, Fort Collins CO 80524

95. Tarjan, Endre Ph.D. 1966
Advisor: Von Korff
Thesis: ``Respiratory Control Ratios and the Regulation of Oxidation Rates in Isolated Rabbit Heart Mitochondria"
Position: Department of Medicine, Harvard Medical School (71)
Address: Unknown

96. Olson, Merle S. Ph.D. 1966
Advisor: Von Korff
Thesis: ``The Metabolic Variability of Isolated Heart Muscle Mitochondria: The Dependency of Metabolic Reactions on the Endogenous Substrates and the External Environment"
Position: Professor, Department of Biochemistry, University of Texas Health Science Center, San Antonio, 1976- , Chairman of the Department, 1983- (94)
Address: Department of Biochemistry, University of Texas Health Science Center
San Antonio TX 78284

97. Sanghvi, Ajitkumar T. Ph.D. 1966
Advisor: Frantz
Thesis: ``Isolation and Chemical Characterization of 4-Beta-Methyl-8,24-Cholestadien-3-Beta-ol from Rat Skin"
Position: Department of Medicine, University of Pittsburgh Medical School (87)
Address: Dept, of Medicine, University of Pittsburgh Medical School, Pittsburgh PA 15261

98. Yasmineh, Walid G. Ph.D. 1966
Advisor: Gray
Thesis: ``On the Mechanism of Action of the Nucleases of Group A Streptococci"
Position: Associate Professor, Department of Laboratory Medicine and Pathology, University of Minnesota Medical School (94)
Address: Department of Laboratory Medicine and Pathology, University of Minnesota
Minneapolis MN 55455

99. Cane, William Ph.D. 1966
Advisor: Wetlaufer
Thesis: ``Studies on Homologous Acyl-Chymotrypsins"
Position: Unknown

100. Ferretti, Joseph J. Ph.D. 1967 (M.S. 1965)
Advisor: Gray
Thesis: ``Studies on the Control of Macromolecular Synthesis in Synchronous Populations of *Rhodopseudomonas spheroides*"
Position: Professor of Microbiology, Health Science Center, University of Oklahoma (92)
Address: Department of Microbiology, Health Science Center
University of Oklahoma, P.O. Box 26901, Oklahoma City OK 73190

101. Leitzmann, Claus Ph.D. 1967
Advisor: Bernlohr
Thesis: ``Studies on Threonine Dehydratase from *Bacillus licheniformis*"
Position: Professor, Institute of Nutrition, Justus Liebig University (94)
Address: Justus Liebig University, Wilhelmstrasse 20, D-6300 Geissen
Federal Republic of Germany

102. Tewfik, Enyat (Mosharrafa) Ph.D. 1967
Advisor: Barnum/Bradley
Thesis: ``Genetic Homologies among Actinomycetes"
Position: Unknown (88)
Address: 5721 Grove Street, Edina MN 55436

103. Peterson, Anne M. Ph.D. 1967
Advisor: Barnum
Thesis: ``Characterization Studies on Phosphorus-32 Labeled Fractions of Ribonucleic Acids from Mouse Liver"
Position: Sloan-Kettering Cancer Institute (76)
Address: Unknown

104. Tan, Agnes W. Ph.D. 1967
Advisor: Ungar
Thesis: ``The Effect of Hypophysectomy and Growth Hormone Treatment on Arginine-Guanido-C14 Conversion to Creatine in the Rat"
Position: Associate Professor of Biochemistry, Metabolism Section, Veterans Administration Hospital and University of Minnesota Medical School, 1976-87 (87)
Address: Metabolism Section, (618.111G), VA Hospital, 54th St. and 48th Ave.
Minneapolis MN 55417

105. Short, Everett Ph.D. 1968 (D.V.M. 1963)
Advisor: Koerner
Thesis: ``Deoxyribonucleases Induced by Infection of *Escherichia coli* with Bacterophage"
Positions: Professor of Biochemistry and Assistant Dean, College of Veterinary Medicine, University of Minnesota, 1972-79; Professor and Head, Physiological Sciences, College of Veterinary Medicine, Oklahoma State University, 1979- (86)
Address: College of Veterinary Medicine, Oklahoma State University, Stillwater OK 74078

106. Brunelle, Thomas E. Ph.D. 1968
Advisor: Carr
Thesis: ``A Study of the Binding of Small Cations by Acid Polysaccharides"
Positions: Vice President for Corporate Research and Technology, Economics Laboratories, 1975-85; Lec Tec Corporation, 1987- , President and CEO, Lec Tec Corp., 1993- (94)
Address: Lec Tec Corporation, 10205 Crosstown Circle
Eden Prairie MN 55344

107. Elam, John S. Ph.D. 1968
Advisor: Koerner
Thesis: ``The Degradation of Bacterial DNA to Mononucleotides Following Infection of *Escherichia coli* with T-2 Bacteriophage"
Position: Professor of Neurosciences, Florida State University (88)
Address: Department of Biology, Florida State University, Tallahassee FL 32306-2043

108. Hof, Hildegarde I. Ph.D. 1968
Advisor: Barnum/Armstrong
Thesis: ``Nuclear RNA of Rat Liver and Morris Hepatoma 5123 D"
Position: Illinois State Psychiatric Institute (75)
Address: Unknown

109. Zacchei, Anathony G. Ph.D. 1968
Advisor: Frantz
Thesis: ``Chemical Synthesis of Two Methylated Sterols and Demonstration of Their Conversion to Cholesterol"
Position: Senior Investigator, Merck Institute for Therapeutic Research (94)
Address: Merck Institute for Therapeutic Research (MSDRL), West Point PA 19486

110. Ahmed, Abdul Karim Ph.D. 1969
Advisor: Wetlaufer
Thesis: ``Kinetics of the Reactivation of Disulfide Reduced RNase"
Position: Senior Staff Scientist and Research Director, National Resources Defense Council; Adjunct Professor, State University of New York, Purchase (86)
Address: SUNY Purchase, Purchase NY 10577

111. Berger, George M. Ph.D. 1969 (M.D.)
Advisor: Mattox/Ungar
Thesis: ``Aspects of the Control of Corticosteroidogenesis in the Adrenal Cortex"
Position: Pathology Department, Red Cross Childrens' Hospital (87)
Address: Pathology Department, Red Cross Childrens' Hospital
Rondebosch, Cape Town, South Africa

112. Dearborn, Dorr G. Ph.D. 1969 (M.D. 1967)
Advisor: Wetlaufer
Thesis: ``Structural Studies on Human Serum Beta-1 Lipoprotein"
Position: Associate Professor, Departments of Pediatrics and Biochemistry, Case-Western Reserve Medical School (94)
Address: Department of Pediatrics, Case-Western Reserve Medical School
2102 Adelbert Road, Cleveland OH 44106

113. Elin, Ronald J. Ph.D. 1969 (M.D. 1966)
Advisor: Armstrong/Singer
Thesis: ``Biochemical and Pathological Studies in Magnesium Deficiency in the Rat"
Position: Chief, Department of Clinical Pathology, National Institutes of Health, 1975- , Chief, Clinical Chemical Services, NIH, 1977- (88)
Address: Department of Clinical Pathology, National Institutes of Health
Bldg. 10, Room 2C-306, Bethesda MD 20892

114. Kolb, Edith Ph.D. 1969 (M.D.)
Advisor: Fleischer/Ungar
Thesis: ``Isolation and Characterization of a Testis Specific Lactate Dehydrogenase"
Position: Laboratory of Molecular Biology, Medical Research Council (80)
Address: Laboratory of Molecular Biology, Cambridge, England

115. Vatessary, Govind T. Ph.D. 1969
Advisor: Armstrong/Singer
Thesis: ``Studies on the Constitution of Bone Mineral and of the Calcification Mechanism"
Position: Associate Professor, Department of Neurology; Director, Neurochemistry Laboratory, GRECC Program, VA Medical Center and Univ. of Minn. Medical School (94)
Address: Neurochemistry Laboratory, VA Medical Center, 54th St. and 48th Ave.,
Minneapolis MN 55417

116. Carlson, Mildred V. Ph.D. 1970
Advisor: Van Pilsum
Thesis: ``Studies in Creatine Metabolism"
Position: Professor, Department of Biochemistry, University of Osteopathic Medicine and Health Sciences (88)
Address: University of Osteopathic Medicine and Health Sciences
3200 Grand Avenue, Des Moines IA 50312

117. Hargrave, Paul A. Ph.D. 1970
Advisor: Wold
Thesis: ``Molecular Properties of Yeast Enolase"
Position: Professor, Department of Biochemistry, University of Southern Illinois, 1972-84; Professor, Dept. of Ophthalmology, Univ. of Florida Medical School, 1984- (94)
Address: Department of Ophthalmology, University of Florida Medical School
JHMHC, Box J-284, Gainesville FL 32610

118. Nuttall, Frank Q. Ph.D. 1970 (M.D. 1965, Utah)
Advisor: Larner
Thesis: ``Studies on the Hormonal and Non-Hormonal Control of the Rat Heart Glycogen Transferase System"
Position: Professor, Department of Medicine; Chief, Metabolism and Endocrinology Section, Veterans Administration Medical Center and University of Minnesota Medical School (94)
Address: Department of Medicine, VA Medical Center, 54th St. and 48th Avenue
Minneapolis MN 55417

119. Ottaway, Clifford A. Ph.D. 1970 (M.D. 1973 Toronto)
Advisor: Wetlaufer
Thesis: ``The Circular Dichroism of Polypeptides in Turbid Systems"
Position: Associate Professor, Department of Medicine, University of Toronto (94)
Address: Department of Medicine, Room 6360, Medical Sciences Bldg., Univ. of Toronto
Toronto, Ontario, Canada M5S 1A8

120. Peters, Louis H. Ph.D. 1970
Advisor: Singer
Thesis: ``The Effect of Aluminum Phosphate on the Gastrointestinal Absorbtion of Fluoride from Diets Containing Fish Protein Concentrate or Casein"
Position: Mount Sinai Medical Center, Miami Beach (76)
Address: Unknown

121. Schaffer, Stephen W. Ph.D. 1970
Advisor: Wetlaufer
Thesis: ``Mechanism of Reactivation of Disulfide Proteins"
Positions: Professor, Department of Chemistry, Lehigh University, 1973-80; Professor, Department of Pharmacology, University of South Alabama College of Medicine, 1980- (88)
Address: Department of Pharmacology, 3174 Medical Sciences Bldg.
University of South Alabama, Mobile AL 36688

122. Sparnins, Velta L. Ph.D. 1970
Advisor: Koerner
Thesis: ``Purification and Characterization of Exonuclease IV-A from *Escherichia coli B*"
Position: Senior Scientist, Department of Laboratory Medicine and Pathology, University of Minnesota Medical School (88)
Address: Dept. of Laboratory Medicine and Pathology, University of Minnesota
Minneapolis MN 55455

123. Spring, Thomas G. Ph.D. 1970
Advisor: Wold
Thesis: "Purification and Characterization of *Escherchia coli* Enolase and Two High Affinity Enolase Inhibitors"
Position: Abbott Laboratories, 1982- (86)
Address: Abbott Laboratories, Chicago IL 60064

124. Statland, Bernard E. Ph.D. 1970 (M.D. 1966)
Advisor: Benson
Thesis: ``The Role of Calcium Ion in Muscle Contraction and a Possible Transformational Change of Action During the Contraction Cycle"
Position: Medical Center, Boston University (87)
Address: Medical Center, Boston University, Boston MA 02118

125. Tuominen, F. William Ph.D. 1970
Advisor: Bernlohr
Thesis: ``The Regulation of Pyruvate Kinase in *Bacillus licheniformis*''
Position: Senior Vice President and Chief Technical Officer, Ecolab Corporation (88)
Address: Ecolab Corporation, 840 Sibley Memorial Highway, Mendota MN 55150

126. Idell-Wenger, Jane Ph.D. 1970
Advisor: Fleischer/Larner
Thesis: ``Mitochondrial Alcohol Dehydrogenase from *Saccharomyces cerevisae*''
Position: Assistant Professor, Department of Physiology, 1974- , Assistant Professor, Department of Medicine, 1981- , Hershey Medical School (87)
Address: 111 Eshelman Rd., Lancaster PA 17601-5643

127. Brown, William E. Ph.D. 1971
Advisor: Wold
Thesis: ``Alkyl Isocyanates: Active Site-Directed Inhibitors of Chymotrypsin and Elastase''
Position: Associate Professor, Department of Biological Sciences, Carnegie-Mellon University, 1975- (94)
Address: Department of Biological Sciences, Carnegie-Mellon University
440 Fifth Avenue, Pittsburgh PA 15213

128. Highland, Joseph H. Ph.D. 1971
Advisor: Bodley
Thesis: ``Characteristics of Synthetic Polynucleotide Translation''
Position: Professor of Environmental Sciences (88)
Address: Princeton University, Princeton NJ 08540

129. Johnson, John A. Ph.D. 1971
Advisor: Van Pilsum
Thesis: ``Purification and Properties of Lamprey Liver Transamidinase''
Position: Professor, Department of Dermatology, University of Nebraska Medical School (87)
Address: Dept. of Dermatology, Univ. of Nebraska Medical School, Omaha NE 68501

130. Marschke, Charles K. Ph.D. 1971
Advisor: Bernlohr
Thesis: ``The Regulation of Phosphofructokinase in *Bacillus licheniformis*''
Position: Research Scientist, Upjohn Company (84)
Address: Upjohn Company, 7000 Portage Road, Kalamazoo MI 49001

131. Ritter, Mary C. Ph.D. 1971
Advisor: Dempsey
Thesis: ``Activators and Inhibitors of Enzymic Cholesterol Biosynthesis''
Position: Department of Medicine, Pritzker School of Medicine, University of Chicago (80)
Address: Dept. of Medicine, Pritzker School of Medicine, University of Chicago
Chicago IL 60637

132. Zieve, Franklin J. Ph.D. 1971 (M.D. 1969)
Advisor: Gutmann
Thesis: ``Inhibition of Ribonucleic Acid Polymerase by the Carcinogen N-Hydroxy-2-Fluorenylacetamide"
Position: Associate Professor, Department of Medicine, Veterans Administration Medical Center Research Service, Medical School of Virginia (87)
Address: Department of Medicine, VA Medical Center
Medical College of Virginia, Richmomd VA 23249

133. Kan, Kenneth W. Ph.D. 1972
Advisor: Ungar
Thesis: ``Steroidogenesis in the Mammalian Adrenal"
Position: Department of Biochemistry, Faculty of Medicine, McGill University (86)
Address: Department of Medicine, Faculty of Medicine
McGill University, Montreal, Quebec, Canada H3G 1Y6

134. Messer, Harold H. Ph.D. 1972 (MDSc. 1962 U. Melbourne)
Advisor: Armstrong/Singer
Thesis: ``Metabolic Effects of Fluoride on Bone in Tissue Culture"
Positions: Professor and Chairman, Dept. of Endodontics, Univ. of Minn. Dental School, 1984-88; Professor, Restorative Dentistry, University of Melbourne (94)
Address: Dept. of Restorative Dentistry, Univ. of Melbourne, Melbourne, Victoria, Australia

135. Petersburg, Sandra J. Ph.D. 1972
Advisor: Jones/Van Pilsum
Thesis: ``The Metabolism of Protein-Bound Cholesterol and Cholesteryl Esters by the Perfused Rat Liver"
Position: Medical Center, University of Kansas (86)
Address: Medical Center, University of Kansas, Kansas City KA 66103

136. Ristow, Sandra S. Ph.D. 1972
Advisor: Wetlaufer
Thesis: ``Nucleation Studies of Lysozyme Folding"
Position: Associate Prof. , Department of Animal Science, Washington State University (94)
Address: Department of Animal Science
Washington State University, Pullman WA 99164-7040

137. Tavernier, Paul E. Ph.D. 1972
Advisor: Gray
Thesis: ``Studies on the Ribosomal RNA from *Rhodopseudomonas spheroides*"
Position: Professor, Department of Chemistry, Bethel College (92)
Address: Department of Chemistry, Bethel College
3900 Bethel Drive, St. Paul MN 55112

138. Anderson, William L. Ph.D. 1974
Advisor: Wetlaufer
Thesis: ``Nucleation of Hen Egg Lysozyme under Physiological Conditions"
Position: Associate Professor, Department of Cell Biology, School of Medicine, University of New Mexico (94)
Address: Department of Cell Biology, School of Medicine
University of New Mexico, Albuquerque NM 87131

139. Calimbas, (Madhok) Thelma D. Ph.D. 1974
Advisor: Dempsey
Thesis: ``Sterol Metabolism in a Protozoan"
Position: Department of Obstetrics and Gynecology, University of Minnesota Medical School, 1981-83 (83)
Address: See above

140. Johnson, Eric R. Ph.D. 1974
Advisor: Wetlaufer
Thesis: ``Regeneration Studies on Hen Egg Lysozyme Fragments: Localization of Nucleation Regions"
Position: Professor, Department of Chemistry, Ball State University (94)
Address: Department of Chemistry, Ball State University, Muncie IN 47306

141. Ophaug, Robert H. Ph.D. 1974
Advisor: Singer
Thesis: ``Magnesium-Fluoride Interrelationships During Acute Magnesium Deficiency"
Position: Associate Professor, Biochemistry Program, Univ. of Minn. Dental School (94)
Address: Biochemistry Program, Dental School, Univ. of Minn., Minneapolis MN 55455

142. Pick, Peter W. Ph. D. 1974 (M.D. 1979 Northwestern U.)
Advisor: Wetlaufer
Thesis: ``Mechanism of Oxidative Regeneration of Native Lysozyme from Reduced Lysozyme"
Position: Resident in Neurology, VA Hospital, University of Minnesota (86)
Address: See above

143. Tormanen, Calvin D. Ph.D. 1974
Advisor: Van Pilsum
Thesis: ``The Purification and Properties of Rat Kidney Transamidinase"
Position: Dept. of Chemistry, Central Michigan University (93)
Address: Central Michigan University, Mount Pleasant, MI

144. Walter, Bert Ph.D. 1974
Advisor: Wold
Thesis: ``The Role of Lysines in the Structure and Function of Ribonuclease"
Position: Ames Division, Miles Laboratory, Inc. (86)
Address: Ames Division, Miles Laboratory, Inc., Elkhart IN 46515

45. O'Brien, Kennedy J. Ph.D. 1975
Advisor: Edstrom
Thesis: ``Isolation and Characterization of Glycoproteins from Lymphocyte Plasma Membrane and Erythrocyte Membrane"
Position: Production Manager, Sorvall Division, Dupont, Inc. (90)
Address: Sorvall Division, Dupont, Inc., Wilmington DE 19898

146. Townsend, DeWayne Ph.D. 1975
Advisor: Singer
Thesis: ``The Effect of Fluoride on Lipid Metabolism"
Position: Research Associate, Dept. of Medicine, Univ. of Minn. Medical School (94)
Address: 3222 39th Ave. S., Minneapolis MN 55406

147. Wegner (Awantung) Mary E. Ph.D. 1975
Advisor: Singer
Thesis: ``The Relationship of Fluoride Intake and an Anemia Resulting from Stress"
Position: Homemaker, husband is in the diplmatic service of Cameroon (85)
Address: Unknown

148. Brenner, Stephen C. Ph.D. 1976
Advisor: Wold
Thesis: ``Human Erythrocyte Transglutaminase and Application as a Protein Reagent"
Position: Post Doctoral Fellow, Vanderbilt University, Nashville TN, 1976-78 (78)
Address: Unknown

149. Wehner, Jeanne M. Ph.D. 1976
Advisor: Koerner
Thesis: ``Alteration of the *Escherichia coli* Induced by Bacteriophage T4 During Nuclear Disruption"
Position: Associate Professor, Institute of Behavioral Genetics, School of Pharmacy, University of Colorado (94))
Address: Institute of Behavioral Genetics, School of Pharmacy
University of Colorado, Campus Box 447, Boulder CO 80309

150. Pahuja, Sham L Ph.D. 1976
Advisor: Edstrom
Thesis: ``Evidence for the Association of Protein with Hyaluronic Acid in Vitreous Body"
Position: Department of Ophthalmology, University of California, Davis (87)
Address: Dept. of Ophthalmology, University of California Davis, Davis CA 95616

151. Kalb, Vernon Ph.D. 1976
Advisor: Bernlohr
Thesis: ``The Pyruvate Dehydrogenase Complex of *Bacillus licheniformis*"
Position: College of Medicine, University of Cincinnati (86)
Address: College of Medicine, University of Cincinnati, Cincinnati OH 45267

152. Apfel, Marilyn A Ph.D. 1977
Advisor: Frantz
Thesis: ``The Chemical Synthesis of a New Sterol (Cholesta-8(14),24-diene-3beta-ol). An Improved Synthesis of Demosterol (Cholesta-5,24-diene-3beta-ol). Introducing a New Method for Preparing delta 24 Sterols"
Position: Unknown
Address: 160 Ironia Road, Flanders NJ 07836 (87)

153. Wititsuwannakul, Rapepun Ph.D. 1977
Advisor: Dempsey
Thesis: ``Studies on the Enzymic Reactions of Purified Ciliar Contractile Proteins"
Position: Professor, Department of Biochemistry, Prince of Songkhala University (90)
Address: Department of Biochemistry, Prince of Songkhala University
HAT-YAI Songhla, Thailand

154. Prendergast, Franklyn G. Ph.D. 1977 (M.D. 1970 Univ. West Indies)
Advisor: Mann
Thesis: ``Physical and Chemical Properties of a Photoprotein System from *Aequorea Forskalea*"
Position: Professor and Chairman, Department of Biochemistry and Molecular Biology, Mayo Graduate School of Medicine (94)
Address: Department of Biochemistry and Molecular Biology
Mayo Graduate School of Medicine, Rochester MN 55905

155. Eccleston, Eric D. Ph.D. 1977
Advisor: Gray
Thesis: ``Regulation of Morphogenesis in *Rhodopseudomonas spheroides*: Role of Nucleotides"
Position: Research Associate, Dept. of Biochemistry, Univ. of Minn. Medical School (94)
Address: Department of Biochemistry, University of Minnesota, Minnepolis MN 55455

156. Kohlmiller, Nancy A. Ph.D. 1978
Advisor: Howard
Thesis: ``The Primary Structure of the Subunit of Protocatechuate 3,4-Dioxygenase"
Position: Carnegie Institute of Washington, Dept. of Plant Biology, Stanford, University (87)
Address: Carnegie Institute of Washington, Department of Plant Biology
Stanford University, Palo Alto CA 94305

157. Larimore, Frederick S. Ph.D. 1978
Advisor: Roon
Thesis: "A Possible Site-Specific Reagent for the General Amino Acid Transport System of *Saccaromyces cerevisiae*"
Position: Eli Lilly Company (88)
Address: I. C. 242, Bldg. 130, 307 East McCarty Street, Indianapolis IN 46285

158. Nesheim, Michael Ph.D. 1978
Advisor: Veneziale
Thesis: ``A Model and Methods for Determining the Velocity of Intracellular Reactions, with Application to the Processes of Glycolysis and Gluconeogenesis in Isolated, Perfused Rat Liver"
Position: Professor, Department of Biochemistry, Queen's University at Kingston (94)
Address: Department of Biochemistry, Queen's University at Kingston
Kingston, Ontario, Canada K7L 3N6

159. Brown, Bevely A. Ph.D. 1979
Advisor: Bodley
Thesis: ``Ultraviolet Light Cross-Linking of Nucleic Acid-Protein Complexes Involved in Protein Synthesis. Primary Structure at the Site in Beef and Wheat Elongation Factor 2 of ADP-Ribosylation by Diptheria Toxin"
Position: Development Manager, Dupont (94)
Address: 331 Treble Cove Rd., North Billerica, MA 01862

160. Citak, Brian P. Ph.D. 1979
Advisor: Gray
Thesis: ``Isolation and Characterization of Cellular Nucleases from *Streptococcus Pyrogenes*"
Position: Unknown (88)
Address: 2516 Dupont Avenue S., Minneapolis MN 55405

161. Lundell, Daniel J. Ph.D. 1979
Advisor: Howard
Thesis: ``Subunit Structure and Sequence of the Cysteinyl Peptides of the Molybdenum-Iron Protein of the Azotobacter *Vinelandii Nitrogenase*"
Position: Senior Scientist, Plough-Schering, Inc. (92)
Address: Plough-Schering, Inc., Madison, N.J.

162. Wong, Kam M. Ph.D. 1979 (M.D. 1985 Case-Western U.)
Advisor: Singer
Thesis: ``The Effect of Fluoride, Hormones, and Drugs on Bone Resorption"
Position: Department of Orthopedic Surgery, Case-Western Reserve Medical School (88)
Address: Department of Orthopedic Surgery
Case-Western Reserve Medical School, Cleveland OH 43210

163. Swenson, Richard P. Ph.D. 1979
Advisor: Howard
Thesis: ``Isolation, Subunit Characterization, and Determination of a Unique, Covalently Modified Alkylamine Sensitive Site of Alpha-2 Macroglobulin, a Plasma Protein Inhibitor"
Position: Associate Professor, Department of Biochemistry, Ohio State University (94)
Address: Department of Biochemistry, Ohio State University, Columbus OH 43210

164. Razel, Anthony J. Ph.D. 1979
Advisor: Gray
Thesis: ``Modification of RNA in Different Morphogenetic States of *Rhodopseudomonas spheroides*"
Position: Mead-Johnson and Company (87)
Address: Mead-Johnson and Company, 2400 Pennsylvania Street, Evansville IN 19898

165. Anton, David L. Ph.D. 1980
Advisor: Hogenkamp
Thesis: ``Nuclear Magnetic and Electron Paramagnetic Resonance Spectroscopy of Modified Cobalamins"
Position: Project Leader, Central Research Department, Dupont Corporation (94)
Address: Central Research Department, Box 80328, Experimental Research Station
Dupont Corporation, Wilmington DE 19898

166. Hurwitz, Mary (Joanne) Y. Ph.D. 1980
Advisor: Edstrom
Thesis: ``Cyclic Nucleotide Phosphodesterases in Human Lymphocytes"
Position: Research Assistant Professor, Dept. of Pediatrics, Baylor College of Medicine (94)
Address: One Baylor Plaza, MC3-3320, Houston TX 77030

167. Johnson, Mark L. Ph.D. 1980
Advisor: Veneziale/Ungar
Thesis: ``Regulation of the Intracellular Concentration and Specific Activity of Pyruvate Kinase"
Position: Unknown

168. Knutson, Victoria P. Ph.D. 1980
Advisor: Ungar
Thesis: ``Steroid Substrate Stereospecifity of Purified Rat Liver Alcohol Dehydrogenase"
Position: Associate Professor, Dept. of Pharmacology, Univ. of Texas Medical School (94)
Address: Department of Pharmacology, University of Texas Medical School
6431 Fannin, P.O. Box 20708, Houston TX 77030-1501

169. Magil, Shiela F. Ph.D. 1980
Advisor: Singer
Thesis: ``The Effect of Fluoride on the Lipids in Mouse Serum, Red Blood Cells, Bone, and Bone Cell Cultures"
Position: Production Manager, Seragen, Inc. (92)
Address: Seragen, Inc., 54 Clayton Street, Arlington MA 02122

170. MarSchel, Ardin H. Ph.D. 1980
Advisor: Bodley
Thesis: ``Studies on the Nature of the Active Sites in *Escherichia coli* Elongation Factors Tu and Ts"
Position: Bethesda Research Laboratories, Inc. (87)
Address: Bethesda Research Laboratories, Inc., P. O. Box 6009, Gaithersburg MD 20877

171. McGuire, Denise M. Ph.D. 1980
Advisor: Van Pilsum
Thesis: ``The Effect of Growth Hormone and Thyroxine on Arginine-Glycine Amidinotransferase in Kidneys of Hypophysectomized Rats"
Position: Assistant Professor, Department of Biology, St. Cloud State University (94)
Address: Department of Biology, St. Cloud State University, St. Cloud MN 56301

172. Murray, Elsa J. Ph.D. 1980
Advisor: Singer
Thesis: ``The Effects of Zinc Deficiency on Bone Metabolism in the Rat"
Position: VA Medical Center, Sepulveda (94)
Address: GRECC, 11-E, VA Medical Center, 16111 Plummer Street,Sepulveda CA 91343

173. Tsai, Pei-Kuo Ph.D. 1980
Advisor: Hogenkamp
Thesis: ``The Purification and Characterization of Adenosylcobalamin-dependent Ribonucleotide Reductase from *Corynebacterium nephridii*"
Position: Merck, Sharpe and Dohme Research Laboratories (94)
Address: Merck, Sharpe and Dohme Research Laboratories, WP 78-302
West Point PA 19486

174. Van Ness, Brian G. Ph.D. 1980
Advisor: Bodley
Thesis: ``The Site of Diptheria Toxin Catalyzed ADP-Ribosylation in Yeast Elongation Factor 2"
Position: Professor, Institute of Human Genetics and Department of Biochemistry, University of Minnesota Medical School (94)
Address: Dept. of Biochemistry, Univ. of Minn. Medical School, Minneapolis MN 55455

175. Bourque, Elizabeth A. Ph.D. 1980
Advisor: Ungar
Thesis: ``Enzymatic Regulation of Cyclic GMP in Rat Cerebellar Synaptosomes"
Position: Scientist, Environmental Health, Dept. of Public Health, State of Mass. (87)
Address: 6 Cambridge Terrace, Alston MA 02134

176. Cox, Daniel E. Ph.D. 1981
Advisor: Edstrom
Thesis: ``Calmodulin Interactions with Phosphorylase Kinase"
Position: Scientist, Angenics Corporation (87)
Address: Angenics Corporation, Cambridge MA 02139

177. Graf, Ernst Ph.D. 1981
Advisor: Penniston
Thesis: ``Ca2+ ATPase from Human Erythrocyte Membranes: Purification, Characterization, and Its Interaction with Calmodulin"
Position: Pillsbury Company (86)
Address: Pillsbury Company, Minneapolis MN 55414

178. Lucas, Paul A. Ph.D. 1981
Advisor: Singer
Thesis: ``The Effect of Vitamin A Deficiency and Fluoride on Glycosaminogycan Metabolism in Bone"
Position: Department of Biology, Case-Western Reserve University (87)
Address: Department of Biology, Case-Western Reserve University, Cleveland OH 44106

179. Meng, Mei Ph.D. 1981
Advisor: Hogenkamp
Thesis: ``Purification, Characterization, and Amino Acid Sequence of Thioredoxin from *Corynrbacterium Nephridii*
Position: Post-Doctoral Program, Department of Chemistry, Carnegie-Mellon University (87)
Address: Department of Chemistry, Carnegie-Mellon University, Pittsburgh PA 15213

180. Kazim, Abdul-Latif Ph.D. 1981
Advisor: Atassi
Thesis: Unknown
Position: Director, Biopolymer Facility, Roswell Park Institute
Address: Roswell Park Institute, CCC-514, Elm and Carlton Sts., Buffalo, NY 14263-0001

181. Sand, Theodore T. Ph.D. 1981
Advisor: Rosenberg
Thesis: ``Thermodynamic and Kinetic Aspects of the Binding of Concanavalin A to Mammalian and Artificial Surfaces"
Position: Unknown

182. Miksicek, Richard J. Ph.D. 1982
Advisor: Towle
Thesis: ``Dietary and Hormonal Regulation of the Hexose Shunt Dehydrogenase"
Position: Institute of Cellular and Tumor Biology, German Cancer Research Center, 1982-88; Assistant Professor, Dept. of Pharmacology, SU NY, Stonybrook, 88- (90)
Address: Department of Pharmacology, SUNY Stonybrook, Stonybrook NY

183. Hausinger, Robert Ph.D. 1982
Advisor: Howard
Thesis: ``Structure Function Studies on the Iron Protein from the Azotobacter *Vinelandii* Complex"
Position: Associate Professor, Department of Microbiology, Michigan State University (94)
Address: Department of Microbiology, Michigan State University, East Lansing MI 48824

184. Song, Min-Kyung Hong Ph.D. 1983
Advisor: Adolph
Thesis: ``Studies on Post-Translational Modifications of Non-Histone Proteins During the Hela Cell Cycle"
Position: Scientist, Federal Drug Administration (90)
Address: Federal Drug Adminstration, Washington D. C.

185. Whittaker, James W. Ph.D. 1983
Advisor: Lipscomb
Thesis: ``Structural and Mechanistic Studies of *Brevibacterium Fuscum* Protocatechuate 3,4 Dioxygenase"
Position: Assistant Professor, Department of Chemistry, Carnegie-Mellon University (90)
Address: Department of Chemistry, Carnegie-Mellon University, Pittsburgh PA 15213

186. Liaw, Chen W. Ph.D. 1983
Advisor: Towle
Thesis: ``Indentification and Characterization of a Rat Gene Regulated by Thyroid Hormone and Lipogenic Diet"
Position: Scientist, Athena Neurosciences (90)
Address: Athena Neurosciences, San Carlos CA

187. Freund, Ronald Ph.D. 1984
Advisor: Koerner
Thesis: ``Pharmacological Characterization of Excitatory Amino Acid Receptors in the Hippocampus"
Position: Post Doctoral Position, Institute of Behavioral Genetics, University of Colorado (90)
Address: Institute of Behavioral Genetics, University of Colorado, Boulder CO 80309

188. Narayan, Prema Ph.D. 1984 (M.S. 1982)
Advisor: Towle
Thesis: ``Transcriptional and Post-Transcriptional Regulation of a Thyroid Hormone Responsive mRNA"
Position: Post Doctoral Position, Department of Biology and Microbiology, Case-Western Reserve University (90)
Address: Department of Biology and Microbiology, School of Medicine
Case-Western University, Cleveland OH 44106

189. Rosenthal-Erickson, Luann P. Ph.D. 1984
Advisor: Bodley
Thesis: ``Borohydride Reduction of Periodate-Oxidized Nucleotides; Isolation and Characterization of the Reduction Intermediates"
Position: Post Doctoral Position, University of Milan (87)
Address: University of Milan, Italy

190. Robinson, Michael Ph.D. 1985
Advisor: Koerner
Thesis: ``Characterization of Excitatory Amino Acid Transmitter Systems in the Rat Central Nervous System"
Position: Asst. Prof., Dept. of Pediatrics, Univ. of Pennsylvania Medical School, 1988- (90)
Address: Dept. of Pediatrics, Univ. of Pennsylvania Medical School, Philadelphia, PA

191. Arciero, David M. Ph.D. 1985
Advisor: Lipscomb
Thesis: ``Structural and Mechanistic Studies of Protocatechuate 4,5 Dioxygenase"
Position: Post Doctoral Position, Dept. of Genetics and Cell Biology, Univ. of Minnesota (90)
Address: Dept. of Genetics and Cell Biology, University of Minnesota, St. Paul MN 55108

192. Chen, Jeou-Yuan Ph.D. 1985
Advisor: Bodley
Thesis: ``Biosynthesis of Diphthamide in the Yeast *Saccharomyces cerevisiae*"
Position: Post Doctoral Position, Dept. of Molecular Biology, University of Louisville (90)
Address: Dept. of Molecular Biology, University of Louisville, Louisville KY 40292

193. Kim, Kyu-Won Ph.D. 1985
Advisor: Roon
Thesis: ``Yeast Asparaginase: Structural Gene Expression"
Position: Assistant Professor, Pusan University (90)
Address: Pusan University, Pusan, Korea

194. Squiers, Thomas Ph.D. 1985
Advisor: Thomas
Thesis: ``A Functional Role for Dynamic Protein-Protein Interactions in Sarcoplasmic Reticulum"
Position: Department of Biochemistry, Division of Biology, Univ. of Kansas (94)
Address: Department of Biochemistry, University of Kansas, Haworth Hall
Lawrence KA 66045-2101

195. Bigelow, Diane Ph.D. 1985
Advisor: Thomas
Thesis: ``Lipid and Protein Dynamics in Sarcoplasmic Reticulum"
Position: Department of Biochemistry, Univ. of Kansas (94)
Address: Department of Biochemistry, University of Kansas, Haworth Hall
Lawrence KA 66045

196. Sun, Shi-Zhang Ph.D. 1986
Advisor: Hogenkamp
Thesis: ``The Purification and Characterization of Ribonucleotide Reductase from *Thermus X-1*"
Position: Post Doctoral Position, Department of Internal Medicine, Health Sciences Center, Dallas, Texas (88)
Address: Dept. of Internal Medicine, Health Sciences Center, Dallas TX 75235-9030

197. Klein, David Ph.D. 1986 (M.D.)
Advisor: Oegema
Thesis: ``Characterization of Glomerular Heparin Sulfate and Dermatin Sulfate Proteoglycans"
Position: Assistant Professor, Dept. of Pediatrics, Univ. of Minnesota Medical School (94)
Address: Dept. of Pediatrics, Univ. of Minnesota Medical School, Minneapolis MN 55455

198. Barnett, Vincent Ph.D. 1987 (M.S. 1982)
Advisor: Thomas
Thesis: ``Saturation Transfer EPR of Spin-Labeled Muscle Fibers: Dependence on Sarcomere Length"
Position: Assistant Professor, Department of Physiology, Univ. of Minn. Medical School (94)
Address: Dept. of Physiology, Univ. of Minn. Medical School, Minneapolis MN 55455

199. Ahn, Byung-yoon Ph.D. 1987
Advisor: Livingston
Thesis: ``A Study of Genetic Recombination in Yeast Plasmids"
Position: Post Doctoral Position, National Institutes of Health (90)

200. Anderson, Gretchen Ph.D. 1987
Advisor: Howard
Thesis: ``Characterization of Oxidation States of the Fe-Protein from *Azotobacter vinelandii*"
Position: Post Doctoral Position, Department of Biochemistry, Ohio State University (90)
Address: Department of Biochemistry, Ohio State University, Columbus OH 43210

201. Leder, Richard Ph.D. 1987
Advisor: Thomas
Thesis: ``Fluorescence Energy Transfer Studies of Bacteriorhodopsin from *Halobacterium halobium*"
Position: Assistant Professor, Grinnell College (90)
Address: Grinnell College, Grinnell IA 50112

202. Lewis, Scott Ph.D. 1987
Advisor: Thomas
Thesis: ``The Molecular Dynamics of the Active Transport Cycle of the Sarcoplasmic Reticulum Calcium ATPase"
Position: Resident, Dept. of Neurology, Univ. Mich. Medical School (90)
Address: Dept. Neurology, Univ. of Michigan Medical School, Ann Arbor MI 48109

203. Yoon, Jong-Bok Ph.D. 1987
Advisor: Towle
Thesis: ``Regulation of Gene Expression by Growth Hormone"
Position: Post Doctoral Position (90)
Address: Dept. of Pediatrics, Univ. of Minnesota Medical School, Minneapolis, MN 55455

204. Kamerud, John Ph.D. 1987
Advisor: Roon
Thesis: ``Expression of Amidases in *Saccharomyces cerevisae*: Asparaginase II and w-Amidase"
Position: R and D Industries (90)
Address: R and D Industries, 9635 Humboldt Avenue South, Minneapolis MN 55431

205. Strand, Andrew Ph.D. 1988
Advisor: Livingston
Thesis: ``Analysis of the Major DNAase Hypersensitive Site on the Yeast Two Micron Plasmid"
Position: Post Doctoral Position, F. E. Hutchinson Cancer Center (90)

206. Chung, Taewon Ph.D. 1988
Advisor: LaPorte
Thesis: ``Cloning and Characterization of the Glyoxalate Bypass Operon of *Escherichia coli*"
Position: Assistant Professor, Yeungnam University, Korea (90)

207. Trescony, Paul Ph.D. 1988
Advisor: Oegema
Thesis: ``Characterization of Bovine Aortic Endothelial Cell Proteoglycans"
Position: Biochemist, Medtronics, Inc. (90)
Address: Medtronics, Inc., 7000 Central Ave. NE, Fridley MN

208. Jacoby, Douglas Ph.D. 1988
Advisor: Towle
Thesis: ``Nutritional Regulatory Sequences Involved in Hepatic Gene Expression"
Position: Post Doctoral Position, Brandeis University (90)

209. Fox, Brian Ph.D. 1989
Advisor: Lipscomb
Thesis: "Mechanistic Studies of the Catalytic Cycle of Methane Monooxygenase"
Position: Post Doctoral Position, Carnegie-Mellon University (90)

210. Murray, Mary Beth Ph.D. 1989
Advisor: Towle
Thesis: "Multiple Thyroid Hormone Receptors and Their Interactions with DNA"
Position: Post Doctoral Position, Johns Hopkins University (90)

211. Sauer-Stueland, Constance Ph.D. 1989
Advisor: LaPorte
Thesis: "Structure and Biological Function of Isocitrate Dehydrogenase Kinase/Phosphatase"
Position: Post Doctoral Position, Scripps Research Institute (90)

212. Whittemore, Edward Ph.D. 1989
Advisor: Koerner
Thesis: "Characterization of Recognition Sites for L-2-Amino-4-Phosphonobutanoic Acid (L-AP4) in the Mammalian Central Nervous System."
Position: Post Doctoral Position, University of California, Irvine (90)

213. Wolgel,Sanford Ph.D. 1989
Advisor: Lipscomb
Thesis: "Mechanistic Studies of Protocatechuate 2,3 Dioxygenase from *Bacillus Macerans*"

214. Broekemeir, Kimberly Ph.D. 1990
Advisor: Dempsey
Thesis: "Mechnaism of the Inner Membrane Permeability Transition in Rat Liver Mitochondria"
Position: Post Doctoral Position, Hormel Institute (90)

215. Harpel, Mark Ph.D. 1990
Advisor: Lipscomb
Thesis" Mechanistic Studies of Pseudomonas Gentisate 1,2 Dioxygenase"

216. Johnson, Anton Ph.D. 1990
Advisor: Ugurbil
Thesis: "Nuclear Magnetic Resonance Studies of the Heart and Brain"

217. Miller, Stephen Ph.D. 1990
Advisor: Bodley
Thesis: "The Ribosomal 'Achilles Heel' of the Elongation Cycle: A Study of the Ribosomal Target Sites of the Protein Cytotoxins"

218. Williams, William Ph.D. 1990
Advisor: Howard
Thesis: "Structure/Function Relationships within the Pig Heart CoA Transferase"

219. Berger, Christopher Ph.D. 1991
Advisor: Thomas
Thesis: "Rotational Dynamics of Myosin Heads Bound to Actin during the Acto-Myosin ATPase Cycle"

220. Dornfeld, Kenneth PhD. 1991
Advisor: Livingston
Thesis: "Characterization of Recombination in a rad52 Mutant of *Saccharomyces Cerevisiae*"

221. Ikeda, Timothy Ph.D. 1991
Advisor: LaPorte
Thesis: "The Structure and Biological Function of Isocitrate Dehydrogenase Kinase/ Phosphatase"

222. Nelms, Keats Ph.D. 1991
Advisor: Van Ness
Thesis: "Regulation of Murine Immunoglobulin Enhancer Function"

223. Veldman, Sarah Ph.D. 1991
Advisor: Bodley
Thesis: "Studies on the Transcriptional Regulation of Elongation Factor-2 in *Saccharomyces cerevisiae:*

224. Boundy-Mills, Kyria Louise Ph.D. 1992
Advisor: Livingston
Thesis: "A *Saccharomyces cerevisiae* rad52 Allele Expressing A C-Terminal Truncation Protein: Activities and Intragenic Complementation of Missense Mutations"

225. Jollie, David Ph.D. 1992
Advisor: Lipscomb
Thesis: "Structure and Mechanism of Formate Dehydrogenase Isolated from the Methanotroph, *Methylosinus trichosporium* OB3b."

226. Ong, Seng Poon PhD. 1992
Advisor: Hogenkamp
Thesis: "The Synthesis of Substrate Analogs and Their Interactions with Ribonucleotide Reductase from *Corynebacterium nephridii"*

227. Peterson, Nancy Ph.D. 1992
Advisor: Koerner
Thesis: "Characterization of the L-2-Amino-4-phosphonobutanoic Acid (L-AP4) Receptor Using Conformationally Constrained Analogues of AP4"

228. Rowen, Donald Ph.D. 1992
Advisor: LaPorte
Thesis: "GLC3: The Gene Encoding the Glycogen Branching Enzyme of the *Saccharomyces cerevisiae"*

229. Schulte, Marvin Ph.D. 1992
Advisor: Koerner
Thesis: "The Mechanisms of Quisqualic Acid Induced Sensitization of Hippocampal Slices to Depolarization by L-2-Amino-4-Phosphonobutanoic Acid (L-AP4)"

230. Schweers, Lora Ann Ph.D. 1992
Advisor: Sanders/Towle
Thesis: "Transcriptional Regulation by Steroid Hormones: The Ovalbumin Gene"

231. Skoufos, Emmanouil Ph.D. 1992
Advisor: Sanders
Thesis: "Regulation of the Expression of the Chicken Ovalbumin Gene by Insulin and Second Messengers"

233. Stein, Richard Ph.D. 1992
Advisor: Thomas
Thesis: "Angle- and Time-Resolved Phosphorescence Antisotrophy: Theory and Application to Contracting Muscle Fibers"

234. Sunnarborg, Alden Ph.D. 1992
Advisor: LaPorte
Thesis: "Regulation of the Glyoxylate Bypass Operon: Cloning and Characterization of iclR"

235. Wei, Haoran Ph.D. 1992
Advisor: Ugurbil
Thesis: "J-Coupling Related Bl Insensitive NMR Technique Development"

236. Xu, Zhaohui Ph.D. 1992
Advisor: Banaszak
Thesis: "The Molecular Structure of the Adipocyte Lipid Binding Protein"

B. M. S. Degree Recipients

The following is a list of those individuals who have obtained the M. S. degree in the program, including those who continued in the program to the Ph. D. degree. Several of those who did not complete the Ph. D. degree here did obtain the M. D. degree either before or after the M. S., and a few of them eventually obtained the Ph. D. degree at another school. The advisor for the M. S. thesis and the title for the thesis is also given.

1. Osterberg, Arnold (1921) Ph.D. 1925
Advisor: Kendall
Thesis: ``Studies Concerning Certain Derivatives of Cyclohexane"

2. Schuck, Cecilia (1923)
Advisor: McClendon
Thesis: ``Vitamine Studies"

3. Swanson, William (1924) M.D. 1925
Advisor: McClendon
Thesis: ``The Effect of Sodium Benzoate Ingestion upon the Composition of the Blood and Urine with Especial Reference to the Possible Synthesis of Glycine in the Body"

4. Whelan, Mary (1925)
Advisor: McClendon
Thesis: ``The Effect of Intravenous Injection of Inorganic Chlorides on the Composition of Blood and Urine"

5. Holloway, Martha (1927)
Advisor: McClendon
Thesis: ``A Quantitative Pettenkofer Test Applicable to the Determination of the Bile Acids in Blood"

6. Conklin, Claire (1929)
Advisor: McClendon
Thesis: ``A Study of the Cyclic Variations in the BMR in Women"

7. Wells, Harold (1929)
Advisor: McClendon
Thesis: ``A Study of Adsorption of the Ovarian Hormone from Urine"

8. Barrett, Earl (1931)
Advisor: McClendon
Thesis: ``Iodine in Minnesota Potatoes in an Attempt to Correlate with Goiter"

9. Holdridge, Curtis (1933)
Advisor: McClendon
Thesis: ``Study of the Analysis of Iodine in Urine"

10. Bernhart, Finn (1934) Ph.D. 1934
Advisor: McClendon
Thesis: ``The Effect of Diathermy on the Blood Volume of Normal and Anesthetized Dogs"

11. Seljeskog, Sigsbee (1935)
Advisor: McClendon
Thesis: ``A Comparative Study of Blood Urea Methods"

12. Kennedy, Barbara (1937)
Advisor: McClendon
Thesis: ``Serum Calcium and Magnesium in Normal and Allergic Conditions"

13. Hastings, Waldon (1938)
Advisor: McClendon
Thesis: ``Studies on Splenic Extract Causing Regression of Transplanted Mouse Tumor"

14. Foster, William (1939) Ph.D.
Advisor: McClendon
Thesis: ``Studies on the Formation of Ammonia by the Kidney"

15. Szego, Clara (1939) Ph.D. 1942
Advisor: Samuels
Thesis: Studies on Color Reactions of Urinary Estrogenic Substances"

16. Perry, Mabel (1941)
Advisor: Armstrong
Thesis: ``The Effect of Increased Fluorine Intake on the Composition of Teeth in Adult Animals"

17. Beck, Paul (1942) Ph.D. 1952 (Ill. Inst. Tech.)
Advisor: Sollner
Thesis: ``Swelling of Collodion Membranes in Aqueous Solutions of Organic Compounds"

18. Greenberg, Robert G. (1942) Ph.D. 1944
Advisor: Arnow
Thesis: " The Extraction of Glutamic Acid from Aqueous Solutions by Normal Butyl Alcohol"

19. Roberts, Sidney (1942) Ph.D. 1943
Advisor: Samuels
Thesis: ``The Influence of Previous Diet on the Insulin Tolerance of Hypophysectomized Rats"

20. Lerner, Aaron (1942) Ph.D. 1945
Advisor: Arnow
Thesis: ``Studies on the Synthesis of Dipeptides of Dopa with Special Reference to the Conversion of L-Tyrosine to L-Dopa"

21. Opsahl, Jeannette (1942) Ph.D. (Yale) M.D. (Univ. of Alberta)
Advisor: Arnow
Thesis: ``Studies on the Isolation of Partly Racemized Glutamic Acid from Protein Hydrolysates"

22. Hirsch, Helen (1943)
Advisor: Samuels
Thesis: ``Steroid Excretion of the Newborn"

23. Cohodas, Leah (1945)
Advisor: Burr
Thesis: ``A Study of the Alkali Isomerization of Fatty Acids"

24. Molander, David (1946)
Advisor: Burr
Thesis: ``A Study of the Absorption of Fat and Carotene from the Gastrointestinal Tract"

25. Schneider, Virginia (1946)
Advisor: Burr
Thesis: ``The Molecular Area of Fatty Acids and Some of Their Derivatives As Measured in Monolayers"

26. Rieckehoff, Irma (1946)
Advisor: Burr
Thesis: ``The Effect on Diet of the Polyethenoid Acids of the Rat"

27. Bitman, Joel (1948) Ph.D. 1950
Advisor: Cohen
Thesis: ``A Study of Barium Chloride Hydrolysis of the Conjugated 17-Ketosteroids of Normal Male Urine"

28. Hakanson, Erick (1948) M.D.
Advisor: Glick
Thesis: ``Hyaluronidase Inhibition by Serum in Human Cancer"

29. Jennings, Elizabeth (1948)
Advisor: Barnum
Thesis: ``The Use of Radioactive Phosphorus in a Phosphorus Turnover Study of Mouse Cell Liver Nuclei"

30. Nash, Charles W. (1948)
Advisor: Barnum
Thesis: ``A Study of the Nucleic Acids of Mouse Liver Cell Nuclei"

31. Clausen, Donald (1950) Ph.D. 1955
Advisor: Barnum
Thesis: ``The Synthesis of Radioactive Analogs of Fluorescein and Their Physiological Distribution in Cancerous Mice"

32. Cohen, William (1950) Ph.D. 1952
Advisor: Frame
Thesis: ``The Effect of Adrenocortical Hormones and of Fasting on the Peptidase Activity of Rat Tissues"

33. Nelson, Walter (1950) Ph.D. 1958
Advisor: Barnum
Thesis: ``Improvements on a Procedure for Isolation of Pentose Nucleic Acid from Mouse Cell Liver Nuclei and a Characterization of Protein Fractions Obtained from Mouse Cell Liver Nuclei"

34. Zak, Edith (1950)
Advisor: Glick
Thesis: ``A Study of the Possible Role of Urea and Urease in Gastric Acid Secretion"

35. Edmondson, Page (1951)
Advisor: Glick
Thesis: ``A Micro Method for the Determination of Hyaluronidase and Hyaluronidase Inhibitors"

36. Fish, Ardelle (1951)
Advisor: Barnum
Thesis: ``The Quantitation of Small Amounts of Nucleic Acid in Tissues"

37. Harris, Ruth Slaton (1951)
Advisor: Cohen
Thesis: ``The Effect of Ovarian Hormones on the Enzymatic Activity of Some Sexual and Non-Sexual Tissues in the Female Mouse"

38. Ochs, Mary Jane (1951)
Advisor: Glick
Thesis: ``A Quantitative Histochemical Method for the Determination of Zinc and Its Application to Studies on the Gastric Mucosa"

39. Rausch, Verna (1952)
Advisor: Frame
Thesis: ``Chromatographic Studies of Urinary Amino Acids in Normal Human Subjects"

40. Engelstad, Wendell (1956) M.D. 1959
Advisor: Carr
Thesis: ``The Binding of the Alkali Metal Cations by Phosphoproteins"

41. Freier, Esther (1956)
Advisor: Glick
Thesis: ``The Determination of Microgram Amounts of Calcium and Magnesium in Mammalian Muscle"

42. Goldfine, Mickey Melvin (1957) M.D. 1960
Advisor: Cohen
Thesis: ``A Study of the Excretion of Urinary Preganediol in the Human"

43. Ramras, Donald (1957) M.D. 1961
Advisor: Barnum
Thesis: ``A Comparison of Some of the Properties of Mitochondria and Microsomes Isolated in Alkaline Saline and 0.88 M Sucrose"

44. Barker, Jovita (1958)
Advisor: Glick
Thesis: ``Development of Method for the Determination Hyaluronidase"

45. Jongedyk, Kathleen (1959)
Advisor: Cohen
Thesis: ``Studies of Solubility Properties and Conditions of Hydrolysis of the Conjugated 17-Ketosteroids"

46. Lansky, Lester (1960) M.D. 1963
Advisor: Von Korff
Thesis: ``Studies on the Chemical Composition of Fibrinogen and Fibrinopeptides"

47. Pothapragada, Sita (1960)
Advisor: Glick
Thesis: ``Succinic Dehydrogenase in Mast Cells"

48. Hallaway, Ben (1961)
Advisor: Barnum
Thesis: ``Hydrogen Equilibria of Myocardial Actin"

49. Hammer, Kathyrn (1961)
Advisor: Barnum
Thesis: ``A Critical Evaluation of a Method for Isolation of Nucleic Acids from Mammalian Liver Tissue"

50. Jenne, John (1961) M.D. 1964
Advisor: Barnum
Thesis: ``A Study of the Acetylation of Isoniazid and p-Amino Salicyclic Acid in Pigeon Liver"

51. Scheiner, Stuart (1961) M.D.
Advisor: Barnum
Thesis: ``Intracellular Enzyme Levels in Human Gastro-Intestinal Mucosa: Comparison of Normal and Neoplastic States"

52. Schulman, William (1961)
Advisor: Ungar
Thesis: Plan B

53. Trelle, Gloria (1961)
Advisor: Unknown
Thesis: ``Studies on the *in vitro* Oxidation of Alpha Tocopherol by Ferric Iron"

54. Armstrong, Raymond G. (1962) M.D.
Advisor: Carr
Thesis: ``A Chromatographic, Electrophoretic, and Immunochemical Study of Ferritin"

55. Coyne, Robert (1962)
Advisor: Von Korff
Thesis: ``Changes in the N-terminal Amino Acid Patterns of Fibrinogen and Fibrin Resulting from the Action of Fibinolytic Enzymes"

56. Goldstein, Meyer (1962)
Advisor: Ungar
Thesis: ``3-Alpha- and 3-Beta-Hydroxysteroid Dehydrogenases"

57. Filonowich, Lydia (1963)
Advisor: Armstrong/Singer
Thesis: ``X-Ray Fluorescence Analysis of Biological Materials"

58. Grage, Theodore (1963) M.D. 1959
Advisor: Ungar
Thesis: ``Bioassay of Antidiuretic Hormone"

59. Merritt, Barbara (1963)
Advisor: Barnum
Thesis: ``Studies of Circadian Variations in Kidney Metabolism"

60. Mills, Donald (1963) Ph.D. (Coll. Biol. Sci.)
Advisor: Von Korff
Thesis: ``N-terminal Studies on the Proteolysis of Human Fibinogen and Fibrin by Plasmin"

61. Simon, Gerald (1963) Ph.D. 1965
Advisor: Barnum
Thesis: ``Glutamate Oxidation in Guinea Pig Cerebral Slices"

62. Yasmineh, Walid (1963) Ph.D. 1966
Advisor: Gray
Thesis: ``Kinetic Studies on the Deoxyribonucleases of Group A Streptococci"

63. Choi, Yong Sung (1964) Ph.D. 1965 (M.D. Korea)
Advisor: Carr
Thesis: ``Calcium Binding Studies of Ribonucleic Acids"

64. Jorgenson, Sally (1964) Ph.D. 1966
Advisor: Koerner
Thesis: ``A New Deoxyribonuclease from *Escherichia coli*"

65. Benson, Robert (1965) Ph.D. (UCLA)
Advisor: Boyer
Thesis: ``Oxygen Exchange Reactions Catalyzed by Myofibrils"

66. Cane, William (1965) Ph.D. 1966
Advisor: Wetlaufer
Thesis: ``Models for Hydrophobic Interactions in Proteins"

67. Ferretti, Joseph (1965) Ph.D. 1967
Advisor: Gray
Thesis: ``Studies on the RNA of *Rhodopseudomonas spheroides* during Physiologic Adaptation"

68. Kellor, Richard (1965)
Advisor: Koerner
Thesis: ``Electrophoresis of 14C-Labeled Protein from Normal *Escherichia coli* and Cells Infected with T2 Bacteriophage"

69. Kennedy, James (1965)
Advisor: Carr
Thesis: ``The Influence of Temperature on the Permeation Rates of Electrolytes through Collodion Membranes"

70. Lewis, Patricia (1965)
Advisor: Frantz
Thesis: ``The Chemical Synthesis of (delta) 24-Cholesten-3Beta-ol and Its Conversion to Cholesterol in Rat Liver Homogenate"

71. Walder, Arnold (1965) M.D.
Advisor: Van Pilsum
Thesis: ``Purification of Human Kidney Transamidinase - An Experimental Study"

72. Bauer, Catherine (1966)
Advisor: Von Korff
Thesis: ``Respiratory Control Ratios, Endogenous Substrates, and the Nature of Substrate Metabolism by Heart Muscle Mitochondria of Several Species"

73. Berman, Samuel (1966) M.D. 1968
Advisor: Van Pilsum
Thesis: ``Studies on the Mechanism of Dephosphorylation of Creatine Phosphate by Rabbit Skeletal Muscle Preparations"

74. Buchwald, Henry (1966) M.D., Ph.D.
Advisor: Frantz
Thesis: ``Cholesterol Absorbtion and Excretion in the Small Intestine: A Study of Localization, Effect of Transit Time, and the Role of Bile"

75. Cohn, Major (1966) M.D., Ph.D.
Advisor: Ungar
Thesis: ``Estrogen Formation in the Male"

76. Elam, John (1966) Ph.D. 1968
Advisor: Koerner
Thesis: ``The Effect of Ultraviolet Radiation of T2 Bacteriophage on the Control of Enzyme Synthesis in Infected Cells"

77. Erickson, Richard (1966)
Advisor: Ungar
Thesis: ``Inhibition of Steroid 18-Hydroxylation by SU-4885"

78. Groff, Terry (1966)
Advisor: Holman
Thesis: ``Mass Spectrometry of an Isomeric Series of Methyl-nonyenate, Methyl-nonemate and Methyldideuteronomemate"

79. McFee, Arthur (1966) M.D.
Advisor: Barnum
Thesis: ``A Study of the Effect of Profound Local Gastric Hypothermia - Gastric Freezing - in the Turnover of Cells in the Normal Rat Gastric Mucosa Employing the Uptake and Incorporation of Tritium"

80. Nordstrom, Karen (1966)
Advisor: Frantz
Thesis: ``The Concentration of Some Cholesterol Intermediates in Normal Rat Liver"

81. Ray, Nell (1966)
Advisor: Wetlaufer
Thesis: ``A Search for Hydrophobic Interactions in Carbohydrates"

82. Buhi, William (1967) Ph.D. (Univ. Fla.)
Advisor: Gray
Thesis: ``Studies on the Purification and Properies of Spleen Phosphorolytic Enzymes"

83. Egwim, Peter (1967)
Advisor: Holman
Thesis: ``Characterization of the Lipids from the Leaf of the African Oil Palm"

84. Mott, Glenn (1967) Ph.D. (Univ. Texas)
Advisor: Von Korff
Thesis: ``Fatty Acid Composition of Myelin Lipids from Regenerating Cat Sciatic Nerve"

85. Kwiatkowski, Frances (1967)
Advisor: Dempsey
Thesis: ``Studies on the Oxygen Exchange Reaction Catalyzed on Contractile Proteins of Cardiac and Skeletal Muscle"

86. Bauder, Doris (1968)
Advisor: Carr
Thesis: ``Studies on a Soluble Protein in the Erythrocyte Stroma"

87. Chu, Marion (1968)
Advisor: Singer
Thesis: ``The Role of the Kidney in Fluoride Regulation"

88. Rosenthal, H. Garrett (1968)
Advisor: Ungar
Thesis: ``Infrared Analysis of Corticosteroid Glucuronides"

89. Sparnins, Velta (1968) Ph.D. 1970
Advisor: Koerner
Thesis: ``Purification of DNAses of *Esherichia coli*"

90. Webster, Robert (1968)
Advisor: Pollara
Thesis: ``Isolation and Partial Purification of Transferrin from the Sea Lamprey, *Petromzon Marinus*"

91. Wenger, Jane Idell (1968) Ph.D. 1970
Advisor: Larner
Thesis: ``Purification and Properties of Skeletal Muscle UDPG: Alpha-1,4 Glucan Alpha-4-Glucosyl Transferase I Kinase: Characterization of Two Different Forms of the Enzyme"

92. DeJesus, Tan (1969)
Advisor: Gray
Thesis: ``Studies on the tRNA of *Rhodopseudomonas spheroides*"

93. Funderburgh, James (1969) Ph.D. (Univ. Wisconsin)
Advisor: Edstrom
Thesis: ``Purification and Properties of the Vi Antigen from *Citrobacter freundii*"

94. Lee, Shui-Mei (1969)
Advisor: Edstrom
Thesis: ``Enzymatic Degradation of Vi Antigen"

95. Ritter, Mary C. (1969) Ph.D. 1971
Advisor: Dempsey
Thesis: ``Partial Characterization and Purification of a Naturally Occurring Activating System of Cholesterol Biosynthesis"

96. Schaffer, Victoria (1969) M.D.
Advisor: Ungar
Thesis: ``Adrenal Steroidogenesis in Mg Deficient Rats"

97. Tavernier, Paul (1969) Ph.D. 1972
Advisor: Gray
Thesis: ``The Effect of Divalent Cations on the Specificity of Streptococcal Nuclease B and D"

98. Brown, Norman (1970)
Advisor: Larner
Thesis: ``Some Physical and Chemical Properties of Rabbit Skeletal Muscle Glycogen Transferase D"

99. Lai, Charles (1970) M.D.
Advisor: Armstrong/Singer
Thesis: ``Phosphatase Activities of Bone and Calcification Mechanism in the Rat"

100. Skrdla, Shirley (1970)
Advisor: Frantz
Thesis: ``Some Aspects of the Effect of Albumin on the Synthesis Rates of Alpha and Beta Lipoproteins"

101. Holmes, Kathleen (1971)
Advisor: Benson
Thesis: ``A Study of the Effects of Tropocalcin on the ATPase Activity of Synthetic Actomycin"

102. McDermott, Katherine (1971)
Advisor: Frantz
Thesis: ``Glucose Formation by a Cell-Free System of Rat Liver"

103. Chen, Mei (1972) M.D.
Advisor: Carr
Thesis: ``Calcium Binding Studies of Rabbit Liver Microsomes"

104. Roth, Terry (1972)
Advisor: Frantz
Thesis: ``Experimentally Induced Changes in the Composition of the Low Density Lipoproteins"

105. Richman, Nathan (1973)
Advisor: Bodley
Thesis: ``Interaction of Polypeptide Chain Elongation Factors with Bacterial Ribosomes"

106. Cheung, Pearl (1974)
Advisor: Frantz
Thesis: ``A Kinetic Study of the Exchange of Cholesterol between Isolated Rabbit Lipoproteins and Erythrocytes"

107. White, Richard (1974)
Advisor: Carr
Thesis: ``The Interaction of Magnesium Ions with Enzymes and Other Proteins"

108. Yu, Emily (1974)
Advisor: Wetlaufer
Thesis: ``Regeneration of Disulfide Proteins under Denaturing Conditions"

109. Cheung, David (1975)
Advisor: Wold
Thesis: ``Chemical Coupling of Oligosaccharides and Glycopeptides with Proteins"

110. Meyer, Gail (1975)
Advisor: Dempsey
Thesis: ``Studies on Lipid Carrier Proteins from Mammalian and Non-mammalian Systems"

111. Rungraunpanaskul, Rapepun (1975) Ph.D. 1977
Advisor: Dempsey
Thesis: ``Studies on the Enzymic Reactions of Cilia Contractile Proteins"

112. Biros, Michelle (1976) M.D. 1979
Advisor: Smith
Thesis: ``Isolation and Characterization of Lactoferrin from Bovine and Human Milk and Human Parotid Saliva"

113. Levy, Jane (1976)
Advisor: Roon
Thesis: ``Uptake and Utilization of L-alanine by *Saccharomyces cerevisiae*"

114. Willie, Glen (1976) M.D. 1978
Advisor: Bodley
Thesis: ``The Characterization of 24, 25-Dihydrofusidic Acid Binding to Ribosomal Complexes"

115. Paulson, Caroline (1976)
Advisor: Edstrom
Thesis: ``Role of the Outer Monosaccharide Units of Plasma Membrane Glycoproteins in the Stimulation of Lymphocytes"

116. Ho, Amy (1978)
Advisor: Carr
Thesis: ``Studies on the Ionic Activation of Beta-Galactosidase"

117. Thompson, Jeffrey (1978)
Advisor: Bodley
Thesis: ``The Number and Nature of the Sulfhydryl Groups of *Esherichia coli* Elongation Factor G"

118. Daum, Henry (1979)
Advisor: Dempsey
Thesis: ``The Role of Squalene and Sterol Carrier Protein in Intracellular Fatty Acid Transport and Metabolism"

119. Kuisk, Ilmar (1979)
Advisor: Roon
Thesis: ``Studies on the General Amino Acid Transport System of *Saccharomyces cerevisiae*"

120. Bradley, Gary (1980)
Advisor: Hogenkamp
Thesis: ``The Synthesis and Characterization of Spin-Labeled Adenine Nucleotides"

121. Kang, Ling (1981)
Advisor: Roon
Thesis: ``Studies on the Regulation of Asparaginase II Biosynthesis in *Saccharomyces cerevisiae*"

122. Newman, Dawn (1981)
Advisor: Martin
Thesis: ``*In Vitro* and *In Vivo* RNA Synthesis in Yeast Mitochondria"

123. Pham, Hung (1981)
Advisor: Martin
Thesis: ``The Effect of Canavanine on Plasmid Maintenance in Yeast"

124. Narayan, Prema (1981) Ph.D. 1984
Advisor: Towle
Thesis: ``Development of Complementary DNA Probes to Messenger RNA Sequences Responsive to Thyroid Hormone and Dietary Factors"

125. Kaufman, Cynthia (1983)
Advisor: Livingston
Thesis: ``Identification and Characterization of a Rat Gene Regulated by Thyroid Hormone and a Lipoprotein Diet"

126. Barnett, Vincent A. (1984) Ph.D. 1987
Advisor: Thomas
Thesis: ``Saturation Transfer EPR of Spin-Labeled Muscle Fibers: Dependence on Sarcomere Length"

127. Keeler, Marilyn (1985)
Advisor: Hogenkamp
Thesis: ``The Characterization of the Active Site of Ribonucleotide Reductase"

128. Tao, Teh-Yi (1985)
Advisor: Towle
Thesis: ``Hormonal and Nutritional Regulation of Rat Hepatic Gene Expression"

129. Wolgel, Sondro (1986)
Advisor: Lipscomb
Thesis: ``Purification and Characterization of Protocatechuate 2,3 Dioxygenase from *Bacillus macerans*"

130. Cooper, Jeffrey (1988)
Advisor: Dempsey
Thesis: ``Sequence Characterization of Sterol Carrier Protein from Rat Liver, Heart, and Kidney Tissue"

131. Whittemore, Edward (1988)
Advisor: Koerner
Thesis: "Novel Binding Site for L-Quisqualate Sensitized Neurons to Depolarization by a Group of Phosphonate-Containing Analogues of Glutamate"

132. Peterson, Nancy (1989)
Advisor: Koerner
Theisi: "Assay of Natural Toxins for Inhibition of Excitatory Synaptic Transmission"

133. Sprowl, Christopher (1989)
Advisor: Thomas
Thesis: "Terbium Luminescence and Binding in the Calcium-ATPase of the Sarcoplasmic Reticulum"

134. Stein, Richard (1989)
Advisor: Thomas
Thesis: "Rotational Dynamics of Phosphorescent-Labeled Cross-Bridges in Contracting Muscle Fibers"

135. Schweers, Lora (1990)
Advisor: Sanders
Thesis: "Characterization of A Steroid Dependent Regulatory Element in the Ovalbumin Gene"

136. Lui, Yi (1991)
Advisor: Lipscomb
Thesis: Complex Formation between the Protein Components of Methane Meneoxygenase from *Methylosinus Trichosporium* OB3b"

137. Ehlen, Sarah (1992)
Advisor: Sanders
Thesis: "Characterization of the Negative Regulatory Element in the Ovalbumin Gene"

138. Lee, Sang-Kyu (1992)
Advisor: Lipscomb
Thesis: Transient Kinetic Mechanism of Methane Monoxygenase Isolated from *Methylosinus trichosporium* OB3b"

139. Liu, Hsien-Ching (1992)
Advisor: Towle
Thesis: "Thyroid Hormone Receptor Regulation of S14 Gene Expression in Hepatocytes"

C. Research Fellows and Post Doctoral Students

In this section is a list of the names of individuals who spent six months or more in the laboratory of one of the senior staff members of the Department carrying out some research project. Almost always they had just completed their Ph.D. work and were truly post-doctoral students. In a few instances it may have been a few years beyond the Ph.D., and the individual had come for some ``refresher" type of research training. The length of time spent in the post-doctoral fellowship was usually 1-2 years, but in a few instances it may have been as long as 5-6 years before the individual left for another position. The name of the advisor is given parenthesis, and the present position of the fellow, when known, is also given. This section undoubtedly has some omissions because the record keeping for these individuals, especially in the early years, has been incomplete.

1. Bratton, A. Calvin 1937-38 (McClendon)

2. Lundberg, Walter 1938-42 (Burr) Executive Director, Hormel Research Foundation, 1949-74 (dec.)

3. Norris, Frank 1939-41 (Burr) Associate Manager, Research and Development, Kraftco Corporation, 1972-78 (ret.) (82)

4. Kass, Peter 1939-42 (Burr) Director of Research, Armour Company

5. Platt, John (1941-43) (Burr) Professor of Physics, University of Chicago, 1946-65; Research Scientist, Mental Health Institute, University of Michigan, 1965-77 (ret.) (82)

6. Barnum, Cyrus 1941-42 (Armstrong) Professor, Department of Physiological Chemistry, University of Minnesota, 1942-1965 (dec.)

7. Szego, Clara 1942-43 (Samuels) Professor, Department of Zoology, UCLA (ret.) (94)

8. Lienke, Roger 1948-49 (Armstrong) Unknown

9. Nygaard, Oddvar 1950-51 (Barnum) Professor of Radiology, Case-Western Reserve Medical School, 1975- ; Director, Division of Radiation Biology, 1976- (92)

10. Geary, John 1955-56 (Glick) Unknown

11. Fromm, Herbert 1956-57 (Boyer) Professor, Biochemistry & Biophysics, Iowa State University (94)

12. Kowalsky, Arthur 1956-62 (Boyer) Program Director, Biophysics, National Science Foundation, Washington, D.C. (94)

13. Schulz, Arthur 1957-58 (Boyer) Department of Pathology, School of Medicine, Indiana University, Indianapolis (88)

14. Deshpande, Panderang 1958-59 (Von Korff) Unknown

15. Westhead, Edward 1958-61 (Boyer) Professor, Department of Biochemistry, University of Massachusetts (94)

16. Seulter, Clarence 1959-61 (Boyer) Professor, Department of Biochemistry, Michigan State University (88)

17. Graves, Donald 1959-61 (Boyer) Professor and Chairman, Department of Biochemistry & Biophysics, Iowa State University (94)

18. Hass, Louis 1959-61 (Boyer) Professor Emeritus, Department of Biological Chemistry, Hershey Medical Center, Penn State University (94)

19. Jacobson, Maynard 1959-61 (Ungar) Professor, Department of Medicine, VA Hospital, Minneapolis (94)

20. Sugimoto, Masamitsu, 1959-60 (Barnum) Unknown

21. Beary, Moira 1960-62 (Ungar) Professor Emeritus, Department of Biochemistry, University College, Dublin, Ireland (94)

22. Ebner, Kurt 1961-62 (Boyer) Professor and Head, Department of Biochemistry, University of Kansas Medical Center (94)

23. Musa, Byron 1961-62 (Ungar) Department of Medicine, University of Oregon (88)

24. Chang, Kim Yong 1961-65 (Carr) Unknown

25. Conner, Robert 1961-62 (Ungar) Professor, Department of Biology, Bryn Mawr College (88)

26. Richards, Oliver 1962-63 (Boyer) Researcher, Dept. Molecular Biology and Biochemistry, University of California, Irvine (94)

27. Hultquist, Donald 1962-63 (Boyer) Professor, Department of Biological Chemistry, University of Michigan Medical School (94)

28. Kreil, Gunther 1962-63 (Boyer) Institute of Molecular Biology, Austrian Academy of Science (88)

29. Hinkson, Jimmy 1962-63 (Boyer) Professor, Department of Chemistry, California State College, Stanislaus (88)

30. Lovrien, Rex 1962-65 (Wetlaufer) Professor, Department of Biochemistry, College of Biological Sciences, University of Minnesota (94)

31. Raman, (Madyastha) Prema 1962-63 (Ungar) Indian Institute of Science, Department of Chemistry, Bangalore, India (88)

32. Colla, John 1963-66 (Ungar) Private practice, St. Louis, Missouri (88)

33. Fogarty, William 1963-67 (Ungar) Private Practice, St. Louis, Missouri (88)

34. Sahagian, Benjamin 1963-64 (Ungar) University of Nebraska, Lincoln (88)

35. Hagen, Arne 1963-65 (Armstrong/Singer) Norway (88)

36. Vogel, James 1963-67 (Armstrong) Director, Occupational Health and Peformance Directorate, U.S. Army Research Institute of Environmental Medicine, Natick MA (94)

37. Mitchell, Robert 1963 (Boyer) Ireland

38. Huijing, Fransiscus 1964-66 (Larner) Professor of Biochemistry and Molecular Biology, University of Miami (88)

39. Schuetz, Allen 1964-66 (Ungar) Professor of Population Dynammics, School of Hygiene and Public Health, Johns Hopkins University (94)

40. Donaldson, Edward 1964-65 (Ungar) Bureau of Fisheries, Vancouver, British Columbia (88)

41. Devi, Sita 1964-65 (Ungar) Department of Chemistry, Andhra, India (88)

42. Uchio, Taro 1964-65 (Ungar) Department of Surgery, Kumamoto City, Japan (88)

43. Desper, P. G. 1964-65 (Ungar) Department of Medicine, Universisty of West Virginia (88)

44. Lakatua, David 1964-65 (Ungar) Department of Pathology, St. Paul Ramsey Hospital (88)

45. Notation, Albert 1964-68 (Ungar) Professor and Chairman, Department of Chemistry, Quinnipiac College, Connecticut (88)

46. Gedalia, Itzhak 1964-65 (Armstrong/Singer) Israel (88)

47. Stahl, Perry 1965-66 (Ungar) Department of Biology, University of Oregon (88)

48. Grosso, Leonard 1965-66 (Ungar) Professor, State University of New York, Downstate (88)

49. Brooks, William 1965-66 (Ungar) Department of Biology, Ripon College (88)

50. Teng, John 1965-66 (Ungar) Department of Human Biological Chemistry and Genetics, University of Texas, Galveston (88)

51. Balasubramanian, 1965-66 (Wetlaufer) Unknown

52. Klicka, John 1965-66 (Ungar) VA Hospital, Minneapolis (88)

53. Voet, Raymond, 1965-66 (Ungar) Department of Pathology, U.S. Naval Radiological Defense Laboratory, San Fransisco (88)

54. Ertel, Robert 1965-66 (Ungar) Professor, Department of Pharmacology, University of Pittsburgh (94)

55. Reynolds, John 1965-67 (Ungar) Professor, Department of Pediatrics, University of Oregon (88)

56. Spencer, Richard 1966-69 (Wold) Professor of Chemistry, Southwest State University (92)

57. Saxena, Vishv P. 1966-70 (Westlaufer) Unknown

58. Bernard, Betty 1966-68 (Ungar) Department of Pediatrics, University of California, Los Angeles (88)

59. Ramachandran, Srinivasa (Ungar) Endocrine Laboratory, Jacksonville, Florida (88)

60. Lai, Charles 1967-69 (Armstrong) Professor, Department of Orthopedic Surgery, University of Minnesota (88)

61. Schlender, Keith 1967-69 (Larner) Professor, Department of Pharmacology and Therapeutics, Medical College of Ohio (94)

62. Thomas, James 1967-68 (Larner) Professor, Department of Biochemistry and Biophysics, Iowa State University (94)

63. Nelson, Thomas 1967-68 (Larner) Department of Rehabilitation, Baylor College of Medicine, Houston (94)

64. Bishop, William 1967-69 (Wetlaufer) Naval Medical Research Unit, Bethesda, MD (85)

65. Harber, Phyllis 1967-68 (Ungar) Department of Biology, Moorhead State University (88)

66. Mason, Thomas 1967-68 (Larner) Department of Biochemistry, University of Massachusetts (94)

67. Lohmar, Phoebe 1967 (Ungar) Department of Biochemistry and Molecular Biology, Mayo Clinic (88)

68. Huibregtse, William 1968-69 (Ungar) Research Center, Mead Johnson Co., Evansville, Indiana (88)

69. Stabler, Timothy 1968-69 (Ungar) Department of Biology, Indiana University (85)

70. Liberti, Joseph 1968-69 (Ungar) Professor, Department of Biochemistry, Medical College of Virginia (94)

71. Clauss, Lorraine 1968-70 (Wetlaufer) Unknown

72. Tang, (Liang) Loretta 1968-69 (Ungar) Professor, Department of Biochemistry, University of Rochester (88)

73. Lin, Yuan-Chuang 1968-70 (Wold) Taiwan

74. Seabloom, Robert 1969-70 (Ungar) Professor, Department of Biology, University of North Dakota (88)

75. Gawronski, Thomas 1969-70 (Wold) Unknown

76. Turnipseed, Marvin 1969-71 (Ungar) Professor, Department of Physiological Chemistry, Quinnipiac College, Connecticut (88)

77. Koroly, Mary Jane 1970-71 (Ungar) Department of Biochemistry and Molecular Biology, University of Florida (94)

78. Wyborny, Leigh 1970-71 (Wold) Department of Biology, Texas Southern University, Houston (85)

79. Belke, Carl 1971-73 (Wold) Chemistry Department, Brandon University, Manitoba (88)

80. Bannai, Chieko 1971-72 (Ungar) Department of Medicine, Tsukuba City, Tokyo, Japan (88)

81. Brahmakshatriya, Raghuvir, 1971-72 (Ungar) Department of Nutrition, Akra, India (88)

82. Hsiao, Joyce 1971-76 (Ungar) Department of Chemistry, Minneapolis Community College (88)

83. Vafiadou, Aphrodite 1971-72 (Dempsey) Greece

84. Twu, Jer-Shung 1971-72 (Wold) VA Hospital, Los Angeles

85. Anderson, Lucy 1972-73 (Ungar) NCI, Fredericksburg, MD (88)

86. McCoy, Kim 1972-77 (Ungar, Dempsey) Washburn University, Topeka, Kansas (85)

87. Tutas, Daniel 1972-73 (Koerner) Unknown

88. Chow, Yeh Mei 1972-73 (Wetlaufer) Unknown

89. Carlson, John 1972-75 (Dempsey) Unknown

90. Magrane, David 1972-76 (Ungar) Department of Biology, Moorehead State University, KY (88)

91. Rohrbach, Michael 1973-76 (Bodley) Associate Professor, Department of Biochemistry and Molecular Biology, Mayo Medical School (dec.)

92. Dunlap, Patricia 1973-77 (Roon)

93. Baca, Oswald 1974-75 (Bodley) Professor of Microbiology and Associate Dean of Graduate Studies, University of New Mexico (88)

94. Oh, Kyung-Ja 1974-75 (Wetlaufer) University of Delaware (75)

95. Anderson, William 1974-75 (Wetlaufer) Department of Biology, University of New Mexico (94)

96. Ionnides, John 1974-75 (Ungar) Department of Medicine, Thessalonia, Greece (88)

97. Frnka, Jerome 1974-77 (Dempsey) Unknown

98. Wang, Yueh 1976-78 (Hogenkamp) Unknown

99. Baker, Nordeen 1976-78 (Dempsey) Tulane University (78)

100. Larimore, Frederick 1978-79 (Roon) Upjohn Company (88)

101. Gupta, Sulbha 1979-80 (Bodley)

102. Hurwitz, Richard 1979-80 (Edstrom) Assistant Professor, Dept. Pediatrics and Cell Biology, Baylor College of Medicine, Houston (94)

103. Watson, Frances 1979-80 (Hogenkamp) Private practice, Minneapolis (90)

104. Kohlmiller, Nancy 1979-80 (Hogenkamp) Carnegie Institute of Washington, Department of Plant Biology, Stanford University (88)

105. Lenz, Gerald 1979-80 (Howard)

106. Eccleston, Eric 1979- (Howard) Department of Biochemistry, University of Minnesota (94)

107. Fanchiang, Y-T 1980-83 (Hogenkamp)

108. Litts, James 1980-81 (Howard)

109. Eads, Thomas 1980-87 (Thomas) Assistant Professor, Purdue University (90)

110. McGuire, Denise 1980-87 (Towle, Dempsey) Assistant Professor, Department of Biology, St. Cloud State University (94)

111. Tsai, Pei-Kuo 1980-82 (Hogenkamp) Merck, Sharpe and Dohme Research Laboratories (94)

112. Rees, Douglas 1981-82 (Howard) Professor, Department of Chemistry and Biochemistry, University of California, Los Angeles (94)

113. Zhang, Guang 1981-82 (Ungar) Department of Urology, VA Hospital, Minneapolis (88)

114. Buchstein, Sara 1982-83 (Livingston) Medical School, University of Minnesota (90)

115. Viskup, Robert 1982-84 (Bodley) Department of Biochemistry, University of Vermont (90)

116. Deits, Thomas 1982-88 (Thomas) Department of Biochemistry, Michigan State University (90)

117. Zieske, Lynn 1983-84 (Howard) Applied Biosystems (90)

118. McMahon, Ann 1983-86 (Dempsey) Valhalla Medical School, New York (90)

119. Hargis, Pamela Stewart 1983-86 (Dempsey) Department of Poultry Science, Texas A & M University (dec.)

120. Polnaszek, Carl 1983- (Thomas) Department of Biochemistry, University of Minnesota (93)

121. Fajer, Piotr 1983- (Thomas) Department of Biochemistry, University of Minnesota (90)

122. Dunkirk, Shawn 1984 (Van Pilsum, Tan) Veterans Administration Hospital, Minneapolis MN (90)

123. Bigelow, Diana 1984-86 (Thomas) Dept. of Biochemistry, Univ. of Kansas (94)

124. Liaw, Chen 1984 (Towle) Scientist, Athena Neurosciences, San Carlos, CA (90)

125. Ludescher, Richard 1984- (Thomas) Asst. Professor, Rutgers Medical School (90)

126. Parentesis, John 1984- (Bodley) University of Minnesota (94)

127. Birmachu, Woubalem 1985- (Thomas)

128. Sanchez, Salvador (de la Pena) 1985-88 (Ungar) Albany College of Medicine, Albany, New York (88)

129. Graeff, Richard 1986- (Goldberg) (88)

130. Schmidt, Jane 1987-88 (Goldberg) Kallestad Diagnostics, Inc., Chaska, MN (90)

131. Willing, Andreas 1987- (Howard)

132. Dawis, Stevan 1986-88 (Goldberg) Rockefeller University (90)

133. Francis, Ralph 1986 (Dempsey) Dight Laboratories, University of Minnesota (88)

134. Kean, Robert 1986- (Howard) Cargill, Inc. (90)

135. Koliakos, George 1987-88 (Dempsey) Department of Laboratory Medicine and Pathology, University of Minnesota (90)

136. Barnett, Vincent 1987 (Thomas) Assistant Professor, Department of Physiology, University of Minnesota (94)

Chapter XII. Faculty Summary - 1888-1988

In this chapter I have organized two lists, long-term faculty and short-term faculty. The distinction will be described in each section.

A. Long-Term Faculty

The following is a chronological listing of the long-term faculty of this program. These individuals were in the program for at least three years and carried out significant classroom teaching or other departmental activities and/or have been advisor to one or more graduate students. Some of them are joint appointees, and the source of their other appointment is given parenthesis.

1. Beard, Richard (dec., Physiology)	1888-1914
2. Bell, John (dec., Chemistry)	1888-1902
3. Carel, Hubert (Chemistry)	1895-1908
4. Wilcox, M. R. (dec., Physiology)	1898-1914
5. Sedgwick, Julius (dec., Pediatrics)	1906-1915
6. Scott, Frederick (dec., Physiology)	1908-1913
7. Schlutz, Frederick (dec., Pediatrics)	1911-1915
8. Gibson, Robert (dec.)	1911-1914
9. Kingsbury, Francis (dec.)	1912-1923
10. Pettibone, C. J. V. (dec.)	1913-1929
11. McClendon, Jesse (dec.)	1914-1939
12. Greisheimer, Esther (dec., Physiology)	1919-1935
13. Medes, Grace (dec.)	1924-1928
14. Pascoe, Truman	1925-1930

15. Hemingway, Allen (dec., Physiology)	1930-1942
16. Cavett, Jesse (dec.)	1930-1937
17. Armstrong, Wallace (dec.)	1934-1974
18. Arnow, L. Earle	1935-1942
19. Samuels, Leo (dec.)	1937-1944
20. Freundlich, Herbert (dec.) (All-Univ.)	1938-1940
21. Sollner, Karl (dec.)	1939-1963
22. Burr, George (dec.)	1940-1946
23. Barnes, Richard (dec.)	1940-1943
24. Mickelson, Olaf (Hospital Labs.)	1940-1945
25. Lundberg, Walter (Hormel Inst.) (dec.)	1944-1949
26. Barnum, Cyrus (dec.)	1942-1965
27. Wood, Harland (dec.)	1943-1946
28. Utter, Merton (dec.)	1944-1946
29. Holman, Ralph (Hormel Inst.)	1944-1946, 1952-
30. Glick, David	1945-1961
31. Cohen, Saul	1946-1956
32. Frame, Elizabeth	1946-1953
33. Carr, Charles	1946-1984
34. Singer, Leon (dec.)	1949-1988
35. Dunshee, Bryant	1949-1952
36. Caster, William	1951-1964
37. Gutmann, Helmut (VA Hospital)	1952-1979

38. Frantz, Ivan (Medicine)	1954-1986
39. Van Pilsum, John	1954-
40. Boyer, Paul	1955-1963
41. Von Korff, Richard (Pediatrics)	1955-1966
42. Ungar, Frank	1958-
43. Carlson, Curtis (dec.)	1959-1964
44. Benson, Ellis (Lab. Medicine & Path.)	1959-1973
45. Smith, Quenton (Oral Biology)	1959-
46. Koerner, James	1961-
47. Dempsey, Mary	1961-
48. Wetlaufer, Donald	1962-1975
49. Gray, Ernest (Pediatrics)	1962-
50. Bernlohr, Robert (Microbiology)	1962-1975
51. Edstrom, Ronald (dec.)	1964-
52. Pollara, Bernard (Medicine)	1964-1969
53. Larner, Joseph	1965-1969
54. Wold, Finn	1966-1974
55. Bodley, James	1967-
56. Pothapragada, Venketaswarlu	1968-1974
57. Short, Everett (Veterinary Medicine)	1968-1974
58. Notation, Albert (Obstetrics & Gynecology)	1968-1976
59. Roon, Robert	1970-
60. Howard, James	1970-

61. Rosenberg, Andreas (Lab. Med. & Path.)	1970-
62. Vatessary, Govind (VA Hospital)	1970-1978
63. Blomquist, Charles (Obstet. & Gynec.)	1970-
64. Kelley, William (dec.) (Obst. & Gyn.)	1972-1976
65. Tan, Agnes (VA Hospital)	1972-1988
66. Gilboe, Daniel (VA Hospital)	1972-
67. Oegema, Theodore (Orthopedic Surgery)	1975-
68. Hogenkamp, Harry	1976-
69. Lipscomb, John	1977-
70. Martin, Nancy	1977-1980
71. Livingston, Dennis	1977-
72. Adolph, Kenneth	1979-
73. Towle, Howard	1980-
74. Thomas, David	1980-
75. LaPorte, David	1983-
76. Sanders, Michel (Medicine)	1986-
77. Van Ness, Brian	1986-
78. Goldberg, Nelson	1987-

B. Short-Term Faculty: Instructors, Assistant Professors and Lecturers

The following is a list of individuals who held short-term appointments in the Program as instructor, assistant professor, or lecturer, most of whom were not included in the earlier description of the faculty in Chapters I-VI. During their tenure these individuals were either here for a short time or did not take part to any significant extent in the activities of the Program other than their own research. Many of them were post-doctoral students who had just finished their Ph.D. work and stayed on for a short time as instructor or assistant professor. In addition some were joint appointees and others were here primarily to do research in the laboratory of one of the senior faculty members but were not considered to be post-doctoral students. Following their names is the source of their appointment in parenthesis, and then is given their current or last known position.

1. Gulick, Addison 1912-13 (Dept.) Unknown

2. Swanson, William W., 1925-27 (Dept.) Prof. Pediatrics, Northwestern University Medical School (ret.)

3. Gregory, Raymond, 1927-29 (Dept.) Professor and Head Internal Medicine, University Medical Branch, Houston, 1940-68 (dec.)

4. Hamilton, Robert, 1933-35 (Dept.) Professor and Chairman, Department of Biochemistry, Temple University Medical School. (ret.)

5. Fankuchen, Isidor 1941-42 (Anderson Institute of Biological Research) Professor, Dept. Chemistry, Brooklyn Polytechnic Institute, 1942-65 (dec.)

6. Szego, Clara, 1942-45 (Samuels) Professor, Department of Biology, UCLA (ret.)

7. Schubert, Jack, 1947-48 (Armstrong) Visiting Professor, Department of Biochemistry, Michigan State University

8. Zbarsky, Sidney, 1948-49 (Armstrong) Professor Emeritus, Department of Biochemistry, University of British Columbia (ret.)

9. Brown, Ernest, 1948-49 (Physiology) Vice Chancellor of the Faculty and Academic Affairs, University of Kansas Medical Center, 1974-77; Professor and Head, Physiology Department, Oral Roberts Medical School, 1977-81 (ret.)

10. Dray, Sheldon, 1951-52 (Dept.) Professor of Microbiology, University of Illinois Medical School, Chicago

11. Malmstrom, Bo 1953-54, (Glick) Professor of Biochemistry and Biophysics, Chalmers University of Technology and Goteborg University; Chairman, Nobel Committee for Chemistry

12. Jarketzky, Christine, 1954-55 (Barnum) Unknown

13. Bollum, Frederick, 1955-56 (Barnum) Professor, Department of Biochemistry, Uniformed Services University of Health Sciences.

14. Bonting, Sjoerd, 1955-56 (Glick) Professor Emeritus, California

15. Ronwin, Edward, 1958-59 (Von Korff) Unknown

16. Greenberg, Leonard, 1960-61 (Glick) Professor, Department of Laboratory Medicine and Pathology, University of Minnesota Medical School

17. Schroepfer, George, 1963-64 (Dept.) Professor, Department of Biochemistry, Rice University.

18. Seal, Ulysses, 1963-68 (VA) Professor of Biochemistry, Veterans Administration Hospital and College of Biological Sciences, University of Minnesota

19. Marshall, William, 1964-67 (VA) Unknown

20. Yarbro, John, 1965-68 (Medicine) Department of Medicine, University of Missouri Medical School

21. Bishop, Jonathon, 1965-69 (Larner) Associate Professor Emeritus, Departments of Medicine and Pharmacology, University of Minnesota Medical School

22. Villar-Palasi, Carlos, 1966-69 (Larner) Professor, Department of Pharmacology, University of Virginia Medical School

23. Burnham, Bruce, 1966-68 (Medicine) President and CEO, Porphyrin Products, Logan, Utah

24. Zieve, Leslie, 1966-73 (Medicine, VA) Professor of Medicine, University of Minnesota (ret.)

25. Anderson, John T., 1966-72 (Physiological Hygiene) Professor of Physiological Hygiene, University of Minnesota (ret.)

26. Umana, C. Roberto, 1967-69 (Dentistry) Unknown

27. Gurpide, Erlio, 1969-72 (Obstetrics and Gynecology) Professor of Biochemistry and Obstetrics and Gynecology, Mount Sinai Medical School

28. Nuttall, Frank Q., 1968-69 (Medicine, VA) Professor, Department of Medicine, Chief, Metabolism and Endocrinology Section, VA Medical Center, Univ. of Minn. Medical School

29. Schachtele, Charles, 1969-71 (Dentistry) Professor of Dentistry and Microbiology, University of Minnesota Dental School

30. Gawronski, Thomas, 1970-71 (Wold) Microbics Operations, Beckmann Instrument Company

31. Choi, Yong Sung, 1971-73 (Pediatrics) Director, Cellular Immunology Laboratory, Ochsner Research Institute, Tulane University, New Orleans

32. Jorgenson, Sally, 1973-74 (Veterinary Medicine) Associate Professor and Associate Dean, College of Veterinary Medicine, University of Minnesota

33. Ophaug, Robert, 1975-76 (Dentistry) Associate Professor, College of Dentistry, University of Minnesota

34. Magrane, David, 1957-76 Department of Biology, Moorehead State University, KY

35. Atassi, M. Zouhair, 1975-76 (Mayo) Robert Welch Professor, Department of Biochemistry, Baylor College of Medicine

Appendix A - Names of the Program

To describe the evolution of the names used for the discipline of Physiological Chemistry, we must go back to the early development of science in Europe, especially in Germany and France. The study of the chemistry of living systems was at first called plant chemistry, animal chemistry, agricultural chemistry, or medical chemistry, depending on what was being studied. In the medical schools, research into the chemistry of human function was at first called medical chemistry. Because much of this research was carried out in the physiology departments, the term, physiological chemistry, began to be used for this field. In 1870-80 such work was carried out primarily in Germany and France, and the first real journal for the field was started in Germany in 1877 by Hoppe-Seyler and a few coworkers, ``Zeitschrift fur Physiologische Chemie[1]."

In this country the first laboratory of physiological chemistry was established in 1874 at Yale University, primarily for the instruction of students intending to study medicine. It would remain the center for study and research in this discipline in this country for many years[2].

The term, physiological chemistry, was used almost exclusively in medical schools in the last quarter of the nineteenth century. In a few instances the term, biological chemistry, was used, and in 1903, an English scientist, A. Neuberger, suggested the term, biochemistry, the English translation of the German word, Biochemie. (Hoppe-Seyler already had used Biochemie as being synonymous with Physiologische Chemie in 1877[1]. Thus, in the early twentieth century some schools began to have departments of biochemistry instead of departments of physiological chemistry.

Courses entitled ``Biochemistry" first appeared in University of Minnesota catalogues in 1913, offered in the Department of Agricultural Chemistry. Then in 1915 that Department had its name changed to Agricultural Biochemistry. In 1905 the American Society of Biological Chemists was organized, and the first American journal was founded for this field, the ``Journal of Biological Chemistry." This use of multiple names continued as shown by the fact that in 1928 the membership of the American Society of Biological Chemists the college departments included 37 called Physiological Chemistry, 30 called Biochemistry, and 15 called Biological Chemistry[2]!

This use of more than one name for what had now become essentially a single discipline continued for the next two decades. For example, in the late 1940s, I know that there were some Departments of Physiological Chemistry who were using textbooks with Biochemistry in the title and conversely, Departments of Biochemistry who were using textbooks with Physiological Chemistry in the title. During the 1950s, however, Physiological Chemistry began to be dropped in favor of Biochemistry, and today there are a few departments that are called Biological Chemistry and only two that I know of that are called Physiological Chemistry. More than 90% of the departments are now called Biochemistry, whether they are in medical schools, colleges of biological sciences, or colleges of agriculture.

References

1. Hoppe-Seyler, F. Z. Physiol. Chem. 1 (1877); Florkin, M. and Stotz, E.H. ``Comprehensive Biochemistry. A History of Biochemistry" Pts. I and II, Vol. 30, Elsevier Publ. Co., Amsterdam, 1972

2. Chittenden, R.H. ``The Development of Physiological Chemistry in the United States" The Chemical Catalog Co., New York, 1930

Appendix B. Biochemical Research at the Mayo Clinic, 1920-1930

In addition to Kendall, other individuals at the Mayo Clinic were also carrying out very significant work in the area of physiological chemistry/biochemistry.

Walter Boothby, Professor of Medicine and Head of the section of Clinical Metabolism, conducted extensive studies concerned with basal metabolism and nutrition. The tables of basal metabolic rates (BMR) for normal human males and females of all ages were established by Boothby and Irene Sandiford in 1922. Their definitive papers, published in the Journal of Biological Chemistry, were ``A Comparison of the DuBois and the Harris and Benedict Normal Standards for the Estimation of the Basal Metabolic Rate" and ``Summary of the Basal Metabolism Data on 8614 Subjects with Specal Reference to the Normal Standards for the Estimation of the Basal Metabolic Rate[1]."

Later Boothby and co-workers conducted investigations of protein metabolism, especially the excretion of urea and its relationship to protein metabolism[2]. In healthy normal individuals on nitrogen-free diets for 30 days, it was found that the minimal nitrogen excretion was about 2 grams per 24 hours compared with about 15 grams per 24 hours on normal diets. This minimal nitrogen comes from the metabolism of tissue protein. It was also established that the quantity of such tissue protein that could be lost without deleterious effects was considerably greater than had been generally assumed. Boothby, although a Professor of Medicine, was listed on the graduate faculty in Biochemistry for many years.

Jesse Bollman, Professor of Physiology, Frank Mann, Professor of Experimental Surgery, and Thoman Magath carried out extensive studies on the role of the liver in metabolism. In 1924 they were the first ones to show that the liver was the only site of urea synthesis[3,5]. In 1925 they showed that glucose from muscle glycogen is not converted directly to glucose[4,5] (and to liver glycogen), which was one step towards the development of the Cori Cycle[6]. In 1942 Jesse Bollman was the advisor for a student who received the Ph.D. in Physiological Chemistry/Biochemistry.

References

1. Boothby, W.B. and Sandiford, I. ``A Comparison of the Dubois and the Harris and Benedict Normal Standards for the Estimation of the Basal Metabolic Rate" J. Biol. Chem. 54 767 (1922); *ibid.* ``Summary of the Basal Metabolism Data on 8614 Subjects with Special Reference to the Normal Standards for the Estimation of the Basal Metabolic Rate" 783; *ibid.* ``Basal Metabolism" Physiol. Revs. 4 69 (1924); See also ref. no. 2, Appendix A, p. 272-273

2. Duell, H.J., Jr., Sandiford, I., and Boothby, W.B. ``A Study of Nitrogen Minimum" J. Biol. Chem. 76 391 (1928)

3. Bollman, J.L., Mann, F.C., and Magath, T.B. ``Studies on the Physiology of the Liver. VIII. Effect of Total Removal of the Liver on the Formation of Urea" Am. J. Physiol. 69 371 (1924); *ibid.* ``XVII. The Effect of the Removal of the Liver on Ammonia Formation" 92 92 (1930)

4. *ibid.* ``XII. Muscle Glycogen Following Total Removal of the Liver" 74 238 (1925)

5. Visscher, M.B. ``Frank Charles Mann" Proc. Natl. Acad. Sci. Biograph. Memoirs 38 161 (1965)

6. Cori, C.F. and Cori, G.T. ``Glycogen Formation in the Liver from from d- and l-Lactic Acid" J. Biol Chem. 81 389 (1929); Cori, C.F. ``Carbohydrate Metabolism" Physiol. Revs. 11 143 (1931)

Appendix C - A Retrospective

I would like to offer a retrospective regarding one era of this program, the era of the late 1920s and the 1930s. At that time the biochemistry program in the Medical School was considered to be at a low point.

The program in Physiological Chemistry may not have seemed to to be very good to someone looking at it in 1930. Indeed, it did not have nearly the visibility of the other basic sciences in the Medical School, and the medical students were not happy with the teaching they were receiving. In addition the graduate program was very small when compared with Gortner's excellent Department of Agricultural Biochemistry on the St. Paul Campus[1].

Let's look back now and review some of the results of that period, at least with respect to the research accomplishments. To begin with, McClendon had made numerous studies on the geographical occurence of simple goiter and the iodine content of the foods grown in the various areas. He unequivocally helped to establish the concept of a ``goiter belt" which led to the introduction of iodized salt. This has essentially eliminated this type of goiter in this country[2].

Secondly, McClendon, on the basis of some of his own work, encouraged Wallace Armstrong to take up the study of fluoride and its effect on teeth. Wallace's work on this subject clearly played an important role in the introduction of fluoridation of municipal water supplies. Today more than sixty percent of the people in this country drink fluoridated water and the incidence of dental caries has dropped dramatically[3].

In 1929 George and Mildred Burr, working in the Anatomy Building, discovered the essential fatty acids[4]. Burr was in the Botany Department, but he worked closely with individuals in the Medical School. Burr and Arild Hansen in the Department of Pediatrics showed that a deficiency of the essential fatty acids in children would cause skin disease[5]. Later Burr served as Director of the Division of Physiological Chemistry, and, in addition, two of his students played a major role in the Hormel Research Institute becoming one of the leading lipid research laboratories in the world.

Finally, I will go outside of the program in the Medical School but within the graduate program in Physiological Chemistry to mention once again the work of Kendall at Rochester. He first discovered thyroxine and named it, and it was his work on the isolation and identification of the adrenal cortical hormones in the 1930s that led to the first clinical application of cortisone[6] (and to a Nobel Prize).

It is true that this is not the work of a single cohesive department but the output of a program in a large multidimensional state university. Nevertheless, looking at these accomplishments, I do not think that any program in biochemistry anywhere at any time can produce a list of research achievements during a period of 15 years or so that can be considered to be any more far-reaching than this.

References

1. Ref. No. 1, Chap. VII
2. Ref. No. 7, Chap. II
3. Ref. No. 39, Chap. III
4. Ref. Nos. 5,6, Chap. III
5. Ref. No. 8, Chap. III
6. Ref. No. 12, Chap. II

Appendix D - Books and Monographs

The following is a listing of the textbooks and monographs published by the faculty in Physiological Chemistry during the time that they were members of the Program.

1. McClendon, J.F. ``Physical Chemistry of Vital Phenomena" Princeton University Press, Princeton, New Jersey, 240 pp. (1917)
2. McClendon, J.F. and Medes, G. ``Physical Chemistry in Biology and Medicine" W.B. Saunders Co., New York, 425 pp., (1925)
3. McClendon, J.F. ``A Manual of Biochemistry" John Wiley & Sons, New York, 439 pp. (1934)
4. McClendon, J.F. ``Advances in the Science of Nutrition" Sasaki & Co., Sendi, Japan, 222 pp. (1937)
5. McClendon, J.F. ``Iodine and the Incidence of Goiter" University of Minnesota Press, Minneapolis, 126 pp. (1939)
6. McClendon, J.F. ``Physiological Chemistry" C.V. Mosby Co., St. Louis, 4th ed., (1929) Also eds. 5-7; see C.J.V. Pettibone
7. Pettibone, C.J.V. ``Intermediate Textbook of Physiological Chemistry" C.V. Mosby Co., St. Louis, 376 pp. (1918) Also eds. 2 and 3
8. Greisheimer, Esther M., ``Physiological Chemistry and Physiology for Nurses, Laboratory Manual," University of Minnesota (1928)
9. Greisheimer, Esther M., ``Physiology and Anatomy," J.B. Lippincott Co., Philadelphia, 569 pp. (1932)
10. Arnow, L.E. ``Introduction to Physiological and Pathological Chemistry" C.V. Mosby Co., St. Louis, 555 pp. (1939) Also eds. 2-9
11. Arnow, L.E., (with Rietz, H.C.) ``Introduction to Organic and Biological Chemistry" C.V. Mosby Co., St. Louis, (1942)
12. Glick, D. ``Techniques of Histo- and Cytochemistry; A Manual of Morphological and Quantitative Micro Methods for Inorganic and Enzyme Constituents of Biological Materials" Interscience Publishers, New York, (1949)
13. Glick, D. ``Quantitative Chemical Techniques of Histo- and Cytochemistry" Volume I ``Histochemistry" (1961); Volume II ``Biological Chemistry, Laboratory Manual" (1963) Interscience Publishers, New York
14. Armstrong, W.D. and Carr, C.W. ``Physiological Chemistry, Laboratory Directions" Burgess Publishing Co., Minneapolis, (1951); 2nd ed. 1957, 3rd ed. 1963
15. Ungar, F., (with Dorfman, R.I.) ``Metabolism of Steroid Hormones" 2nd ed. 1965, Academic Press, New York, 716 pp.; 1st ed. Burgess Publishing Co., Minneapolis, (1953)
16. Wold, F. ``Macromolecules, Structure and Function" Prentice-Hall, Englewood Cliffs, NJ, 274 pp. (1971)
17. Van Pilsum, J. and Roon, R. ``Medical Biochemistry; Principles and Experiments" Univ. Minn. Press, 1986

Appendix E - The Hormel Institute

In October 1938 the Hormel Foundation gave the University of Minnesota a grant of $25,000 per year to carry out research in food technology. This grant allowed each of four individuals to have one post-doctoral scientist to carry out the work; these individuals were Ross Gortner, George Burr, H. Orrin Halvorson, Prof. of Bacteriology in the Medical School, and Walter Lauer, Prof. of Organic Chemistry. Processes of industrial value would be patented by the University, and any proceeds would be split evenly between the University and the Foundation. Also the George A. Hormel Company would be entitled to free but non-exclusive licensing during the lifetime of the patent. The University would have the right to terminate the grant at the end of four years[1].

The Hormel Institute was founded on November 30, 1942 at the end of the four year period, in another agreement between the Hormel Foundation and the University. It was to be a research unit of the Graduate School of the University for the purpose of carrying out research in the areas of chemistry and biology. The laboratory facilities were provided by the Hormel Foundation, and in the early days the Foundation provided one third of the operating funds. The rest of the support came from several sources of outside funding[2,3].

The broad nature of its proposed goal is shown in the following statement from its annual report of 1944-45[2].

``*To promote education and research in plant, animal, and poultry production and utilization. The activities are to include studies in such fields as the relation of animal products to disease, and to treatment of disease, animal and poultry disease, and food technology and nutrition. Also included are tree culture and wood technology and principles and techniques of management in relation thereto, and such other subjects as may mutually be agreed upon.*"

Supervision of the operation would be invested in a Board consisting of representatives of the Chemistry and Biochemistry Departments of the University in the Twin Cities, a representative of the Mayo Foundation, a trustee of the Hormel Foundation, and the Dean of the Graduate School as Chairman of the Board. The members of the first Board included the Chairman, T.C. Blegen, Dean of the Graduate School, C.H. Bailey, Dean of the College of Agriculture, W.M Lauer, the aforementioned Professor of Organic Chemistry, F.C. Mann, Professor of Experimental Surgery at the Mayo Clinic, and R.P. Crane of the Board of Trustees of the Hormel Foundation.

The first Executive Director of the Institute was H.O. Halvorson. Prof. Halvorson had been in the Bacteriology Department for some time and had been active in the planning that had set up the Institute. His field of expertise was waste water management, especially sewage disposal, and he was a consultant to the State Board of Health in its sanitation control activities. In 1949 he resigned from the University to become Head of the Department of Bacteriology at the University of Illinois in Urbana. During his association with the Institute, he was a co-author of many papers, dealing mostly with bacteriological problems associated with food technology[4].

In 1948 it was reported that there were 16 different research projects in progress, divided into 4 major areas: (1) Soils research, the effects of various nitrogen, phosphate, and potassium treatments; (2) Fats and oils research, varying from specifics of metabolism to new industrial uses of fats and oils; (3) Bacteriological research, prima-

rily dealing with food technology; (4) Animal nutrition studies, such as the nutritional requirements of hogs and the need for trace elements[3].

In 1949, after Prof. Halvorson left, W.O. Lundberg, *vide supra*, was named Executive Director. Prof. Lundberg had joined the Institute when it was founded and was named Resident Director in 1944. He had been working in Prof. Burr's laboratory when the Institute was begun, and he continued to carry out research in the area of lipid biochemistry. When he became the Executive Director, the Institute's research emphasis began to shift towards lipid biochemistry.

In 1951 Ralph Holman came back to Minnesota to join the staff of the Institute, *vide supra*. He was appointed as Associate Professor and had a joint appointment in the Department of Physiological Chemistry in Minneapolis.

In 1952 Hermann Schlenk joined the Institute as Assistant Professor with a joint appointment in the St. Paul Department of Agricultural Biochemistry. Prof. Schlenk was born in Germany and came to this country in 1949 as a faculty member of Texas A. and M. University where Ralph Holman had come one year earlier. His area of research was also in the field of lipid biochemistry.

In the 1950s the research emphasis of the Institute shifted markedly towards lipid research. The annual reports of that period show the following trends in research publications: The 1953-55 report lists 10 papers in lipids and 8 in other fields, 1957-58 there were 11 on lipids and 5 in other fields, and in 1960-61 there were 29 in lipids and 1 in another field. Thus the Institute became known mainly for its lipid research.

Dr. Lundberg served as Executive Director from 1949 to 1974, at which time he had reached the mandatory age for retirement. During this period he published many papers on the chemistry and metabolism of fatty acids and other lipids, with special emphasis in the area of the oxidation of fatty acids[5]. He served as President of the American Oil Chemists Society in 1963-64, President of the International Society for Fat Research in 1968-70, and was President of the World Congress of those two societies which was held in 1970. In 1957 he received the Norman Medal of the German Society of Fat Science, the Bailey Award of the American Oil Chemists Society in 1967, the Marques de Acapulco Medal of the Spanish Institute for Fat Research in 1970, the Chevreul Medal of the French Association of Specialists in Fats and Oils in 1970, and the Award in Lipid Chemistry of the American Oil Chemists Society in 1975.

Dr. Holman became the Executive Director in 1975 and served in this position until 1985. His specialty in the area of lipid biochemistry has been in the study of the chemistry and metabolism of the essential fatty acids/polyunsaturated fatty acids[6]. One of his publications in this area eventually became a Citation Classic[7]. He has also brought his hobby of growing orchids into the laboratory by studying their taxonomy with the analysis of the odors and fragrances of orchid species collected from the all over the world[8].

Ralph has been a Professor of Biochemistry in the Minneapolis Department since he joined the Institute in 1951; during this time he was the advisor of two students for the Ph.D. degree and three students for the M.S. degree. He has also been a Professor of Biochemistry at the Mayo Medical School since 1977.

Ralph was President of the American Oil Chemists Society in 1974-75, and he has received the Borden Award of the American Institute of Nutrition in 1966, the Bailey Award of the American Society of Oil Chemists in 1972, their Lipid Chemistry

Award in 1978, and the Fachini Prize of the Italian Oil Chemists Society in 1974. He has served as Editor of Progress in the Chemistry of Fats and Other Lipids since 1951. In 1980 he was elected to the National Academy of Sciences, the second faculty member of this program to have received this honor at the time of being a member of the faculty. (Edward Kendall of the Mayo Clinic was the first).

References

1. Minn. Alumni Weekly, Oct. 1938, p. 110

2 ``Annual Report, Hormel Institute, 1944-45" Univ. Minn. Press

3. Halvorson, H.O. and Lundberg, W.O. ``Hormel Institute Continues to Grow" Chem. Eng. News 26 1526 (1948)

4. e.g., Lundberg, W.O. and Halvorson, H.O. ``Solubilities and Other Properties of Several Antioxidants in Plant Fats" Proc. Inst. Food Tech. 1945 115; Ulrich, J.A. and Halvorson, H.O. ``Changes in Foods During Storage in Frozen Conditions" Hormel Institute Annual Report 48 48 (1947); *ibid.* ``Chemical and Microbial Studies on Sliced Canadian Bacon" Adv. Food Res. 3 291 (1951)

5. e.g., Hanson, H.T., Barnes, R.H., Lundberg, W.O., and Burr, G.O. ``The Deposition of Antioxidants in the Abdominal Fat Depots" J. Biol. Chem. 156 673 (1944); Lundberg, W.O. ``Lipids of Biological Importance. Peroxidation Products and Inclusion Compounds in Lipids" Am. J. Clin. Nutr. 6 601 (1958); Lundberg, W.O. ``Some Recent Developments in Fat Nutrition" Chem. Ind. 1965 572; Lundberg, W.O. ``Chemical, Biochemical, and Nutritional Aspects of Soybean Oil" Fette, Seifen, Anstrichem. 74 557 (1972)

6. e.g. Holman, R.T. ``Essential Fatty Acid Requirement" Intern. Dairy Federation Ann. Bull. 1962 Pt. 2, p. 87; Holman, R.T., Hayes, H.W., and Christie, W.W. ``Mass Spectra of Cyclopentenyl Fatty Acids and Their Derivatives" Arch. Mass Spectra Data 2 4 (1971); Holman, R.T. ``Deficiency of Essential Fatty Acids in Humans" Essential Fatty Acids, Miles Symp. (4th) 1975 (Publ. 1976) Hawkins, W.W., ed., Med. Dept., Miles Lab. Ltd., Rexdale Ont., p. 45-58; Holman, R.T. and Johnson, S.B. ``The Effects of Disease and Nutrition upon Metabolism of Polyunsaturated Fatty Acids" in ``Fats for the Future" Brooker, S.G., Renwick, A., Hannan, S.F., and Eyres, L., eds. Duromark Publ., Auckland, N.Z. (1983) pp. 206-212; Holman, R.T. ``Essential Fatty Acids and Nutritional Disorders" in ``Lipids in Modern Nutrition" Horisberger, M. and Bracco, U., eds., Nestle Nutrition, Vevey Switzerland, and Raven Press, New York (1987) pp. 157-171

7. Holman, R.T. ``The Ratio of Trienoic:Tetraenoic Acids in Tissue Lipids As A Measure of Essential Fatty Acid Requirement" J. Nutrition 70 405 (1960), Reprinted as a Citation Classic, Current Contents, 12 18 (1981)

8. e.g., Holman, R.T. and Heimermann, W.H. ``Identification of Components of Orchid Fragrances by Gas Chromatography and Mass Spectrometry" Am. Orchid Soc. Bull. 42 678 (1973)

Appendix F - Academic Achievement at Minnesota 1935-1945

Several times I have referred to the period prior to and including World War II as a time when it seemed to me that the University of Minnesota had reached world-class status in many areas. I am referring especially to the extremely competent faculty in these areas and the various accomplishments that resulted therefrom. I was especially aware of the achievements of those programs encompassing the physical and biomedical sciences, particularly those in the Institute of Technology and the Medical School. To show that this is not just the biased and nostalgic recollections of an old professor, I would like to present a list of such achievements that were forthcoming from these two units during the period of 1935-1945. This list may have important omissions, for it represents only my knowledge of the period. This knowledge has been obtained through association with several of the individuals who were involved with or knew about the work, through direct involvement in a few instances, and through recent library research to confirm my memory. They are listed chronologically as nearly as possible, so it does not in any way indicate the order of importance. I have included three items from Physics and Astronomy, and this unit actually did not become a part of the Institute of Technology until after World War II.

Medical School

1. During this period the Pathology Department was headed by Elexious T. Bell, an internationally recognized pathologist. Among other things he made a long series of contributions dealing with diseases of the kidney, especially glomerulonephritis and diabetic and hypertensive renal pathology[1], and he published an extensive monograph on that subject[2]. His ``Textbook of Pathology" went through 8 editions, 1931-1956, and it was used throughout the world[3]. He was also recognized as an outstanding teacher.

2. The Bacteriology Department had several members who were widely recognized for their outstanding research. Winford Larson, Head of the Department, was the first to develop an active anti-pneumococcus serum made from rabbits[4]. Arthur Henrici, sometimes known as the ``American Bacteriologist" of his era, carried out research in several areas, including dental bacteria and the role of bacteria in dental caries, morphological variation of bacteria, and immunological aspects of mycotic infections[5]. His monograph ``Molds, Yeasts, and Actinomycetes" was a classic of its time[6]. Robert Green had a general interest in animal diseases. It is said that he saved the national silver fox industry, first by his discovery and control of fox encephalitis, then by ultimately developing a vaccine effective against canine distemper in foxes, and finally by his discovery of a vitamin deficiency that had caused widespread death of foxes[7].

3. Leo Rigler became the first Head of the new Department of Radiology in 1927. In the next 30 years he would establish one of the best Departments in the country, and it would become a leading academic training grounds for leaders-to-be in radiology. His own work ``encompassed all facets of radiologic diagnosis, but his most significant

contributions concerned the viscera of the two large body cavities, the abdomen and the thorax. In both these areas he made important observations....[8]." He was the author of several books and more than 250 journal articles on radiology. He thus became known as "the father of modern-day radiologic diagnosis[8]."

4. In 1930 Irvin McQuarrie became Head of the Department of Pediatrics when Frederick Schlutz left to go to Chicago. (McQuarrie said he came here because there was a "galaxy of renowned scholars" and a "saturated solution of talent" in the University[9].) He published many papers on his studies of various unusual childhood diseases[10]. He also edited the 8-volume Brennemann-McQuarrie treatise on "The Practice of Pediatrics," and he was one of the founders of the journal "Pediatrics." During his tenure there arose the expression of the "McQuarrie tradition" which reflected on the number of his students who became full-time teachers, scientific investigators, or professors[11].

5. By 1935 Owen Wangensteen, Head of the Surgery Department, was well-known for innovative ideas in the field of surgery. In 1931 he had demonstrated the usefulness of a suction device in the management of surgery patients, a technique that immediately began to save many lives. In 1937 his monograph on the subject, "The Therapeutic Problem in Bowel Obstruction - A Physiologic and Clinical Consideration," was very popular, for it went through three editions[12]. In 1935-45 he pioneered in the use of radical surgery for patients with cancer of the gastro-intestinal tract. This approach, accompanied by better surgical procedures, led to a very significant reduction in operative mortality rate and an increase in the five-year survival rate for such patients[13].

6. Cecil Watson and Samuel Schwartz in the Department of Medicine, made major advances in our knowledge of the biochemistry of the porphyrins which then made it possible to understand and treat diseases of porphyrin metabolism[14,15].

7. In 1935 Wallace Armstrong in Physiological Chemistry began to study the fluoride content of teeth and his work with Peter Brekhus of the School of Dentistry published in 1937 showed a correlation of dental caries with low fluoride content. In 1943 with Dr. Knutson of the U.S. Public Health Service he showed that topical application of fluoride solutions on the teeth of school children reduced the incidence of dental caries[16]. These studies, along with those of others, led to the large-scale testing of fluoridation of public water supplies.

8. In the 1930s Edward Kendall, a Physiological Chemist of the Mayo Clinic and the University of Minnesota Graduate School, began research that in the next ten years led to the identification and properties of several adrenal steroid hormones. This work eventually resulted in the clinical application of these steroids, especially cortisone[17].

9. In 1937 Wesley Spink joined the faculty in the Department of Medicine. He immediately became involved in studying brucellosis when he was asked to treat patients who were dying from drinking milk from infected cows. He eventually became an international expert in the understanding and treatment of brucellosis. Also in 1938 he introduced the use of sulfa drugs in Minnesota and eventually published a monograph on their use. In 1942 he introduced the use of penicillin to treat staphyloccucus infections, and the death rate from these kinds of infections in the University Hospital dropped from 80% to 35%[18].

10. In 1938 the Department of Anatomy had four of its faculty as starred scientists in American Men of Science, Richard Scam-

mon, Hal Downey, Howard Rasmussen, and Edward Boyden. This placed it first in the country in this respect[19]. Prof. Downey edited a four-volume Handbook of Haematology which was published in 1938. He became known as the ``father of hematology'' in this country not only because of this handbook but also because of his research and the number of students that he trained[20].

11. In 1940-41 Harland Wood of Iowa State University collaborated with Alfred Nier in the Physics Department and Allen Hemingway in Physiological Chemistry in the use of heavy carbon to confirm the mechanism of the Wood-Werkman reaction for the fixation of carbon dioxide in bacteria. In 1943 Wood and in 1944 Merton Utter of Iowa State University moved to Minnesota in the Physiology Department. In 1944 Wood and Utter showed that carbon dioxide labeled with heavy carbon was incorporated into pyruvate in pigeon liver, one of the early demonstrations that carbon dioxide is actively taken up in such tissues[21]. In 1945 Wood, along with Nathan Lifson, and Victor Lorber of the Physiology Department, using substrates labeled with heavy carbon, showed that the carbon atom of carbon dioxide was incorporated into glucose only at the number 3 or 4 position of glucose. This work resulted in the confirmation of the Krebs citric acid cycle[22].

12. In 1940 J. Charnley McKinley, Head of the Department of Medicine, and Starke Hathaway in Clinical Psychology developed the Minnesota Multiphasic Personality Inventory (MMPI) which is still being widely used for psychiatric screening purposes[23].

13. In 1941 the well-known K-rations for combat troops in World War II was developed in Ancel Keys' laboratory. In 1944-45 the Keys' laboratory conducted a major study of human starvation. Using conscientious objectors as subjects, they kept 36 men on a semi-starvation diet for 24 weeks, following the physiological and psychological changes in great detail. This was followed with a 12-week period in which recovery was studied. A two-volume publication of the results in 1950 still remains as one of the most complete scientific studies of human starvation[24].

14. Maurice Visscher, Head of the Department of Physiology, carried out research in cardiac energy metabolism which was to serve as a basis for the techniques that were developed later for open-heart surgery[25]. Not only his early studies but also the training of surgery residents in Physiology were both important. For many years surgery residents were expected to spend at least a year in the Physiology Department to enhance their training in basic science[26].

In 1940-43 Visscher and his laboratory group carried out a major research program studying intestinal absorbtion with the use of newly-available radioactive and heavy isotopes. In some of these experiments as many as three tracer isotopes were used at the same time, the first time such work was carried out. The quantitative measurement of one-way fluxes for solutes in biological systems was demonstrated for the first time[27].

15. In 1941-42 in George Burr's laboratory in Physiological Chemistry a method was invented for converting vegetable oils into more unsaturated oils with quick drying properties. These oils could be used for various kinds of paints and varnishes used in place of natural tung oil, no longer available in this country during the war[28]. Also in 1942 the Hormel Institute was founded as a unit of the Graduate School, and the two individuals who were Directors between 1944 and 1984, had received training in George Burr's laboratory. Subsequently it would become one of the leading lipid research laboratories in the world. (See Appendix E).

16. In 1943 Karl Sollner, Charles Carr, and Harry Gregor invented ``permselective membranes,'' thin films that have at the same time relative low resistance and nearly perfect selectivity for cations vs. anions and vice versa. The term ``permselective'' was coined by Karl Sollner, a new concept in the field of artificial membranes[29]. In 1950 the University of Minnesota received the first patent for these kind of membranes, and this work opened up a new field in membrane technology that led to the development of membranes for the electrodialytic desalination of salt water, specific membrane electrodes, and artificial kidney membranes.

Institute of Technology

1. In 1935-45 Willem Luyten in the Astronomy Department identified the majority of ``white dwarf'' stars that were known up to that time. He also discovered the first ``double white dwarf'' star[30].

2. In 1936 the University of Minnesota established in its Department of Aeronautical Engineering a specific professorship for the study of problems relating to the stratosphere, the first university in the country to establish such a position. Dr. Jean F. Piccard, world renowned balloonist and researcher of the stratosphere, was appointed to this position, and under his and Professor John Akermann's leadership, regular lectures and research work by undergraduate and graduate students was started at this time. One of the goals of this research was the development of equipment for investigations at altitudes of approximately 10 miles. Three different balloon flights were made in the late 1930s, an unmanned flight of 13 miles in 1936, a manned flight of 2 miles in an open gondola in 1937, and an unmanned flight of more than 10 miles in 1939[31].

3. In the 1930s the production of artificial radioactive isotopes became possible. Thus in 1936 at the University of Minnesota, a committee of biomedical and physical scientists under the chairmanship of Prof. John Tate, Head of the Physics Department, received a grant from the Rockefeller Foundation for funds to construct a Van de Graaff generator with a capacity of three million electron volts. The generator was constructed behind the Physics building under the direction of a young Assistant Professor of Physics, John Williams[32]. (Prof. Williams later would have a major role in the construction of the atom bomb at Los Alamos in 1943-45[32,33]). The Van de Graaff generator was completed in early 1940, and shortly thereafter several radioactive isotopes became available to the research community of the University*.

4. Lee Irvin Smith of the Chemistry Department is credited as the investigator who proved the stucture of Vitamin E. Also he and his laboratory group published the total synthesis of Vitamin E in 1938, just a week or so later than Paul Karrer's group in Switzerland[34].

5. In 1938 under the leadership of Lorenz Straub, a laboratory for the study of hydraulic engineering was constructed near St. Anthony Falls. Its collection of small rivers, harbors, dams, and spillways made it one of the most complete of its kind in the world for the study on a scientific basis of nearly all phases of hydraulic engineering[35].

6. In 1939 I. M. Kolthoff of the Chemistry Department along with his colleague, James Lingane, introduced the technique of polarography to the scientists of this country. Although polarography had been invented

*In 1940-41, I was working for Dr. Visscher's intestinal absorbtion project. After a small dish of fused NaOH was bombarded, I would bring the "hot" dish back to Millard Hall and prepare solutions containing the radioactive sodium which would be used for the experiments.

16 years earlier and work had been done with it in other countries, it was new to the United States. Kolthoff and his students continued to exploit the new technique, and many offshoots of this type of electrochemical analysis soon became widely used in laboratories throughout the country. One of the early offshoots was the publication of an analytical technique by Kolthoff and Pan in 1939 for which they coined the term ``amperometric titrations[36,37].''

7. In the late 1930s Alfred Nier of the Physics Department made improvements in the mass spectrometer, and in 1940 he discovered that U-235 was the fissionable isotope of uranium. He had been requested to make the measurements by Enrico Fermi, for Nier's spectrometer was the only instrument in the world at that time which was capable of making this discovery[38]. To call it the outstanding scientific event of the year would hardly be an exaggeration.

Prof. Nier also set up a thermal diffusion column in the Physics Building for the production of heavy isotopes. Using methane, he produced heavy carbon, carbon-13, which was used by several investigators in the biomedical sciences. This included the previously cited work of Harland Wood[21,22] and some ground-breaking work of George Burr and his students in which plants were grown in an atmosphere of CO_2 enriched with carbon-13[39]. Thus a new technique became available to study photosynthesis and translocation in plants.

8. It was during the 1930s that Edward W. Davis of the Mines Experiment Station (a part of the Institute of Technology) developed a process for extracting high grade iron ore from taconite. By 1941 it was considered ready for commercial use, and tax relief was asked from the legislature. In 1955 the first large plant for processing taconite was opened to be followed by several more in the ensuing years[40].

9. In 1943-45 the laboratory of I. M. Kolthoff made several contributions to the development of the synthetic rubber program, such as new analytical methods, the elucidation of the mechanism of mercaptan disappearance, and better understanding of the oxygen effect on polymerization. This work also laid the foundation for the development of the ``cold rubber'' recipe which was carried out in Kolthoff's laboratory in 1945-47. This recipe led to a considerable improvement in synthetic rubber[37,41].

References

1. Myers, J.A. ``Tommy Bell'' Journal Lancet 84 237 (1964)

2. Bell, E.T. Renal Diseases'' Lea & Febiger, Philadelphia, 1946; *ibid.* ``Experimental Diabetes Mellitus'' C.C. Thomas, Springfield, Ill., 1948

3. Bell, E.T. ``Textbook of Pathology'' Lea & Febiger, Philadelphia, 1931

4. Bell, E.T. ``Winford Potter Larson'' Minn. Med. 30 496 (1947)

5. Larson, W.P. ``Arthur Trautwein Henrici'' Science 98 77 (1943); Myers' history, p. 608, 609

6. Henrici, A. ``Molds, Yeasts, and Actinomycetes'' John Wiley & Sons, New York, 1931

7. Anon., ``Robert K. Green'' Minn. Med. 30 1092 (1947); Myers' history, p. 610

8. Wangensteen, O.H. ``Tribute to a Wonderful Colleague, Teacher, and Humanist'' Minn. Med. 63 791 (1980); Wilson's history, p. 298-300

9. McQuarrie, I. ``Autobiographical Sketch'' Persp. Biol. Med. 6 61 (1962)

10. e.g., Hansen, A. and McQuarrie, I. ``Study of Certain Tissue Lipids in Generalized Lipodistrophy ('Lipohistiodiaresis')'' Proc. Soc. Exptl. Biol. Med. 44 611 (1940); McQuarrie, I., Johnson, R.M., and Ziegler, M.R. ``Plasma Electrolyte Disturbance in A Patient with Hypercortical Adrenal Syndrome Contrasted with that Found in Addison's Disease'' Endocrin. 21 762 (1937)

11. Myers, J.A. ``Irvine McQuarrie, Clinician, Investigator, Educator, and Beneficent Friend of Humanity" J. Lancet 81 552 (1961); Hansen, A.E. ``Irvine McQuarrie, 1891-1961" J. Peds. 62 448 (1963); Wilson's history, p. 346, 347

12. Wangensteen, O.H. ``The Therapeutic Problem in Bowel Obstruction - A Physiological and Clinical Consideration" C. C. Thomas, Springfield, Ill., 1937

13. Wilson's history, p. 307-315, 463,464; State, D., Moore, G. and Wangensteen, O.H. ``Carcinoma of the Stomach: A Ten Year Survey (1936 to 1945 Inclusive) of Early and Late Results of Surgical Treatment at the University of Minnesota Hospitals" J. Am. Med. Assoc. 135 262 (1947); Anon. ``The Chief, Owen H. Wangensteen" Univ. of Minn. Med. Bull. Spring 1978, p. 3

14. e.g., Watson, C.J. and Schwartz, S. ``Formation of Stercobilin from Mesobilirubinogen in Human Feces" Proc. Soc. Exptl. Biol. Med. 49 647 (1942); *ibid.* ``Nature of Urobilin Obtained after Amalgam Reduction of Human Fistula Bile" 636; Watson, C.F. and Larson, E.A. ``The Urinary Coproporphyrins in Health and Disease" Physiol. Revs. 27 478 (1947)

15. Moore, M. ``Science and Patient Care, Cecil James Watson" Health Science Magazine, Winter 1985, p. 10; Wilson's history, p. 326, 327

16. Ref. Nos. 36-38, Chap. III

17. Ref. No. 12, Chap. II

18. Wilson's history, p. 329, 476; Spink, W.W. ``Sulfanilamide and Related Compounds in General Practice" Year Book Publishers, Chicago, 1st ed. 1941, 2nd ed. 1943; Ref. No. 12, Chap. VII, p. 519; Spink, W.W. ``The Drama of Sulfanilamide, Penicillin, and Other Antibiotics, 1936-1972" Minn. Med. 56 551 (1973)

19. Zabel, H.E. ``Minnesota's Contribution to American Men of Science" A Paper Presented at the Annual General Meeting of the Minnesota Academy of Science, April 22, 1939, Univ. Minn. Arch.

20. Downey, H. ``Handbook of Haematology" P.B. Hoeber, Inc., New York, 1938; Wells, L.J. and McKinlay, C.A., ``Hal Downey, Ph.D., 1877-1959" Journal Lancet 80 445 (1960); Michels, N.A. ``Hal Downey, Pioneer Hematologist" Science 130 778 (1959)

21. Ref. No. 46, Chap. III

22. Ref. No. 47, Chap. III

23. Hathaway, S.R. and McKinley, J.C. ``A Multiphasic Personality Schedule (Minnesota): I. Construction of the Schedule" J. Psychol. 10 249 (1940); *ibid* ``II. A Differential Study of Hypochrondiasis" 255; *ibid.* ``Manual for the Minnesota Multiphasic Personality Inventory" (Revised) Psychology Corp., New York, 1943; Myers' history, p. 347; Anon. ``MMPI Is Updated by U of M Professor" Minn. Med. Bull., Fall 1984, p. 9

24. Ref. No. 51, Chap. III

25. e.g., Visscher, M.B. ``Physiological Principles of Importance in Heart Failure and Its Treatment" J. Lancet 57 309 (1937); *ibid.* ``The Restriction of Coronary Flow As A General Factor in Heart Failure" J. Am. Med. Assoc. 113 987 (1939); *ibid.* ``Heart Failure, Parts I and II" Modern Concepts of Cardiovascular Diseases, Vol. 14, Nos. 8 and 9, 1945; Wilson's history, p. 393,394

26. Moore, M. ``National Leadership, Maurice Visscher" Health Science Magazine, Winter, 1985, p. 9; See Ref. No. 37, Chap. II, p. 1; Wilson's history, p. 395; Brown, D.M. ``The Basic Medical Sciences" Univ. Minn. Med. Bull. Winter 1987, p. 16

27. Ref. No. 10, Chap. IV

28. Ref. No. 42, Chap. III

29. Ref. No. 48, Chap. III

30. Luyten, W. ``The White Dwarfs" Science 101 79 (1945); Luyten, W. ``Autobiography" Published privately

31. Akerman, J.D., Letter to the Editor, J. Aeronaut. Sci. 5 320 (1938); Akerman, J.D. and Piccard, J.F. ``Upper Air Study by Means of Balloons and Radiometeorgraph" *ibid.* 4 322 (1937); Gray's history, p. 332

32. Nier, A.O. ``John Harry Williams" Proc. Natl. Acad. Sci., Biograph. Memoirs 42 339 (1971)

33. Gray's history, p. 418; Brochure of the Brady

Science Museum of Los Alamos on the building of the Atomic Bomb.

34. Smith, L.I. and Ungnade, H.E. ``The Chemistry of Vitamin E. IV. The Synthesis of Tocopherols" J. Org. Chem. 4 311 (1938); Emerson, O.H. and Smith, L.I. The Chemistry of Vitamin E. XXIV. The Structure of Gamma Tocopherol" J. Am. Chem. Soc. 62 1869 (1940); Smith, L.I. and Miller, H.C. ``The Chemistry of Vitamin E. XXVIII. ``A New Synthesis of 6-Hydroxychromans, Including Alpha Tocopherol" J. Am. Chem. Soc. 64 440 (1942); Anon. ``Salute to Inspiring Prof" Chem. Eng. News 36 (Nov.) 90 (1958); Anon. ``Minnesota Award" *ibid.* 36 (47) 90 (1958)

35. Anon. ``St. Anthony Falls Hydraulic Laboratory, Minneapolis" Engineering 147 609 (1939); Grays history, p. 333; Minn. Alumni Weekly, Nov. 1938, p. 192

36. Kolthoff, I.M. and Lingane, J. ``The Fundamental Principles and Applications of Electrolysis with the Dropping Mercury Electrode and Heyvroski's Polarographic Method of Analysis" Chem. Revs. 24 1 (1939); Kolthoff, I.M. and Pan, Y. ``Amperometric Titrations. I." J. Am. Chem. Soc. 61 3402 (1939); Shepherd, P.T. ``An Interview with I.M. Kolthoff" Trends in Anal. Chem. 1 1 (1981)

37. Laitenen, H.L. and Meehan, E.J. ``Happy Birthday I.M. Kolthoff, The Scientific Achievements of Izaak Maurits Kolthoff Are Hailed on the Occasion of His 90th Birthday" Anal. Chem. 56 248A (1984)

38. Nier, A.O., Booth, E.T., Dunning, J.R., and Grosse, A.V. ``Nuclear Fission of Uranium Isotopes" Phys. Revs. 57 546 (1940); Nier, A.O. ``Some Reminiscences of Isotopes, Geochronology, and Mass Spectrometry" Ann. Rev. Earth and Planetary Sci. 9 1 (1981); Morrison D. ``A Measure of History" Univ. Minn. Alumni Magazine, March-April 1989, p. 22

39. Ref. No. 3, Chap. III, p. 49; ref. No. 1, Chap. III, p. 537

40. Davis, E.W. ``Iron Ore Beneficiation" Univ. Minn., Inst. Tech., p. 52, Oct., 1949; Kunde, M.A. ``The Agglomerization of Taconite Concentrate" Mine Mag. 42 (May) 39 (1952), Minn. Alumni Weekly, Feb. 1941; Blegen, T.C. "Minnesota, A History of the State" Univ. Minn. Press, 1963, p. 381, 382

41. Letter from E.R. Gilliland, Office of Rubber Reserve, to I.M. Kolthoff, Sept. 1944; Dunbrook, R.F. ``Contributions of Organic Chemistry to the War Effort - Synthetic Rubber - I" India Rubber World 117 202 (1947); *ibid.* ``II" 355; *ibid.* ``III" 486; *ibid.* ``IV" 617

Appendix G - The Interface of Biology and Medicine Symposia

In the year 1974-75 the Department began to sponsor an annual series of symposia under the general title of ``The Interface of Biology and Medicine.'' The primary motivation arose from a ``correlation of forces'' which resulted in the fact that we would be without three of our top graduate faculty members during 1974-75. Wallace Armstrong was to retire, Finn Wold was to leave to go to the St. Paul Department, and Frank Ungar was to be on sabbatical during the year. It was felt that some kind of special program of well-known speakers from outside would serve as an extra stimulus for the ``excitement of research'' in the Department.

During the last week of June we had our last staff meeting with Wallace as Department Head. When other business was finished, the subject of special lectures was brought up. After 15-20 minutes of fruitless discussion, Wallace suggested that I appoint a small committee to look after it. Thus in early July, I asked Mary Dempsey, Don Wetlaufer, and Jim Bodley to be in charge of the program of guest lecturers for 1974-75. It was then agreed that Mary would take charge of the regular weekly seminar series for the whole year, Don would represent us in planning with the St. Paul Department for a special series in which they were interested, and Jim would look into a special event for us during the year. We felt that we could plan something special that was quite extensive because we thought that we would be able to use the salary money of our ``missing Professors'' to sponsor visitors.

It was at this point, entirely through the great efforts of Jim Bodley, that the planning for a special event really got off the ground. In mid-July he contacted Philip Leder with whom he was acquainted, who was becoming quite well-known in the field of molecular biology, who was on leave from the National Institutes of Health, and in addition had taken his residency training in the Department of Medicine at the University of Minneota. Jim proposed to Dr. Leder that he organize a symposium in the area of biochemical genetics and that he also come to the University sometime before the symposium to give a series of lectures in the subject area of the symposium. The purpose of the introductory lectures would be to provide the students and staff with the biochemical and medical background which would form the basis for the symposium. Dr. Leder agreed to this general idea, and it also sounded good to the Department. We then contacted the Dean's office and were assured that we could use unexpended professors' salaries for this purpose. Dr. Leder was then given the go-ahead to make specific plans within the frame-work of the general proposal.

Jim Bodley was in charge of the local arrangements, and he proposed that the title of the symposium would be ``The Interface Between Molecular Biology and Medicine - Prospectives in the Study of Gene Organization and Control.'' Ms. Barbara Howard, Department Administrator, looked after the arrangements of financial matters, visitor housing, and special dinners.

The Symposium was to be held April 9-11, 1975. Dr. Leder came to the Campus as a Visiting Professor at the end of March and for a week and a half gave a series of introductory lectures for the students and staff. These lectures were excellent for the purpose at hand and were very well attended. The classroom that was available held 200 persons, and each day it was filled to standing room only.

For the symposium, Dr. Leder had assembled key leaders in the scientific and

clinical communities who were making active contributions to the study of gene organization and control. When the symposium began on Wednesday, April 9, the main floor of the Mayo Auditorium was nearly filled, ca. 400 persons! The symposium maintained a high quality throughout, and when it was over there were many very favorable comments. Most of the participants wrote later that it was a very enjoyable experience for them, and within the University the remarks of many people were strongly enthusiastic, suggesting that this type of symposium might be repeated.

Because the first symposium was such a success, and because we still had plenty of unexpended instructional funds in 1975-76, we planned for another one. Leon Singer agreed to be the local organizer, and he contacted Dr. Sidney Fleischer at Vanderbilt University to see if he would organize a symposium in the area of biological membranes. Dr. Fleischer agreed to the proposal to be a Visiting Professor and to organize a symposium with the same format as for the first one. The title of the symposium would be ``The Interface of Biology and Medicine - The Molecular Biology of Membranes."

Dr. Fleischer came to the Campus in early May and gave eight introductory lectures that were again very well attended. We were able to get a larger room than for the first time, and it proved to be needed. For the symposium, which was May 19-21, 1976, Dr. Fleischer had once more assembled an all-star cast, and the sessions were attended by large numbers of students, staff, and outside visitors. Afterwards the comments from both the participants and the University staff and students were at least as enthusiastic and complimentary as for the first symposium.

In the spring of 1976 Harry Hogenkamp had accepted the Dean's offer to become Department Head in September 1976, and he attended the Membrane Symposium in May. He was enthusiastic about it and agreed that we should continue with it. In 1976-77 we would still have some unexpended instructional funds to use for this purpose.

For the third symposium, Frank Ungar agreed to be the local organizer, and it was decided that the topic should be concerned with some aspect of hormone biochemistry. Frank contacted Dr. Bert O'Malley, a leading investigator in the field hormone receptors, and he consented to arrange a symposium for the following spring, again with the same format. The symposium would be entitled ``The Interface between Biology and Medicine - A Symposium on Molecular Action of Hormones." Once more a very successful symposium took place. Dr. O'Malley's introductory lectures were very well received, and he had assembled a first class group of experts for the 2 1/2 day symposium.

For the following year Harry Hogenkamp agreed to be the local organizer, and he tried to get Dr. William Lipscomb to be the symposium organizer. Dr. Lipscomb is a Professor of Chemistry at Harvard University, a Nobel Laueate, and a former Professor of Chemistry at the University of Minnesota. He was not available for the spring of 1978 but said that he would be willing to come in the spring of 1979. At this point it was too late to make any other arrangements, and it was decided not to have a symposium in 1978 but to wait until 1979.

In the spring of 1979 Dr. Lipscomb agreed to our established format and organized a symposium entitled ``The Interface between Biology and Medicine - A Symposium on the Structure-Function Relationships in the Proteins, Nucleic Acids, and Viruses." Dr. Lipscomb came here for two weeks as Visiting Professor and gave seven introductory lectures. He also had arranged for 14 top experts in this field to come here for the 2 1/2 day symposium. Again the overall

quality and the responses of participants and attendees were equal to the previous symposia.

For the next year (1979-80), Ralph Holman, Director of the Hormel Research Institute, wanted to organize a symposium in honor of the 50th anniversary of the discovery of the essential fatty acids. His suggestion that this could be the Interface Symposium for 1980 was readily accepted. Dr. Holman went ahead and organized a symposium that was of quite different format from the previous ones, and considerably more extensive in its coverage. The title of this Interface Symposium was ``The Golden Jubilee International Congress on Essential Fatty Acids and Prostaglandins" and was held May 5-7, 1980. It was to commemorate not only the discovery of the essential fatty acids by George Burr and Mildred Burr at the University of Minnesota but also the discovery of prostaglandins by Ulf S. von Euler at the Karolinska Institute in Stockholm.

This symposium was sponsored jointly by the Hormel Institute, the Department Biochemistry of the Medical School, and the Department of Biochemistry of the College Biological Sciences, and it was supported by contributions from more than twenty organizations. Dr. Holman was President of the Congress, there was a local committee of seven people, three program coordinators, and an international committee of fourteen more individuals. The program itself had three plenary sessions, nine mini-symposia which ran concurrently, and seven poster sessions. The papers from this symposium were then published in a monograph of 910 pages[1]. Needless to say, this was a well-attended, very successful affair.

The following year the Interface Symposium was returned to its original format. To spread the coverage of topics, the sponsorship was widened to include the Department of Anatomy of the Medical School. The title chosen for the symposium being given in 1980-81 was ``Interface of Biology and Medicine - A Symposium: Cellular Interactions." The local organizers were Drs. Ronald Edstrom and Harry Hogenkamp of the Department of Biochemistry and Drs. Robert Sorenson and David Hamilton of the Department of Anatomy. The organizer and chairman of the symposium was Dr. Saul Roseman, Professor of Biology of the McCollum-Pratt Institute at Johns Hopkins University. Dr. Roseman, as Visiting Professor, presented four one and one-half hour introductory lectures on Apr. 30, May 1, 4, and 5, and the symposium was May 6-8. Once more everything went very successfully.

For the next year, 1981-82, it was recognized that the rapidly growing field of biotechnology should be a good topic for a symposium. This topic covers several disciplines, and larger organizing committees were established. Funds for these symposia had been getting more difficult to get, and for this symposium contributions were obtained from several sources.

The Scientific Advisory Committee included Drs. Victor Bloomfield and Stanley Dagley of the Department of Biochemistry of CBS, Harry Hogenkamp of the Department of Biochemistry, Medical School, H. Ted Davis of the Department of Chemical Engineering, Richard Hanson of the Gray Freshwater Institute of the College of Biological Sciences, and Alexander Hollaender from Associated Universities, Inc., Washington, D. C. There was also a local organizing committee of ten individuals. Sponsors and contributors were eight University of Minnesota Departments, the U. S. Department of Energy, the Office of Naval Research, and four local companies.

The organizer of the symposium and Visiting Professor for the introductory lectures was Dr. Allen I. Laskin of Exxon

Research and Engineering Co., Linden, N. J. The symposium began with an opening session on the evening of Tuesday, May 25 and continued through noon of Friday, May 28, including evening sessions on Wednesday and Thursday. There were 28 faculty that took part in these sessions, including four from the University of Minnesota. The papers from this symposium were eventually published in a monograph entitled ``Basic Biology of New Developments in Biotechnology[2]."

This Symposium in 1982 was the last one in the Interface series. The series was discontinued primarily for financial reasons, for the costs for such a symposium had doubled since 1975, and it was becoming more difficult to raise funds for this purpose.

References

1. Ref. No. 11, Chap. III

2. Hollaender, A. Laskin, A.I., and Rogers, P., eds., ``Basic Biology of New Developments in Biotechnology" Vol. 25 in Basic Life Sciences, Plenum Press, New York, 1983, pp. 575

Appendix H - Colloid Chemistry at the University of Minnesota, 1938-1942

Colloid chemistry is a branch of chemistry that deals with solutions of large molecules and other dispersed particles, both in biological and non-biological systems. In the last part of the nineteenth century and the first half of the twentieth century, the work of colloid chemists had a profound effect on biochemistry. Several concepts that underlie much of our present biochemical knowledge were originally developed by colloid chemists. These concepts include osmotic pressure, micelle formation, membrane structure and function, the weak interaction of small molecules with large molecules (adsorption), the electrophoretic behavior of large, charged, molecules, and some of the basic insights concerning the molecular nature of proteins. When colloid chemists did research on biological systems, they would also be biochemists.

As has already been pointed out in Chapter VII, Ross Gortner joined the faculty of the University in 1913 and soon became distinguished both as a colloid chemist and biochemist[1]. In addition to Gortner, the University slowly began to obtain as faculty members several individuals who already were or would soon become well-known colloid chemists, some of whom would also qualify as biochemists.

Lloyd Reyerson became a member of the faculty in the Chemistry Department in 1920. In 1927-28 he spent a year in the laboratory of Herbert Freundlich, Head of the Division of Colloid Chemistry in the Kaiser Wilhelm Institute of Physical and Electrochemistry in Berlin-Dahlem, Germany. Reyerson had already carried out some research on catalysis and continued to do work in this area when he returned to Minnesota, dealing especially with the adsorption of small molecules on a variety of surfaces. This research was largely restricted to inorganic systems; however, in retirement he established a laboratory for the study of biological materials at the New England Institute for Medical Research[2].

Because Minnesota had some experts in colloid research, the Third Annual Colloid Symposium of the American Chemical Society was held in Minneapolis in June, 1925, and Herbert Freundlich was the Invited Foreign Guest. Freundlich stayed on in the summer and presented a six-week course in Colloids. In 1937 the Colloid Symposium was also held in Minneapolis, and Freundlich was again the Invited Foreign Guest, and again stayed to give a six-week course. Thus it is perhaps not surprising that Freundlich was asked to join the faculty here in 1938 when it was apparent that he would not have a permanent position in England[3].

Herbert Freundlich was known as the ``father of colloid chemistry" because of his pioneering work in elucidating many of the fundamental principles underlying the science. Most of his early work was with non-biological systems; however, he was always interested in biological systems and for many years promoted the idea that elucidation of the problems of colloid chemistry would lead to the understanding of biological systems[4].

In 1927 I.M. Kolthoff came from the Netherlands to be Chief of the Division of Analytical Chemistry. He began a major research program on co-precipitation and the formation of precipitates. This subject deals considerably with colloid chemistry, and by 1940 he had published 40 papers on this subject[5].

In 1934 Lawrence Moyer came here on a post-doctoral fellowship to work in Ross

Gortner's laboratory. He was a very promising young investigator whose primary interest was electrophoresis. He had already shown in 1933 that microorganisms could be classified on the basis of their electrophoretic mobility. In 1936 he was appointed Assistant Professor in the Botany Department on the Minneapolis campus[6]. He continued to carry out excellent research on electrophoresis, and in 1942 he was a co-author of what was to be the major monograph on this subject for many years[7].

In 1936 David Briggs, who had previously obtained the Ph.D. degree with Gortner in 1926, came back here as Professor in the Department of Agricultural Biochemistry. His research was primarily concerned with electrokinetics and the technique of electrophoresis[8].

In 1938 Wilfred Heller, a refugee from Nazi Germany, joined the Chemistry Department. He was an international authority on colloid optics, which deals with the interaction of electromagnetic radiation with colloidal particles[9].

As has already been detailed in Chapter III, Karl Sollner, a protege of Freundlich's, came to the Department of Physiology in 1939[10]. He was an authority on the problems of membrane structure and function.

By 1938 it was recognized that there was a strong nucleus of highly talented colloid chemists at the University, and a few individuals began to make plans to set up an Institute of Colloid Chemistry[11]. However, this extraordinary group of experts in colloid chemistry did not exist for very long; by 1946 only 3 of the 8 remained at Minnesota. Freundlich died in March 1940 at the age of 61, Gortner died in October 1942 at the age of 57, Moyer was killed in October 1942 in a balloon accident off the east coast of the United States while working as a civilian for the U.S. Army, Heller went to the University of Chicago in 1942 to take part in war-related research and did not return after the war, and Sollner went to the National Institutes of Health in 1946. Thus the idea of a Colloid Research Institute at the University never got off the ground.

References

1. Refs. 1-8, Chap. VII

2. Anon. ``Lloyd Reyerson" Chem. Eng. News 47 74 (1969)

3. Freundlich, H. ``On the Electrokinetic Potential" Third National Symposium on Colloid Chemistry, H.N. Holmes, ed., p. 7; Ref. No. 26, Chap. III

4. e.g., Freundlich, H. ``Die Adsorption und Ihre Bedeutung fur Chemische und Biologische Probleme" Chemisch Weekblad 10 772 (1913); *ibid.* ``Some Mechanical Properties of Sols and Gels and Their Relation to Protoplasmic Structures" in ``The Structure of Protoplasm" W. Seifriz, ed., (1942) p. 85-98

5. e.g., Kolthoff, I.M. ``Adsorption on Ionic Lattices" 13th National Symposium on Colloid Chemistry, H.B. Weiser, ed., Williams and Wilkins Co., Baltimore, 1937, p. 87; *ibid.* ``Aging of Crystalline Precipitates" Suomen Kemistilehti 16A 89 (1943)

6. Abramson, H.A., Gorin, M.H., and Moyer, L.S. ``The Polar Groups of Protein and Amino Acid Surfaces in Liquids" Chem Revs. 24 345 (1939); Seifriz, W. ``Lawrence S. Moyer" Science 96 103 (1942); Ref. No. 3, Chap. III, p. 43,47

7. Abramson, H.A., Gorin, M.H., and Moyer, L.S. ``Electrophoresis of Proteins and the Chemistry of the Cell Surfaces" Reinhold Press, New York, 1942

8. e.g., Briggs, D.R. ``The Determination of the Zeta Potential on Cellulose - A Method" J. Phys. Chem. 32 641 (1928); *ibid.* ``Streaming Potential Measurements" Cold Spring Harbor Symposium on Quantitative Biology" 1 14 (1933); Hankinson, C.L. and Briggs, D.R. ``Electrokinetics. XXV. The Electroviscous Effect 2. In Systems of Calcium and Sodium Caseinate" J. Phys. Chem. 45 943 (1941)

9. e.g., Heller, W. and Quimfe, G. ``Effect of Particle Size in Colloidal Solutions on Their Optical Anisotropy" Compt. Rend. 205 971 (1937); Heller, W., Quimfe, G., and Ta, Y. ``The Magnetic and Optical Anisotropy of Selected Microscopic Crystals and the Linear Magneto-Optical Anisotropy of Their Suspensions" Phys. Rev. 62 479 (1942)

10. Ref. Nos. 27, 28, Chap. III

11. Reyerson, L.H. Copy of an outline of the basis for forming a Colloid Institute at the University of Minnesota, unpublished, files of the Dept. of Biochemistry; Correspondence between likely members of the proposed Institute, Univ. of Minn. Arch.

Appendix I - How I Joined the Program

It was a rather unusual and unplanned set of circumstances that led to my association with the Program and my becoming a biochemist of sorts. In late September 1934, at the age of 17, I came to the University of Minnesota to begin study with a major in chemistry. (I had been encouraged to pursue this subject by my high school chemistry teacher). Rather than go for a B.A. degree with a chemistry major, I chose the chemistry curriculum in the newly organized Institute of Technology. This was a very intensive course in chemistry with very few courses outside of the physical sciences. In 1938 I finished with a B. Chem. degree, but at that time such training was not much in demand. Of the 20 or so who finished with this degree, the top 5 students obtained teaching assistantships at various Big Ten universities, and the rest of us went back to working at what we had been doing before starting the University. For me it was back to the farm for the summer of 1938.

In the fall of 1938 with nothing else to do, I came back to the University and started working towards a Master's degree in chemistry. I had heard that it took one year to complete a Master's degree, and in the spring of 1939 I completed the degree with I. M. Kolthoff as advisor and a major in Analytical Chemistry. In the spring and summer of 1939 I had interviews with Goodrich Rubber Company and Linde Air Products but was unsuccessful in landing a job. In November 1939 I heard of an opening for an analytical chemist in the Physiology Department, and I applied for it and got it. I was hired by the Head of the Department, Prof. Visscher, and my immediate supervisor was Dr. Karl Sollner. My work consisted of doing analyses for several research projects of the Department concerned with intestinal absorb-

partment, Prof. Visscher, and my immediate supervisor was Dr. Karl Sollner. My work consisted of doing analyses for several research projects of the Department concerned with intestinal absorbtion and to carry out experiments for Dr. Sollner in his membrane research.

I got along well with Dr. Sollner, and in the spring of 1940 he persuaded me to get a Ph.D. with a major in Colloid Chemistry and a minor in Physiological Chemistry. That summer I took Physiological Chemistry 100, 101, today's 5100, 5101, the first and only formal course in the biological sciences that I have ever taken. Thus I became a biochemist mostly by on-the-job training.

By June 1943 I finished the work for my degree. At this time we were in the middle of World War II, and it was necessary for me to use my training for war-related research. Thus in July 1943 I went back to the Chemistry Department and Dr. Kolthoff's lab to work on synthetic rubber research. I continued with this work until March 1946 when I returned to Millard Hall for some temporary post-doctoral work with Dr. Sollner (on thermoosmosis).

The war was now over, I had been married since the previous June, and our first child was about to be born. It was necessary to consider more permanent employment. After doing full-time research for three years on the Rubber Project, I decided I would prefer academic type of work, with time for both teaching and research. For me to get some teaching experience, Dr. Sollner talked with Wallace Armstrong, and it was arranged that I could work as an extra teaching assistant in the spring quarter lab course which was under the supervision of Dr. Ralph Holman. In May I was told by Dr. Armstrong that Ralph was taking a year's leave of absence to do research in Sweden, and he asked me if I would like to take Ralph's place for the coming academic year, 1946-47. Because Dr. Sollner was leaving to go to NIH in September, I accepted the temporary position immediately, not knowing exactly what I was getting into. (Earlier I had applied for a post-doctoral fellowship to work in the Department of Soils Chemistry at Cornell University, but I was informed in April that I would not be getting it).

In the winter quarter of 1947, Dr. Armstrong told me that Ralph was going to stay in Sweden for another year, and he asked me to stay on with the lab teaching. I liked what I was doing, so I quickly agreed. In that next year it turned out that Ralph accepted a position at Texas A. and M. in 1948-49. Dr. Armstrong again asked me to continue with the lab teaching, and again I accepted, this time for a tenure-track position. I had never applied for the position, had never been interviewed, and had never been given a written offer for the position. Things are quite different today!

Charles W. Carr