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HISTORY OF THE LABORATORY OF CHEMISTRY

from its inception, as the

DIVISION OF CHEMISTRY, HYGIENIC LABORATORY,

U. S. PUBLIC HEALTH AND MARINE-HOSPITAL SERVICE,

June 20, 1905,

through the administration of

DR. CLAUDE S. HUDSON, 1950

Written by

Dr. Elias Elvove

April, 1953

BRIEF HISTORY OF THE LABORATORY

OF CHEMISTRY, NIAMD

Introduction

What is now known as the Laboratory of Chemistry of one of the Institutes of the National Institutes of Health, namely, the National Institute of Arthritis and Metabolic Diseases, was known originally as the Division of Chemistry of the Hygienic Laboratory, U.S. Public Health and Marine-Hospital Service. The original Division of Chemistry was organized June 20, 1905. Its first Chief was Joseph Hoeing Kastle. In the following brief historical outline, the subject will be divided corresponding approximately to the periods of time served by each Chief.

JOSEPH HOEING KASTLE

(1905 - 1909)

As the organizer and first Chief of the Division of Chemistry, Joseph Hoeing Kastle brought to the Division of Chemistry a chemical research spirit traceable directly to that great American pioneering chemist, Ira Remsen of the Johns Hopkins University, where Kastle was awarded the degree of Doctor of Philosophy in 1886. Judging from the high caliber of the men who were selected for Chiefs of the various Divisions of the old Hygienic Laboratory, it appears that it was the policy of the U.S. Public Health Service to try to obtain the services of the very ablest men in their respective fields. Thus we find that the Chief of the Division of Pathology and Bacteriology was Milton J. Rosenau, who later became Professor of Preventive Medicine and Hygiene at the Harvard Medical School and the first Director of the Harvard School of Public Health; and the Chief of the Division of Pharmacology was Reid Hunt, who later became Professor of Pharmacology at the Harvard Medical School. When it came to appointing the Chief of the Division of Chemistry, Kastle was selected. Kastle had already made a great reputation as one of the leading American chemists of his time; and in addition, Kastle demonstrated a high ability as a teacher of chemistry, his students becoming so enthusiastic about chemistry that many of them chose chemistry as a career. He tried to persuade his chemistry students to pursue "pure" research chemistry and not aim primarily to use

PROFESSOR JOSEPH HOEING KASTLE
FIRST CHIEF, DIVISION OF CHEMISTRY
HYGIENIC LABORATORY, 1905 - 1909

chemistry as a means for obtaining the "filthy lucre." Organizing the first Department of Chemistry at the University of Kentucky, he succeeded in turning out a comparatively high percentage of chemistry students who became leaders in their fields and devoted to research in chemistry; as for example, Arthur S. Loevenhart, who became Professor of Pharmacology and Toxicology at the University of Wisconsin and Chief of the Pharmacology Research Section of the Chemical Warfare Service during World War I; and J. C. W. Frazer, who became Professor of Chemistry at the Johns Hopkins University.

The personnel of the Division of Chemistry as of May 1, 1909, and its work during the previous four years, was reported as follows:

"The Chief of the Division,	Dr. Joseph H. Kastle
Student Officer,	Passed Assistant Surgeon Norman Roberts
Technical Assistant,	Elias Elvove
General Assistant,	F. A. McDermott
Attendant,	F. G. Wilsselblad

"The work of the Division of Chemistry for a period of approximately four years, from July 1, 1905 to May 1, 1909:

1. Organization.
2. Analytical Work: 1055 analyses of water, milk, drugs and miscellaneous substances.
3. Expert Opinions: 23 expert opinions on chemical subjects.
4. Laboratory Instruction and Demonstrations for the Officers of the U.S. Public Health and Marine-Hospital Service: Methods of Analysis of Water, Milk and Gastric Contents.
5. Investigations: 24 subjects investigated.
6. Publications: 17 separate publications as bulletins, articles in chemical journals, etc."

"Opinions and Reports Rendered on Subjects Pertaining to the Public Health.

"1. Fallacies of the Knott theory of yellow fever.
2. On the dietetic value of 'Blossom', a commercial fat preparation, as a substitute for cod-liver oil.
3. On the advisability of cooperation on the part of the U.S. Public Health and Marine-Hospital Service with the Council of the American Medical Association in the matter of giving publicity to the composition of patent and proprietary medicines and drugs.
4. Suggestions to the Director of the Hygienic Laboratory relative to matters to be brought to the attention of the Advisory Board of the Hygienic Laboratory.
5. Sawdust as a factor in stream pollution.
6. On the dietetic value of 'Antiphthisis'.
7. Tests and methods for the determination of formaldehyde.

8. On the efficiency of the 'Thermalite' bag.
9. Outline of the Proceedings of the 7th Annual Convention of the State Food and Dairy Departments, especially as regards the discussion on milk.
10. On the utility of paraffined-paper milk containers.
11. On the effect of vegetable acids on the digestion of the higher carbohydrates.
12. On the right to the use of the label 'Karo (trade mark) Corn Syrup with Cane Flavor', by the Corn Products Refining Co. of New York.
13. Variations in the amount of carbon dioxide in the atmosphere under different meteorological conditions and the possible significance of such variations in the causation of disease.
14. Methods for the determination of carbon dioxide in the atmosphere.
15. Suggestions as to the subjects to be treated in the Annual Report of the Director of the Hygienic Laboratory.
16. On small ice-machines and the methods of storage of vaccine virus, etc.
17. Excretion of drugs in the milk.
18. Effect and determination of moisture in the atmosphere.
19. Pasteurization of milk.
20. Effect of smoke in the atmosphere."

On March 23, 1909, Dr. Kastle was appointed to the Professorship of Chemistry in the University of Virginia to succeed Dr. John W. Mallet, this appointment to take effect September 15, 1909. As already indicated in the above, it appears to have been the policy of the Service to obtain as the head of the Division of Chemistry a professor of chemistry who had already established a high reputation at an American university. It took about two years to find a suitable candidate for this position. In the meantime, the organization of the Division of Chemistry as left by Dr. Kastle continued to function and to handle the public health problems which presented themselves.

For references to publications, see list at end under "Publications"

EDWARD CURTIS FRANKLIN

(1911-1913)

On June 17, 1911, Edward Curtis Franklin took the oath of office as Professor of Chemistry at the Hygienic Laboratory. Like Dr. Kastle Dr. Franklin was awarded his Doctor of Philosophy degree by the Johns Hopkins University. He was Professor of Chemistry at Stanford University before coming to the Hygienic Laboratory. Dr. Franklin had already made a great reputation with his pioneering researches on the ammonia system of acids, bases and salts. It appears that as an inducement to him to accept this position, he was permitted to continue his researches on the

PROFESSOR EDWARD CURTIS FRANKLIN
CHIEF, DIVISION OF CHEMISTRY
HYGIENIC LABORATORY, 1911 - 1913

ammonia system of compounds, letting the other members of the Division of Chemistry continue with the work bearing directly on public health problems. He served two years and then returned to his former position as Professor of Chemistry at Stanford University.

In Dr. Franklin's annual report for the fiscal year 1912-1913, the personnel of the Division of Chemistry, in addition to the Chief of the Division, is listed as follows:

"One scientific assistant;
One attendant whose duties were those of general helper;
One attendant whose duties were to keep the laboratory clean and wash glassware."

This report states that "the work of the Division naturally falls into the following four groups: (I) Analytical Work; (II) Research Work; (III) Consultation and Special Investigations; (IV) Public Lectures."

Under the heading "Analytical Work," this report lists:
"1. Drug Analysis.- Fifty-two samples of drugs were examined as to their purity and freedom from adulteration. These drugs were representative samples of those which were purchased for use in the U.S. Marine-Hospitals. This work represents one branch of the routine analytical work carried out in the Division of Chemistry. When the Division first undertook this work, a very large percentage of the drugs examined had to be rejected, on account of the impurities which were found in them. Some of the drugs were even found to contain harmful and dangerous ingredients, e.g., comparatively large amounts of arsenic. While we cannot say definitely that these impurities in the drugs were due to intentional adulteration or simply to carelessness on the part of the manufacturers, the fact nevertheless remains that ever since the first rejections, the quality of the drugs supplied to the U.S. Marine-Hospitals has been continually improving. Nearly all of the drugs examined this year were found to be of a very high grade of purity, and the very few which did not comply with all the requirements of the U.S. Pharmacopoeia were rejected rather because they lacked in the quantitative requirements than on account of qualitative deficiency.

"2. Milk Analysis.- In connection with the experimental work on infant feeding which has been in progress at the Hygienic Laboratory, the Division of Chemistry has done the analytical work required. This work has been a daily routine and has required the daily attention of one of the men in the Division. In this connection, the Division has carried out two hundred and sixty-five determinations of the fat in milk.

"3. Water Analysis.- The Division of Chemistry has also done work on water analysis during this year. Samples of water, which were sent for examination by various health officers and others interested in the sanitary condition of the waters in question, were analyzed in the Division and reported to the Director. Altogether twelve samples of water have

been analyzed during the year. On ten of these, the complete sanitary analysis was carried out; on the remaining two, complete percentage analyses of the mineral constituents were made.

"4. Preparation and Analysis of the Carbolic Acid Standard for Disinfectants.- The Division prepared and analyzed, from time to time, the carbolic acid standard for disinfectants. In this connection, samples of phenol, which were intended to be used in the preparation of this standard were examined as to their purity and freedom from the cresols.

"5. Preparation of Analytical Reagents and Standard Solutions for the Division of Pathology and Bacteriology.- The Division of Chemistry was called upon to prepare a number of analytical reagents and standard solutions for use in the Division of Pathology and Bacteriology. Chief among these were Griess' sulphanilic acid and alpha-naphthylamine reagents which are used in testing for the presence of nitrites, and standard solutions of potassium hydroxide which were required in the preparation of various media.

"6. Miscellaneous Analyses and Preparations.- During this year, the Division was called upon to examine vaccine points, human milk, and 'Mammala'. The Division also prepared several grams of pure tryptophane."

Under the heading "Consultation and Special Investigations," this report states:

"1. An investigation was carried out on the radio-activity of the waters of Hot Springs, Arkansas. In connection with this special investigation, several special pieces of apparatus had to be constructed in the Division. After considerable work of preparation had been carried out in the Division, the Chief of the Division made a special trip to Hot Springs, and there established a temporary laboratory. The Chief of the Division remained at Hot Springs about a month. All of this time was required for the experimental part of the investigation. Considerable additional time was required then in summarizing and studying the experimental results obtained and in preparing the Report.

"2. In connection with certain questions affecting the public health, which primarily came under the jurisdiction of the Pure Food Officers of the Department of Agriculture, the Chief of the Division was occasionally consulted and gave the required assistance. In such connection, the Chief of the Division made two special trips to New York, during the year, for the purpose of aiding the Pure Food Officers in keeping out of the country certain adulterated teas. A very strong fight was made in the courts by the importers and expert testimony by chemists of high reputation was required in order to convince the courts that the contentions of the importers were wrong. This testimony was given by the Chief of the Division before the proper courts in New York.

"3. Assistance was rendered to the U.S. Civil Service Commission in answering questions relating to chemistry and in the examining and grading of certain papers.

"4. Assistance was rendered in the International movement which has for its ultimate object the establishment of uniform figures for the physical constants in chemistry. A considerable number of papers were abstracted and the abstracts forwarded to those in charge of the work.

"5. In compliance with a request made by the War Department that a Report be furnished as to the food value of the infant food known as "Mammala," as compared with condensed milk, the Division made the required investigation.

Under the heading "Public Lectures," this report states:

"The public lectures given by the Chief of the Division during this year have been received with the highest enthusiasm and appreciation. The demand for lectures was much greater than what was found possible to grant. As evidence of the fact that these lectures were highly appreciated, we may mention the fact that all the organizations under whose auspices the lectures were held, were willing to pay all the expenses involved, so that the Service did not have to spend anything on this account. Thirteen public lectures were given during this year as follows:

"1. Lecture before the Lehigh Valley Section of the American Chemical Society, South Bethlehem, Pa.

"2. Lecture before the Philadelphia Section of the American Chemical Society, Philadelphia, Pa.

"3. Lecture before the Chemical Department, Lafayette College, Easton, Pa.

"4. Lecture before the Baltimore Section of the American Chemical Society, Baltimore, Maryland.

"5. Lecture before the New York Section of the American Chemical Society, New York City, N. Y.

"6. Lecture before the New England Section of the Society of Chemical Industry, Boston, Massachusetts.

"7. Lecture before the Chemical Department of Clark University, Worcester, Massachusetts.

"8. Lecture before the Washington Academy of Science, Washington, D. C.

"9. Lecture before the Bureau of Standards, Washington, D. C.

"10. Lecture before the Chemical Department of Columbia University, New York City, N. Y.

"11. Lecture before the Chemical Society of Virginia, Richmond, Va.

"12. Lecture before the Chemical Department, Sheffield Scientific School, Yale University, New Haven, Connecticut.

"13. Lecture before the American Philosophical Society, Philadelphia, Pa.

For references to publications, see list at end under "Publications."

EARLE BERNARD PHELPS

(1913-1918)

Earle Bernard Phelps succeeded Dr. E. C. Franklin as Professor of Chemistry at the Hygienic Laboratory in 1913, making his first monthly report for September under date of October 3, 1913. Professor Phelps had been previously at the Massachusetts Institute of Technology. He carried out pioneering researches on sanitation and sewage purification. Under Professor Phelps' administration, the size of the resident personnel of the Division of Chemistry at the Hygienic Laboratory remained about the same as before but there was a comparatively large expansion of field work for which additional personnel was obtained. Professor Phelps organized what was at first known as the Water and Sewage Laboratory located chiefly at Cincinnati, Ohio, with substations at such locations as Pittsburgh, Pa., Portsmouth, Ohio, and Louisville, Ky.

An idea of the nature of the work carried out during Professor Phelps' administration might be obtained from the following titles of publications:

"The chemical measures of stream pollution and specifications for sewage effluents."

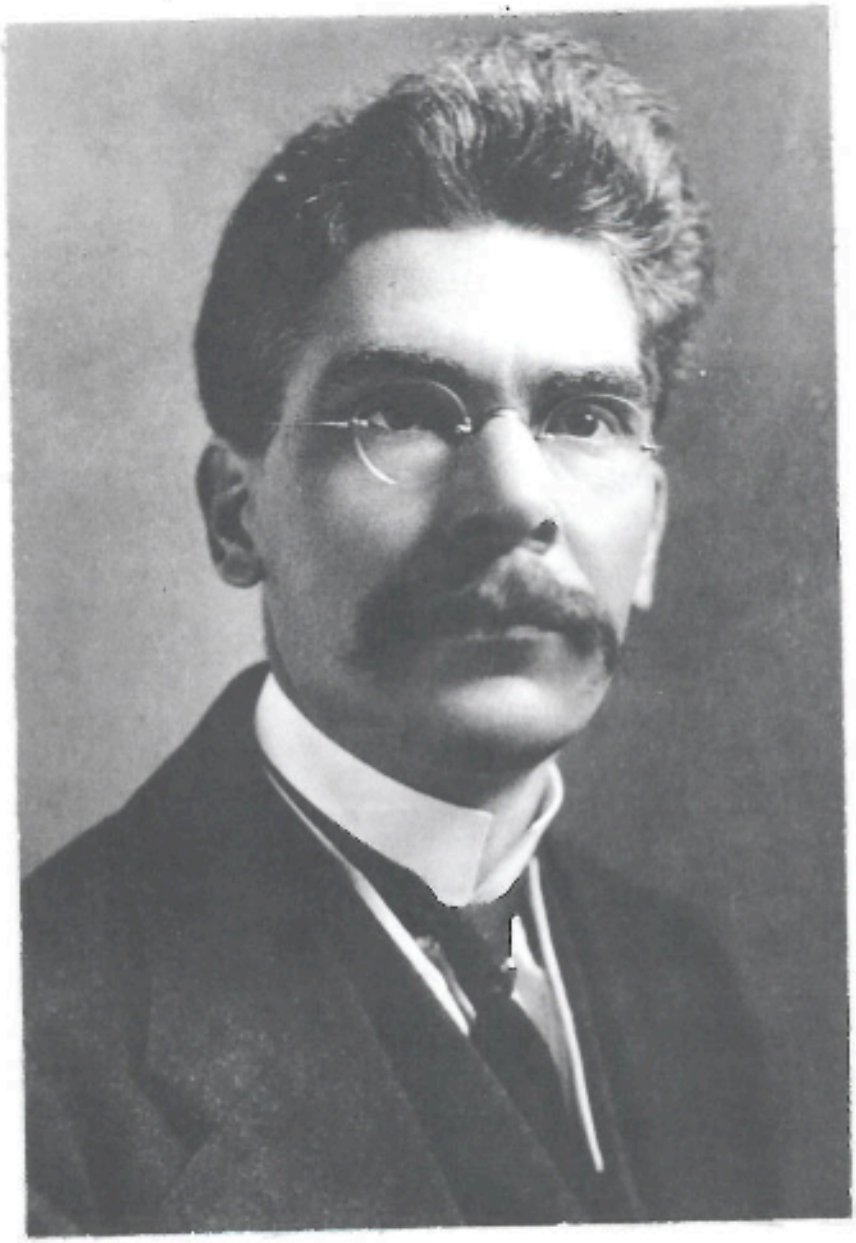
"A comparison of methods for the determination of oxygen in waters in presence of nitrite."

"Detection of white phosphorus in matches."

"Experimental studies with muscicides and other fly-destroying agencies."

"A colorimetric method for the estimation of the cresol or phenol preservative in serums."

"Chemical studies of the pollution of the Ohio River."



PROFESSOR EARLE BERNARD PHELPS
CHIEF, DIVISION OF CHEMISTRY
HYGIENIC LABORATORY, 1913 - 1918

DR. ELIAS ELVOVE

ACTING CHIEF, DIVISION OF CHEMISTRY

HYGIENIC LABORATORY, 1919 - 1920

"The chemical composition of rubber used in nursing nipples and in some rubber toys."

"Chemical disinfection of water."

"Studies on the self-purification of streams."

"Results of the first year's experiments with small sewage treatment plants in the United States Public Health Service."

"Experimental studies of strawboard waste purification."

"Note on a new apparatus for use with the Winkler method for dissolved oxygen in water."

"Detection and estimation of small amounts of methyl alcohol."

"A method for the colorimetric estimation of small amounts of aniline."

"A colorimetric method for the estimation of the cresol or phenol preservative in serums."

"The detection and estimation of small amounts of certain organic nitro compounds, with special reference to the examination of the urine of TNT workers."

"An efficient liquid disinfectant."

Professor Phelps resigned his position as Professor of Chemistry at the Hygienic Laboratory about the early part of 1919. During the interval between Professor Phelps' resignation and the appointment of Dr. W. Mansfield Clark, about the latter part of 1920, Dr. Elias Elvove was in charge. The work of the Division of Chemistry continued, during this interval, along the same general lines as before.

For references to the publications, see list at end under "Publications."

WILLIAM MANSFIELD CLARK

(1920-1927)

William Mansfield Clark became Professor of Chemistry at the Hygienic Laboratory about the latter part of 1920. Like the first (Kastle) and second (Franklin) holders of this position, Dr. Clark was awarded the degree of Doctor of Philosophy by the Johns Hopkins University. He held the position of research chemist in the Dairy Division of the U.S. Department of Agriculture prior to his appointment as Professor of Chemistry at the Hygienic Laboratory. He had already established his reputation as a

PROFESSOR WILLIAM MANSFIELD CLARK
CHIEF, DIVISION OF CHEMISTRY
HYGIENIC LABORATORY, 1920 - 1927

pioneer in the field of studies on methods for determining hydrogen ion concentration. On his coming to the Hygienic Laboratory, he started his pioneering and classical studies on oxidation-reduction, publishing the first ten papers of the series as Hygienic Laboratory Bulletin No. 151, entitled "Studies on Oxidation-Reduction, I-X." In this Bulletin it is stated:

"The investigations reported in these papers were the contributions of the cooperating members of the staff of the Division of Chemistry, Hygienic Laboratory. While the authorship of the several papers credits those who were the more intensely engaged in each of the several subjects, substantial aid was given by Mr. Hall, Doctor Elvove, Doctor Merrill, and Mr. Remsburg, whose names do not appear on the title-pages. In addition to the experimental aid given by these members of the staff, Miss Lansdale has been invaluable in her careful preparation of tables and manuscript."

The scientific staff of the Division of Chemistry, about the time of the publication of Hygienic Laboratory Bulletin No. 151, was listed as follows: Harry D. Gibbs, Elias Elvove, Barnett Cohen, Charles G. Remsburg, Alice T. Merrill, Wallace L. Hall, and M. X. Sullivan.

Dr. Elias Elvove was in charge of the analytical work, in which he was assisted by Mr. Charles G. Remsburg. The analytical work included the chemical examination of the arsphenamines, biologicals, etc. for the Biologics Control Laboratory; the analysis of waters, foodstuffs, and various substances submitted by other branches of the Service; and research work on methods of analysis.

Professor Clark as Chief of the Division of Chemistry was not only the commanding general leading the oxidation-reduction workers, but when the occasion required could, and did, function like a first class soldier even outside his immediate responsibilities. An occurrence, which may illustrate this, happened during the investigation of the health hazard from tetraethyl lead gasoline (Public Health Bulletin No. 163):

"Early in 1923 lead tetraethyl began to be used in an endeavor to increase the efficiency of the gasoline as a motor fuel. The possible danger from such wide distribution of a lead compound aroused fear on the part of those concerned with the public health, and these fears were intensified when fatal poisoning occurred in the manufacture and mixing of the concentrated tetraethyl lead itself in Deepwater, N. J., Dayton, Ohio, and Bayway, N. J. As a consequence of such apprehensions, the distribution of tetraethyl lead was stopped on May 5, 1925, and the sale of gasoline containing tetraethyl lead was thereby general discontinued.

"On May 20, 1925, a conference called by the Surgeon General of the Public Health Service met to consider the possible health hazards from the manufacture, distribution, and use of this lead compound as a substance to be added to gasoline. The proceedings of this conference have been published as Public Health Bulletin No. 158. Those in atten-

dance generally recognized that the production and handling of the concentrated tetraethyl lead involved a distinct industrial hazard, and attention was principally focused on the question which remained open, as to the dangers to the public, automobile drivers, and garage workers, from the general use of lead-containing gasoline."

Since the distribution of tetraethyl lead was stopped and the sale of gasoline containing tetraethyl lead was generally discontinued, it was important to proceed with the investigation as rapidly as possible. The Division of Chemistry had to make the chemical analyses of many samples of feces, particularly for lead, and it was necessary to have an electric furnace with means for properly controlling the temperature. Such an electric furnace was not available at that time. Professor Clark donned overalls and proceeded to build a large electric furnace, starting with the bricks and the necessary wire, and making also the thermocouple for measuring the temperature. This necessary apparatus supplied promptly as a result of Professor Clark's skill, labor, and helpfulness, made possible the completion of this investigation without delay.

There were many other instances when Professor Clark made, for members of the chemistry staff, complicated pieces of apparatus, mostly involving highly skilled glass blowing. When one became familiar with this great scientist, as he was working in the laboratory, a feeling of admiration soon developed not only for his great ability as a chemist but also for combining with this, skill as a glass blower and machinist. Feeling the need of mechanical tools for the construction of apparatus for the research work, Professor Clark set aside a room, in the Division of Chemistry, for use as a machine shop, supplying it with a lathe and other mechanical tools. His skill with the machine tools combined with his skill in glass blowing enabled him to make almost any desired piece of apparatus; and when he constructed a piece of apparatus for a member of the chemistry staff, it was always with the utmost friendliness and kindness.

CLAUDE SILBERT HUDSON

(1928-1950)

Claude Silbert Hudson had the distinction of serving as Professor of Chemistry at this Laboratory longer than any of his predecessors, having remained in this position for over 22 years. Professor W. Mansfield Clark, who served the next highest number of years, held this position for only about 7 years. Dr. Hudson also succeeded in drawing a sharper line between what might be termed practical chemical problems in public health and fundamental researches in a field of chemistry important to public health and also to chemistry in general. He made his great reputation by concentrating on fundamental researches in the field of sugar chemistry; and he freed himself from the interference and loss of

PROFESSOR CLAUDE SILBERT HUDSON
CHIEF, DIVISION OF CHEMISTRY
HYGIENIC LABORATORY, 1928 - 1950

time which would result from the handling of the so-called practical problems in public health by delegating authority and responsibility to Dr. Elias Elvove to continue that type of work as before.

As of January 1929, the scientific staff of the Division of Chemistry, exclusive of Dr. Hudson but including two chemists who held Fellowships, numbered 12. They were listed as follows: V. Birckner, W. D. Chase, E. Elvove, H. D. Gibbs, W. C. Hess, E. L. Jackson, A. T. Merrill, E. M. Montgomery, C. G. Remsburg, M. X. Sullivan, C. B. Purves, and E. Pacsu. About July 1936, the number of scientific workers, in addition to Dr. Hudson, increased to 14. They were listed as follows: M. Adams, E. Elvove, R. M. Hann, W. T. Haskins, E. L. Jackson, A. E. Knauf, W. D. Maclay, F. J. McClure, A. T. Merrill, E. M. Montgomery, C. B. Purves, C. G. Remsburg, H. K. Richtmyer and E. B. Tilden. As might be expected, there were some changes in the personnel during the subsequent years of Dr. Hudson's administration but the numbers as indicated above may give an idea of the approximate size of the scientific staff during Dr. Hudson's years as Chief of the Division of Chemistry; and names of scientific personnel not included in the above may be found in the list of publications given at the end.

Division of Chemistry - A Service to Other Laboratories

The Division of Chemistry had been in operation for about 23 years when Dr. Hudson was appointed as its Chief. Since his tenure of that office was about 22 years, the beginning of his administration would represent about the midpoint of the time period of 1905-1950. It might be well, therefore, at this point to make a brief survey of that period as a whole.

It may be recalled that in 1905 American chemistry might have been characterized as still in its infancy. Even what we now know as "Chemical Abstracts," and which is presently recognized as the "Key to the World's Chemical Literature" did not exist at that time. The Public Health Service was then known as the "Public Health and Marine-Hospital Service," with considerable emphasis on its marine hospital function. It appears that excepting possibly one chemist who was employed in the recently organized Division of Pharmacology of the Hygienic Laboratory, this entire Service did not have a chemist to whom public health problems involving chemistry could be referred. When, therefore, the Division of Chemistry was established at the Hygienic Laboratory, every public health problem in the solution of which a chemist could help, was referred also to the Division of Chemistry. Among these public health problems was the problem of typhoid fever. Typhoid fever was still taking many American lives every year.

A scientific team was organized consisting of an expert in the field of chemistry (Kastle), an expert in the field of bacteriology (Rosenau) and an expert in the field of epidemiology (Lumsden). They worked hard and published their results in Hygienic Laboratory Bulletins Nos. 35 and 44, entitled "Report on the origin and prevalence of typhoid

fever in the District of Columbia." There was published also Hygienic Laboratory Bulletin No. 41, entitled "Milk and its relation to the public health." In a comparatively short time thereafter, it became generally recognized that a large factor in the causation of typhoid fever can be eliminated by supplying the public with drinking water and milk of good quality.

Recognizing the importance to public health of drinking water of good quality, pure milk and proper sanitation, attention was concentrated on problems in these fields during Professor Phelps' administration of the Division of Chemistry. Problems relating to the chlorination of water supplies, self-purification of streams, methods of measuring stream pollution, methods for the sanitary disposal of sewage, and milk pasteurization were studied extensively. These studies resulted in the establishment of what was at first known as the Water and Sewage Laboratory with headquarters at Cincinnati, Ohio, and which since then has expanded still further.

The Service recognized the need for studying problems in industrial hygiene. Dr. Schereschevsky came to the Division of Chemistry where he started his pioneering work which later developed into the organization of the Industrial Hygiene Division; and for a number of years thereafter, much chemical work for the Industrial Hygiene Division was carried out in the Division of Chemistry.

The Division of Chemistry assisted Dr. Joseph Goldberger in connection with his classical studies on pellagra, analyzing the chemicals required in the preparation of salt mixtures for the animal diets and analyzing various foodstuffs. Experimental work was also carried out in connection with the preparation of active concentrates.

During Dr. Hudson's administration, in addition to the fundamental researches on the chemistry of the sugars, cooperative work was continued with the Biologics Control Laboratory, involving the analysis of arsphenamine, neoarsphenamine, sulfarsphenamine, and the devising of analytical methods for new arsenicals; and similar work was done with biologicals. Cooperative work was continued with the Division of Pharmacology on such investigations as the epidemic of so-called ginger paralysis. Some idea of this epidemic and the interest which it aroused at the time of its occurrence, may be obtained from the following quotation from an editorial in the Journal of the American Medical Association (November 29, 1930, pages 1672-1673):

"Within the past year a peculiar form of paralysis has afflicted many persons, particularly throughout some of the Midwestern or Southwestern states. Government experts have asserted confidently that the number of the patients run into the thousands, thus exhibiting what may reasonably be termed epidemic proportions. Evidence has rapidly accumulated indicating that the unique effect is closely associated with the drinking of fluidextract of ginger. The latter has been sold extensively

for many years, since the introduction of the Volstead Act, for beverage purposes, because of a ruling of the Prohibition Bureau to the effect that the official fluidextract of ginger is a nonpotable beverage, thus removing the restriction from its sale. The disease that has come to be designated as "ginger paralysis" could scarcely have been by the familiar U.S.P. fluidextract; otherwise the morbidity would have been much greater and the incidence of the paralysis far more widespread. Many of the victims freely admitted having used fluidextract of ginger for years without effects other than those attributable to its alcohol content; hence the conclusion that an adulterated and poisoned product was being circulated for sale last Winter.

"An investigation was undertaken by the United States Public Health Service as soon as the seriousness of the situation became manifest. Many puzzling features attended the early clinical examinations. The quantity of the ginger fluid consumed was apparently not the determining factor in the seriousness of the symptoms. A single drink is known to have produced essentially the same result as that following prolonged use of the product over a period of some days. Transitory alcoholic intoxication often occurred, as might be expected; but the really untoward symptoms were delayed, usually about ten days. The victims presented bilateral wrist drop and foot drop of varying degrees of severity. The picture became that of a flaccid paralysis for the most part of the distal muscles of the lower and upper extremities, pointing to involvement of the lower motor neurons localized in the lower lumbar and lower cervical regions of the cord. The unsuspected presence of arsenic or lead and other heavy metals in the beverage was soon ruled out by careful chemical examination of samples of the offending product. Phenol compounds were found to be present.

"The familiar phenols, such as carbolic acid, are prompt in their toxic action, in contrast to the delay in the paralysis produced in the ginger victims. Confusion was added by the observation that, whereas rabbits and calves responded to the dangerous fluidextracts somewhat as the human victims did, monkeys seemed to be immune. The effective investigations of Smith, Elvove and their co-workers in the Public Health Service seem to have fixed responsibility for the unusual human disease on tricresyl phosphate, and more specifically on the triorthocresyl isomer."

Other important Public Health Service investigations which aroused great public interest and in which the Division of Chemistry cooperated, related to the dental disease referred to in the early literature as "mottled enamel." In 1931, the results of laboratory experiments with rats indicated probably that human "mottled enamel" is caused by the presence of fluoride in the drinking water. Dr. H. Trendley Dean was assigned to the National Institute of Health to study the mottled enamel problem. It was necessary to develop a sensitive method for determining traces of fluoride in water, accurate to 0.1 part per million, and to prove its accuracy and reliability. While the research work on the chemical method for the accurate determination of small amounts of fluoride was progressing in the Division of Chemistry, Dr. Dean was also developing a method for expressing mottled enamel on a quantitative basis. It thus became possible

finally to determine "the minimal threshold of the dental sign of chronic endemic dental fluorosis (mottled enamel)."

The successful solution of the mottled enamel problem and the determination of the "minimal threshold" of the fluoride concentration of the drinking water served, at least, two purposes: (1) The application of quantitative epidemiological methods supplied direct evidence in humans that the severity of the mottled enamel is proportional to the fluoride concentration of the drinking water, thus supplementing the rat experiments and supplying conclusive evidence of the "mottled enamel"-fluoride relationship. (2) It was demonstrated that there is a fluoride concentration of drinking water which will not cause mottling of the enamel, and this safe concentration was determined as being about one part per million.

Studying the mottled enamel problem broadly and thoroughly, Dr. Dean was able to observe that mottled enamel teeth were less susceptible to decay, or dental caries than normal teeth. When, therefore, it was determined that a fluoride concentration in the drinking water of about one part per million will not cause mottling of the teeth, the possibility of adjusting the fluoride concentration to the optimal for dental health appeared as an important public health measure desirable to attain. In order to ascertain experimentally the degree of dental caries reduction which might be expected when the drinking water has a concentration of fluoride that will not produce mottled enamel, a series of extensive studies were undertaken on the general subject of the relation of the chemical composition of domestic waters to dental caries. Twenty-one American cities were covered in these investigations. The results showed that whereas in Michigan City, Indiana, for example, the public water supply of which contained only 0.1 part per million of fluoride, the dental caries experience per 100 children rated 1037, the corresponding figure for Aurora, Illinois, where the public water supply contained about 1.2 parts per million of fluoride, the corresponding dental caries experience was rated as only 258. These studies, which have been published as a series of papers under the general title of "Domestic Water and Dental Caries," represent the experimental basis for the present practice of water fluoridation to reduce dental caries.

When Dr. Hudson came to the Hygienic Laboratory, he continued the line of sugar research work which he began in connection with his previous work in the Bureau of Chemistry of the U.S. Department of Agriculture and at the National Bureau of Standards. This dealt mostly with the relations between rotatory power and structure in the sugar group. Enzyme studies began at the Bureau of Chemistry, principally on invertase, were continued and extended also to the amylases. A very important new method, which greatly facilitated the studies on the sugars and also made possible a very large extension of fundamental sugar researches, was developed in the Division of Chemistry and published, in 1937, under the title of "A New Method for Determining Ring Structures and Alpha and Beta Configurations of Glycosides." Important researches were carried out also on the biochemical oxidation of sugar alcohols to ketoses; on the synthesis of higher-carbon sugars; on anhydro sugars and anhydro sugar alcohols; and on the acetals of sugar alcohols.

A fruitful series of biochemical studies was started during Dr. W. Mansfield Clark's administration and was continued for some time during Dr. Hudson's administration. It was based on the development, in the Division of Chemistry, of a new distinctive test for cysteine. The results obtained were published in a series of papers under the general title of "Studies on the Biochemistry of Sulfur." Another line of research work carried out in the Division of Chemistry, which started during Dr. Clark's administration and continued to Dr. Hudson's administration, has been published in a series of papers bearing the general title of "Phenol Tests."

Dr. Hudson received many honors in recognition of his leadership in fundamental sugar researches. He was awarded the Nichols medal, the Willard Gibbs medal, the Hillebrand prize, the Richards medal, the Borden medal, and the Cresson medal. He was also awarded a $10,000 prize by the Sugar Research Foundation.

The Division of Sugar Chemistry and Technology of the American Chemical Society held a "Hudson Celebration" at their annual meeting in September 1946, in honor of Dr. Hudson's sixty-fifth birthday which occurred during that year.

Princeton University honored Dr. Hudson by conferring upon him the honorary degree of Doctor of Science, at its Bicentennial Convocation on February 22, 1947. The citation on this occasion was as follows:

"A keen and persistent investigator in the field of organic chemistry, who for forty years has engaged in masterly research into the structure and properties of sugars; to the many honors which his scientific colleagues have bestowed upon him, his Alma Mater now adds her tribute of esteem."

The Federal Security Agency awarded him its first medal for Distinguished Service in 1950. Dr. Hudson retired from his position as Professor of Chemistry on January 31, 1951.

For references to publications, see list at end under "Publications."