VOL. XXXIV, No. 9 JUNE, 1957

The NUCLEUS

OF THE NORTHEASTERN SECTION OF THE AMERICAN CHEMICAL SOCIETY

Photograph by Fay Foto Service, Boston

Miss Carr and Miss Sherrill receiving the James Flack Norris Award from Chairman Atkinson, May 9, 1957.

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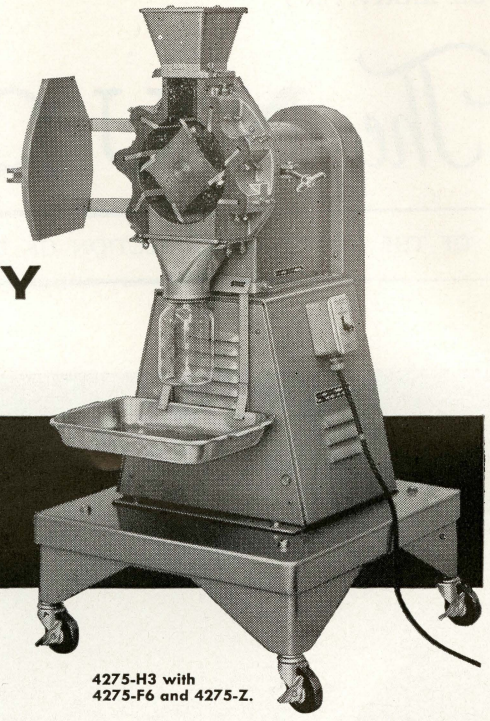

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The other members of the Committee, elected by the Section, are Paul D. Bartlett, and John C. Sheehan. Their terms expire in 1959.

The three members of the Committee, not residing in the Section, are W. Albert Noyes, Jr., ex-officio, as editor of the Journal of the American Chemical Society, Frank R. Mayo of the General Electric Research Laboratory, Schenectady, N. Y., term expires in 1959, and Donald F. Hornig of Brown University, term expires in 1961.

ANNUAL MEETING OF THE DIRECTORS

The annual business meeting of the Directors of the Northeastern Section will be held at 4:00 p.m. on Wednesday, July 17, 1957, in the Moore Room on the third floor, east, of the Eastman Laboratories, M.I.T. Reports of the retiring officers and of committee chairmen will be presented. Dinner will be available at the Graduate House, if it be desired.

By custom, the meeting is open to members of the Northastern Section.

NORRIS AWARD ADDRESSES ON WGBH-FM

The Lowell Institute Broadcasting Council, WGBH-FM, 89.7 megacycles, announces that the addresses made by Miss Carr and Miss Sherrill, when they received the Norris Award will be broadcast on Tuesday, June 25th at 7:15 p.m. It is the thought of the Council that many who could not attend the meeting would appreciate hearing the recordings.

OCTOBER MEETING AT TUFTS

Continuing the very pleasant custom of recent years, the first fall meeting of the Northeastern Section will be held away from Cambridge. On October 10, 1957, Tufts University will be host to the Section on its spacious campus on the Medford Hillside. Dr. Willard F. Libby, of the U. S. Atomic Energy Commission, Washington, D. C., will be the evening speaker.

The NUCLEUS

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Forms close for advertising on the 15th of the month and for text on the 12th of the month preceding issue.

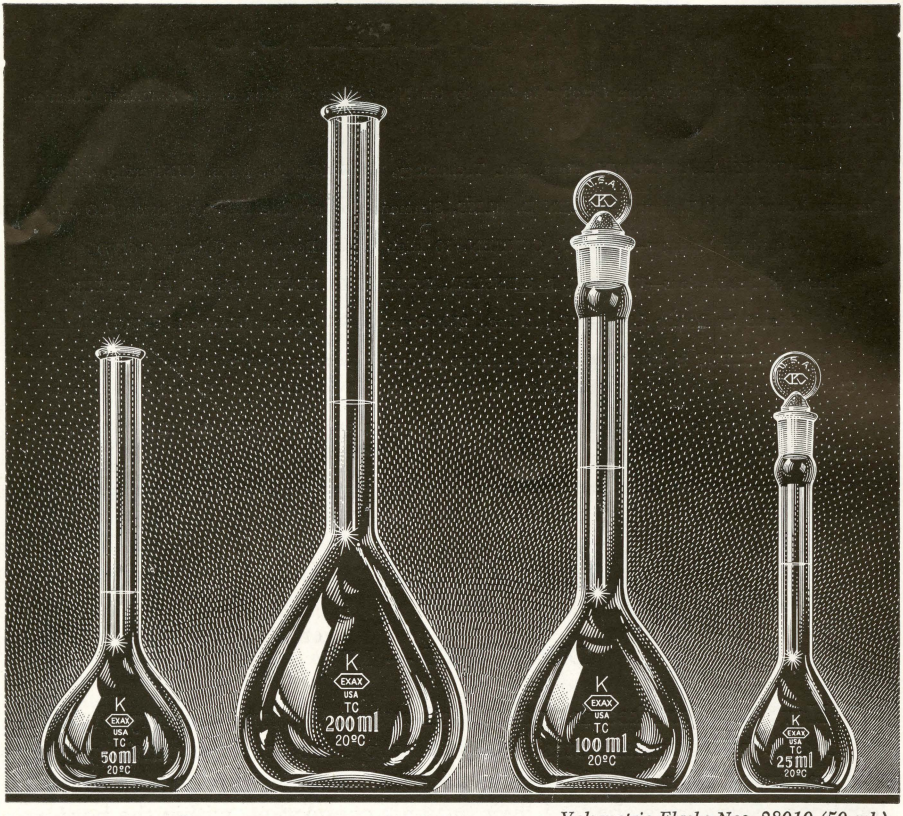
Editorial

DIRECTORY — 1957

Have you been keeping your Northeastern Section Directory of 1953 up to date by marginal notes? If you have done so, even partially, you will be struck by many changes in address. People have moved to new locations. Some have changed their business connections within the borders of the Section. Some have left the New England scene altogether, seeking a livelihood in far off places like Texas or California or in nearer states such as Pennsylvania or Missouri or Minnesota. Then, too, there will be many omissions. In this year alone 118 new members have joined the Section.

Four years ago, if you were a freshman in college, today you are a graduate holding the long-sought baccalaureate. If the graduate school were your status in 1953, then you have completed whatever advanced training you contemplated, most likely the doctorate. The opportunities thus opened to you have led to many a new occupation. Perhaps the academic halls were your choice and you have joined the ranks of the instructor. Perhaps an industrial research laboratory or the problems of plant development were your aim.

Whatever may have been your situation four years ago — student, a member of the newly employed groups, or one of the older, long established citizens, the years have brought changes. The 1957 directory will smooth out the thin and frayed pages of 1953 and bring information up to date. It is coming along just as fast as the address cards, now in your possession, are filled out and sent along through the nearest mail box.



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M. Kent Wilson	Arthur A. Vernon
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Term expires Jan. 1, 1960	**Term expires Jan. 1, 1960**
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LYMAN CHURCHILL NEWELL GRANTS

Stephen S. Winter of Boston University, Chairman of the Lyman Churchill Newell Committee, has announced the awardees for 1957. The recipients will receive $75.00, each, to defray the cost of attending the Summer Conference of the New England Association of Chemistry Teachers to be held at Colby College, Waterville, Maine, August 19-24, 1957.

Samuel Greenwald, Holten High School, Danvers, Mass.

Charles R. Jingozian, Needham High School, Needham, Mass.

Edward Miley, Pepperell High School, Pepperell, Mass.

First Alternate

Sister Ernestine Marie, Msgr. Ryan Memorial High, Dorchester 24, Mass.

ANALYTICAL GROUP

DONALD L. GUERNSEY, Chairman, M.I.T., UN 4-6900, Ext. 3306

FRANK O'HALLORAN, Secretary - Treasurer, Water Laboratory, Commonwealth of Massachusetts, UN 4-6900, Ext. 3306

The Analytical Group held its final meeting of the year on May 15, 1957 in the Massachusetts Institute of Technology.

The newly elected officers are,

President: William H. Stahl, Quartermaster Research and Development Center, Natick, Massachusetts.

Vice-President: David N. Hume, M.I.T

Secretary-Treasurer: Frank O'Halloran, Water Laboratory, Department of Public Health, Commonwealth of Massachusetts.

Executive Committee: Donald L. Guernsey, M.I.T.; George R. Sommer, Howe and French; Harvey M. Cole, Godfrey L. Cabot; Russell T. Werby, Werby Laboratories, Boston.

Auditors: Jack Lowen, Lincoln Laboratories, M.I.T.; Edgar B. Read, Nuclear Metals, Inc., Cambridge.

The first meeting will be held on Wednesday, October 16, 1957 in room 2-131, M.I.T.

ELASTOMER & PLASTICS GROUP

JOHN B. GREGORY, Chairman, Frederick S. Bacon Laboratories, WAtertown 4-5000

MAX TAITEL, Chairman-elect, Union Bay State Chemical Corporation, TRowbridge 6-8076

The first fall meeting of the group will be held at 8:00 p.m. on Tuesday, October 15, 1957 in Science Park Museum at the Charles River Dam Bridge, Boston 14, Massachusetts. The meeting will be preceded by a prepandial hour in the first Exhibition Hall (Optional at $1.00 but reservations necessary). At 7:00 p.m. dinner will be served in the Morse Auditori-

(*Please turn to next Page*)

ELASTOMER & PLASTICS GROUP

(*Continued from previous page*)

um. The details will appear in the October issue of THE NUCLEUS.

The annual meeting, with election of officers, will precede the address of the evening. It is planned to have a speaker from R. T. Vanderbilt Company of South Norwalk, Connecticut, present a summary of recent developments in Rubber Compounding. The address will cover curing systems, antioxidants and antiozonants.

MEETING OF THE DIRECTORS

The May meeting of the Directors of the Northeastern Section of the American Chemical Society was held at 4:30 P.M. on April 30 in the Moore Room at M.I.T., Chairman Edward R. Atkinson presiding. The following members were present: Avery A. Ashdown, Austin W. Fisher, Laurence S. Foster, Thomas R. P. Gibb, Jr., Lawrence J. Heidt, Arno H. A. Heyn, David M. Howell, Lockhart B. Rogers, Martha B. Thomas, Lloyd H. Perry, M. Kent Wilson and Stephen S. Winter. The minutes of the April meeting were accepted as published in the NUCLEUS.

Martha B. Thomas presented the Treasurer's report. During the period March 4 to April 29, 1957, the income was $24.75, with expenses of $303.14. This leaves a balance of $4,640.07.

The report of the Membership Committee was read by Arno H. A. Heyn. An official audit shows the section to have 2193 paid members, 27 emeritus members and 138 unpaid members.

According to Stephen S. Winter, the television program series is proceeding satisfactorily and on schedule.

Stephen S. Winter also reported for the Committee on Chemistry Education. The new Lyman Churchill Newell Award Committee consists of Stephen S. Winter, Chairman, David M. Howell and Laurence S. Foster. The recipients have been chosen and are being notified.

Avery A. Ashdown announced that 2,999 copies of the May issue of THE NUCLEUS were mailed. This is the largest mailing in history.

A report from the Committee on Amendments to the Constitution and By-Laws was given by Thomas R. P. Gibb, Jr. The Committee had been requested to consider rewording By-Law Article VI, Section 1, re the Norris Award. This Section now reads "The James Flack Norris Award shall be made for outstanding achievement in the teaching of chemistry, as distinguished from research, etc.". It has been suggested that "as distinguished from research" be deleted to avoid any possible interpretation minimizing the value of research in teaching. The sentiments of the original Norris Bequest Committee were canvassed. The Committee concluded that (a) the present wording was most carefully considered by the Norris Bequest Committee, (b) it was discussed and approved by the directors and by the membership of the Section, (c) the tradition of an award based solely on teaching ability is now established, (d) the proposed change in the wording is more than an editorial revision, and is, therefore, beyond the authority of the present Committee.

The report was accepted.

Chairman Edward R. Atkinson reported for the Awards Committee. Chemists from the Northeastern Section will be nominated for all principal A.C.S. Awards.

The annual meeting date was set for Wednesday, July 17, 1957, at 4:00 P.M. It will be held in the Moore Room, 6-321, in the Eastman Laboratories, M.I.T.

Under old business, a series of motions was acted upon to transfer funds from the income accounts of the Permanent and Publications Trust Funds to cover the current operating deficit of THE NUCLEUS.

On motions duly made and seconded, it was

VOTED: that a sum of $500.00 be made available from the income account of the Permanent Trust Fund for meeting the operating deficit of THE NUCLEUS for the 1956-1957 season.

VOTED: that the Board of Trustees be authorized to make available the sum of $500.00 from the in-

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MEETING OF THE DIRECTORS

(*Continued from Page* 208)

come account of the Permanent Trust Fund for meeting the operating deficit of THE NUCLEUS for the 1956-1957 season.

VOTED: that a sum of $200.00 be made available from the income account of the Publications Trust Fund for meeting the operating deficit of THE NUCLEUS for the 1956-1957 season.

VOTED: that the Board of Trustees be authorized to make available the sum of $200.00 from the income account of the Publications Trust Fund for meeting the operating deficit of THE NUCLEUS for the 1956-1957 season.

There being no further business, the meeting adjourned at 5:45 P.M.

Respectfully submitted,

RIDGLEY G. SHEPHERD, JR.
Secretary of the Northeastern Section of the American Chemical Society.

NEW DIVISION OF INORGANIC CHEMISTRY HOLDS SUCCESSFUL MEETING AT MIAMI MEETING OF A.C.S.

The new Division of Inorganic Chemistry, in its first program at a National Meeting of the American Chemical Society, gave every indication that it will grow vigorously in the years ahead. Among the high spots of its program at Miami were addresses by Dr. Glenn T. Seaborg, Nobel Prize Laureate, on the "Actinide Elements", by Dr. R. S. Nyholm of University College, London, on "The Renaissance of Inorganic Chemistry and its Future Development", and by Dr. Wilhelm Klemm, of the University of Munster, on "Oxo- and Fluorocomplexes of the Transition Elements with Special Reference to Unusual Oxidation States". Dr. Klemm's address was delivered at the divisional dinner and followed talks by Dr. Roger Williams, President of the American Chemical Society, and Dr. John C. Bailar, Jr., Chairman of the Division.

Dr. Seaborg described the investigation which led to the identification of Mendelevium on a sample containing only a few atoms of the element. He also described plans for the formation of elements of atomic number greater than 101, perhaps as high as 107, by methods now being developed at the University of California. Drs. Seaborg and Nyholm were participants in a symposium on "The Present Status of Inorganic Chemistry" presided over by Dr. A. Adamson. Other speakers on this symposium were Drs. H. Taube, L. F. Audrieth, A. B. Burg, and E. G. Rochow, who summarized recent developments in isotopic studies of structure and mechanism, non-aqueous solvent systems, borane chemistry, and inorganic polymers, respectively.

Dr. Jacob Kleinberg presided over a symposium on "Unfamiliar Oxidation States of the Elements" and Drs. D. H. Busch, L. C. W. Baker, and E. O. Brimm presided over the general sessions.

Photograph by Fay Foto Service, Boston

On the occasion of the James Flack Norris Award, May 9, 1957, C. Pauline Burt, Jean V. Crawford, Edward R. Atkinson, Avery A. Ashdown, Emma P. Carr, Mary L. Sherrill.

THE JAMES FLACK NORRIS AWARD

By EDWARD R. ATKINSON

Introductory remarks at the presentation of the James Flack Norris Award, jointly, to Miss Emma Perry Carr and Miss Mary Lura Sherrill, May 9, 1957.

In presenting the James Flack Norris Award this evening we of the Northeastern Section are honoring the memory of one of our most distinguished members. I suppose that the time will come when it will be appropriate on such an occasion for the chairman to review the life and works of Professor Norris. Tonight however this is not necessary, for many of us here studied under Professor Norris, and were his associates in the activities of the Massachusetts In stitute of Technology and of the Northeastern Section of the American Chemical Society.

In addition to his well known activities in research, Professor Norris was an outstanding teacher, fully aware of the influence which he had on young men electing to enter the profession of chemistry. For this reason it was most appropriate that to perpetuate the memory of Professor Norris the Northeastern Section established this award for outstanding achievement in the teaching of chemistry.

The James Flack Norris Award was made possible by the act of Mrs. Norris who gave half the residue of her estate to the Northeastern Section.

The nature of the Award and the details of its presentation were established by a committee headed by the late Gustavus J. Esselen. The Award is currently given each year for "outstanding achievement in the teaching of chemistry, as distinguished from research, when demonstrated at college or secondary school levels". The first award was made to Professor George Shannon Forbes of Harvard in 1951. Subsequent recipients were the late John Xan, Harry N. Holmes, and Norris W. Rakestraw.

The Award is in charge of a committee of seven members, four of whom are elected for four year terms by the membership of the Section. The Editor of the *Journal of Chemical Education* is a member of the committee by virtue of his position. Two other members of the committee, not members of this Section, are elected by the five members mentioned.

This year for the first time the James Flack Norris award is being made jointly to two distinguished chemistry teachers each of whom will receive one thousand dollars and a scroll to commemorate this happy occasion.

THE CITATIONS ENGROSSED ON THE SCROLLS

EMMA PERRY CARR

MOUNT HOLYOKE COLLEGE
SOUTH HADLEY, MASSACHUSETTS
May 9, 1957

In recognition of forty-one years devoted to the teaching of chemistry at Mount Holyoke College; initiating a research program as a vital part of the instruction; carrying the spirit of American education to the Institute of Chemistry at the National University of Mexico, while on leave in 1944, and continuing interest in teaching during emeritus years. This award is made, as well, for the great stimulus engendered by the team, Carr and Sherrill, in furthering the ideals of the New England Association of Chemistry Teachers to enhance chemistry education in the secondary schools, and in encouraging, particularly, women students, interested in chemistry throughout the world.

MARY LURA SHERRILL

MOUNT HOLYOKE COLLEGE
SOUTH HADLEY, MASSACHUSETTS
May 9, 1957

In recognition of forty-four years of active teaching of chemistry and for continuing interest during emeritus years. This teaching experience, gained first in the South-land with nine years at Randolph-Macon Woman's College, was followed by two years at the Woman's College of the University of North Carolina and concluded by thirty-three years at Mount Holyoke. This award is made also for the great stimulus engendered by the team, Sherrill and Carr, in furthering the ideals of the New England Association of Chemistry Teachers in enhancing chemistry education in the secondary schools and in encouraging, particularly, women students, interested in chemistry throughout the world.

EMMA PERRY CARR

By C. PAULINE BURT
SMITH COLLEGE

An address on the occasion of the presentation of the James Flack Norris Award to Emma Perry Carr, by the Northeastern Section of the American Chemical Society, Thursday, May 9, 1957

I was the first graduate student Emma Perry Carr ever taught, and she was the first graduate professor I had ever seen. Since that time she has taught so many students that she cannot possibly remember that morning as vividly as I do.

This was back in 1914 ("the last year that ever was," as Michael Arlen called it), that quiet halcyon period before wars and rumors of wars cut across our lives, when it was still possible for college students and college professors to withdraw to their ivory laboratorial towers. I had graduated from Pennsylvania College for Women in Pittsburgh the preceding June, and had received an appointment as graduate assistant from Mount Holyoke, sight unseen on both sides, for I had never seen Mount Holyoke and no one at the college had ever seen me.

The best possible proof that there is no such thing as evolution — in spite of Darwin and Scopes — is the Boston and Maine Railroad, which has shown no progress since 1880. I should know, for I have travelled by it for forty years. It is now, and was then, bad enough in the daytime, but after a rattling night I had been decanted at the Holyoke station at six a.m. I made my way by trolley car to South Hadley and early in the morning, I sat in Miss Carr's waiting room, weary from travel, just a little frightened, waiting for my first sight of a graduate professor who — although I knew Miss Carr's sex — was somehow in my mind to be a terrifying gray-beard. Suddenly there entered a tall dark slim young woman with a disarming smile.

She looked so young — indeed she *was* so young — that it seemed incredible that at the age of 33 she had already become a professor and head of the Department of Chemistry, probably the youngest person ever to receive such an appointment. At the time I first saw her, she had received her B.S. and Ph.D. degrees from the University of Chicago, where she had worked with Alexander Smith and Julius Stieglitz, the great teachers of chemistry in that generation, whose texts for beginning students, which remained standard for many years as we all know, had blazed a new trail and established a point of view that looked forward rather than backward and which had the greatest possible influence upon the teaching of Chemistry. These were the books Miss Carr used in her own teaching; and the new methodology of these two great teachers she not only shared but transcended. Their approach and hers were to become standard in another generation but it was radical and epoch-making in the early years of this century. A newer approach was not to be possible until after atomic developments in recent years.

From the University of Chicago she returned to Mount Holyoke where she had already served for three years, and where she was to remain throughout her distinguished academic career, a career marked by devotion to the interests of the college on which she has conferred such lustre. On occasions she went far afield from South Hadley: to work with Professor A. D. Stewart at Queen's University in Belfast in 1919; in 1925 to study with Professor Victor Henri at the University of Zurich, where she returned in 1929 when she held the Alice Freeman Palmer Fellowship of the American Association of University Women. In 1944 she was visiting Professor at University of Mexico. But always she went back to Mount Holyoke to carry on a career that combined teaching and research, which to her have never been *two* ways of life. In our profession, as we all know, there are some whose engrossing interest is in research and who consider teaching only a necessary means of earning a livelihood — even an inter-

ruption to the hours they would prefer to spend in the laboratory; there are others whose emphasis is exclusively upon teaching. But Emma Perry Carr became the great teacher she was and remained because she knew that the two were not separate but integral and inevitable parts of a single whole, and that the richest undergraduate teaching comes from those who are carrying on research. I think that there has never been a time during her long administration when the younger members of the Mount Holyoke Chemistry Department were not active in the laboratory and in the publication of their results; but I am sure that as they look back they realize, as did I in that early period, that Miss Carr's emphasis upon research was inherent in her conception of what constitutes a great teacher of science. Unlike some scientists who have spent their lives in undergraduate colleges, Miss Carr never forgot that the primary function of a college is undergraduate education: that the first responsibility of the teacher is to *teach*.

A great teacher is known not only by her reputation in the academic world but by the example she sets to a rising generation. I do not know, and probably she does not, the number of her students who have taught Chemistry in secondary schools, but I am aware that while she was departmental chairman 43 of her B.A.'s and 25 of her M.A.'s went on to the Ph.D. Throughout the country, in practically every women's college and in many great universities they are to be found, the majority of them professors, carrying the torch she lighted for them at Mount Holyoke.

Many first-rate scholars and scientists in undergraduate colleges are interested only in advanced courses in their own highly specialized fields. Miss Carr always insisted that the most important of all courses was the elementary one, which demanded and should have the benefit of the most experienced teachers. Not only did she continue to teach the basic course during her long years at Mount Holyoke, but as I came to realize during those early years, she was constantly teaching us to teach. I shall never forget that freshman course, so vivid, so clear that the young assistant sitting at the end of the front row became as instinctively aware of what was necessary in the lecture demonstration as does the surgical nurse, who can anticipate the surgeon's need without a word. Not only were the lectures beautifully organized and lucid, but Miss Carr had a peculiar genius for demonstration which I have never seen surpassed. Unlike too many teachers, she did not impoverish her students by doing too much of their work for them; her demonstrations were quite different from the experiments they performed in the laboratory periods. She never took away from them the excitement which even a youngster may feel in making a discovery for herself, making the young amateur for a moment one with Archimedes.

Her teaching was, of course, not limited to the introductory course. Her course in Physical Chemistry was always famous. Here again as seniors she found the students whose interest in her subject she had stimulated in the freshman year, and was able to enjoy them again at a more mature level. Again she led them in such a way that they shared something of the excitement every discoverer experiences for himself. I say she "led" them, and indeed she did. Since I have been reminiscing about my recollections of a day in 1914, I find my mind going back to a story often told during the First World War, to indicate the difference between German and American officers. When zero hour approached, the German officer shouted: "Go on, boys, I'm *behind* you." But the American officer said quietly: "Come on, boys. Follow me and we'll go over the top." In every sense of the word, Emma Perry Carr was a *leader* of students.

According to the Mount Holyoke records Miss Carr retired in 1946, but those of us who know her are aware that she has never retired: she continued to do some teaching when she was needed; she has continued to work on the problems of absorption spectra in the ultraviolet which have brought her scientific fame. She has devoted her extra-curricular efforts to civic problems

(*Please turn to the next page*)

EMMA PERRY CARR

(*Continued from the previous page*)

in South Hadley — to what she herself calls "the four S's: schools, streets, sewers and septic tanks." If I were to choose one word in which to express the central interest of her distinguished career, I would choose "adsorption". The young woman I first saw on that autumn morning back in 1914 had been absorbed in her work with Smith and Stieglitz, as later in her research. She has been absorbed in her academic life, most of all in her teaching and in her students. And in another sense, during all these years those who have surrounded her — young undergraduates, assistants like myself, and colleagues — have absorbed from her. The light she has cast has been visible light, but to many of us it has been also the ultraviolet with which she has worked so long, through which she has shown those of us who have tried to follow her not just what *was* the structure of organic substances but what *is* the structure of the substance of a teacher. And so in joining in this tribute to Emma Perry Carr — great teacher and chemist — I find myself paraphrasing the phrase spoken so long ago: "In her light have we seen light."

SCIENTIFIC RESEARCH IN A LIBERAL ARTS COLLEGE

By Emma P. Carr
Mount Holyoke College

The James Flack Norris Award address, May 9, 1957

"In a liberal arts college for women, like Mount Holyoke, the primary function of the college is undergraduate education and the teacher's first responsibility is to the undergraduates. The graduate work leading to the M.A. degree is offered primarily for the graduate assistants of the department, and the research activities of members of the staff are supported and encouraged largely because these contribute directly or indirectly to their effectiveness as teachers." This was the statement of the educational philosophy and policy of the Mount Holyoke Chemistry Department which I gave in an article in the *Journal of Chemical Education* shortly after my retirement from teaching ten years ago. I will not undertake tonight to discuss the many basic problems which might well be considered but rather to review briefly the way in which teaching and research have been combined over a period of almost forty years in one institution and only one department, although it is indeed the policy of all of our science departments today.

I must ask your indulgence for recounting, in too great detail, my own personal experience. My excuse is the request of the Award Committee, through its secretary, that my address should be "on some of the most interesting phases of your work at Mount Holyoke." Dr. Ashdown added the further suggestion that "it would be desirable to couple the challenge of teaching with the growth of your research."

It is difficult for me to untangle the web of interlocking interests between teaching and research and quite impossible to ascribe due credit to the different members of the department whose individual and cooperative contributions have made possible what success our department has had. I have been rarely fortunate in my colleagues and in our length of service together. For thirty years I was associated with Dr. Dorothy Hahn, a stimulating teacher of organic chemistry and distinguished investigator in the field of hydantoin chemistry; the same length of time with Dr. Louisa Stevenson, who contributed more than any of us to the teaching renown of the department; twenty-five years with Dr. Sherrill and a mere sixteen with Dr. Lucy Pickett.

Many others have been with us for shorter times and have made valuable contributions. Too great stability in a department may at times be a handicap but not where the team-work has made possible the carrying out of long-time projects both in research and teaching as it has in our department.

It is to my undergraduate teachers that I must turn for my initial interest in chemistry, my basic principles of teaching and my enthusiasm for research as a necessary corollary of effective teaching. My undergraduate work, first at Ohio State, then two years at Mount Holyoke followed by two years as lecture assistant here, and finally my senior year at The University of Chicago, was at a time when the universities were small enough for the undergraduate to know and be known by his professors, — a privilege too seldom possible today. I was most fortunate during those formative undergraduate years in having courses with Professor William McPherson at Ohio State, Professors Nef, Stieglitz, McCoy and Alexander Smith at Chicago.

These were men who exerted a profound influence on the development of American chemistry both in teaching and research during the early part of this century. Their names and work are less well-known to the chemistry students of today and I wish there were time to point out their most significant contributions. Personally, my two and a half years of assisting in Dr. Smith's General Chemistry course was responsible in large part for the organization not only of our first year chemistry course at Mount Holyoke but also for certain salient features of the department organization. He emphasized always the paramount importance of the laboratory work in the teaching of beginning chemistry and the necessity for having the most experienced teachers conducting the laboratory and weekly class discussions. It was rarely that Dr. Smith did not himself make the rounds of each laboratory section, asking questions, correcting misconceptions and giving the student a sense of genuine interest and concern for his progress. He insisted on the close correlation of lectures with laboratory and class discussion.

Another policy of our department which was modelled directly on Dr. Smith's procedure as chairman of the department, was the appointment of a trained chemist as an assistant director of the laboratory who was responsible for the behind-the-scenes work of the department, — inventory, orders, direction of student help; in short, the non-teaching responsibilities so vital to the efficiency of the department but so time-consuming for the teaching staff. More than any other single factor, this arrangement made it possible for members of the staff to carry on research in addition to the regular teaching program.

Finally, Dr. Smith's text-book, *Introduction to General Inorganic Chemistry,* first published in 1906 and continued through many editions and revisions, revolutionized the teaching of general chemistry in this country. Based as it was on the application of the principles of chemical equilibrium and the newer theories of physical chemistry to inorganic chemistry, the Smith texts very quickly came into widespread use and the general treatment became the model upon which many of the more recent texts were built. The publication of the Pauling textbooks represents, in my judgment, the first radical departure from the Smith tradition.

Dr. Stieglitz' treatment of qualitative analysis marked an important departure from the established methods in use at that time. Smith in his *General Inorganic Chemistry* and Stieglitz in his text *Elements of Qualitative Chemical Analysis* were pioneers in applying the theories of Ostwald and Arrhenius, Nernst and Van't Hoff to the elementary courses in inorganic chemistry. With that background the teaching of college chemistry became to me an exciting adventure.

I returned to Mount Holyoke in 1910 to undertake the administration of the department. In the meantime Dr. Dorothy Hahn had joined the department. She was a Bryn Mawr alumna and had begun work for the doctorate with Dr. E. P. Kohler. She was continuing her research, — the synthesis of certain cyclopropane derivatives, — in the Mount Holyoke laboratory. My doctoral problem had been in Kinetics but I wanted to take up some type of physico-chemical research that could be combined with Miss Hahn's synthetic organic studies in order that we might give master's degree candidates an introduction to research methods in both organic and physical chemistry.

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SCIENTIFIC RESEARCH IN A LIBERAL ARTS COLLEGE

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The British and continental chemical journals were publishing numerous articles on the relation between ultraviolet absorption spectra and the structure of organic molecules and it seemed a promising field for our research. At that time no work had been reported from any laboratory in this country. I knew nothing about the technique except what I had read in the foreign journals but we went ahead and ordered our first Hilger spectrograph and began work in 1913. I had hoped to go abroad for study but with the outbreak of war in 1914 this was not possible until 1919 when I worked for a semester with A. W. Stewart at Queen's University, Belfast. Our first publication in this field was in 1918 and reported results on a series of cyclopropane derivatives prepared by Miss Hahn and also by Dr. Kohler. We owe much to his continued interest and encouragement. These earlier measurements were based on qualitative methods in general use at that time. The purchase of a new spectrograph in 1924 made possible quantitative measurements of intensities and widened the scope of our work. This was a valuable tool in studying the structure of fairly complex molecules, and in a number of cases where the chemical evidence was inconclusive, the spectral measurements gave the clue to the correct structural formula.

The compounds studied were much too complex for any theoretical deductions as to why certain wavelengths of light were absorbed by certain atomic groups. We knew that light absorption was associated with unsaturation in the molecule, but little was known as to the absorption due to a specific atomic grouping. For any theoretical analysis we must use simpler molecules with fewer variable factors. Dr. Sherrill and I decided to undertake a joint research project, — a systematic study of the characteristic light absorption of one chromophoric group, the carbon-carbon double bond. We would prepare in our laboratory the simplest possible compounds, the mono-olefins, and would vary only one factor at a time, the position of the double bond in the molecule. The synthesis and purification of the different hydrocarbons and the measurements of their spectra with the quartz spectrograph offered excellent problems for honor's and master's degree students. Miss Sherrill began with the preparation of the isomeric pentenes. With these six hydrocarbons, we would have two with one alkyl substituent on the carbon atoms of the double bond; three with two substituents, including the cis- and trans-isomer and one with three. Dr. Frank Whitmore supplied the necessary hexene, tetramethylethylene.

Saturated hydrocarbons are very transparent and in vapor phase transmit light almost undiminished in intensity down to 1650 Å. The introduction of one double bond into the molecule gives a broad region of low intensity absorption in the quartz ultraviolet and high intensity bands beginning, in the mono-olefins, below 2300 Å. This is the region which must be investigated for data on the simpler organic molecules, but light of these short wavelengths is absorbed by the oxygen of the air and by a quartz optical system. Vacuum spectroscopy, particularly with organic compounds which are easily decomposed, is a quite complicated technique and except for one or two early publications from German laboratories, no work had been done on organic compounds. It was necessary to work out our own methods.

In 1929 I was given an A.A.U.W. fellowship and spent the year learning what I could about the problems of vacuum spectroscopy. Most of this time I was in the laboratory of Professor Victor Henri at the University of Zürich, where I had invaluable experience in helping to set up a new vacuum spectrograph. A grant from the National Research Council and Mount Holyoke College made possible the purchase of an excellent Hilger fluorite prism spectrograph together with auxiliary equipment for the work in vacuum spectroscopy in our own laboratory and we embarked on this research adventure in the fall of 1931.

Thanks to a research grant from the Rockefeller Foundation in 1934, Dr. Hildegard Stücklen of the Institute of Physics in Zürich could join our group and she was able to give almost full time to the spectrographic work for three years. For the others, it was what might be called a "leisure time activity" in addition to the usual teaching schedule. Week-ends and holidays went into the game in which our student collaborators frequently joined. Dr. Pickett with her students had been working on spectrographic problems in the near ultraviolet and she began work in the far ultraviolet about 1940. The work on the mono-olefins had been extended to include di-olefins and cyclic hydrocarbons as well as aliphatic when the general program was interrupted for the immediate demands of war work. The spectrographic studies were resumed after the war under the able leadership of Dr. Pickett and Dr. Anna J. Harrison and there have been great advances both in technique and results over our earlier work where the position of the absorption bands could be measured accurately but the intensities only estimated. A method for the quantitative measurement of intensities of absorption as well as the wavelengths has added much to the value for theoretical analysis.

Probably the most important result of our earlier work was the identification of two different types of electronic bands between 2300 and 1600 Å in the spectra of the 16 mono-olefins which were included in a report published in the *Journal of Physical Chemistry* in 1936. There is a broad band of high intensity with a maximum in the region of 1850 - 1750 Å; superimposed on this band is a group of narrow diffuse bands of much lower intensity and at longer wavelengths. The position of these narrow bands is determined by the immediate environment of the double bond in the molecule, *i.e.,* the number of alkyl groups bound to the carbon atoms of the double bond, and there is a progressive shift toward the visible with increasing *number* of alkyl substituents but the nature of the alkyl group has only a slight influence. On the other hand, the position of the broad intense band depends on the structure of the molecule as a whole and in the mono-olefins seems to be related to the *shape* of the molecule. In the conjugated di-olefins there is very little change in the position of the narrow bands but a very large shift toward the visible with the high intensity band.

Fortunately for our work, Price and Wood in 1935 had measured and analyzed the absorption spectrum of ethylene in this far ultraviolet region and had classified the group of sharp bands in ethylene which were analogous to these narrow diffuse bands in the ethylene derivatives as the first member of a Rydberg series, the limit of which is the ionization potential of the molecule. The corresponding bands in the derivatives were therefore classified by us in 1939 as Rydberg bands, due to a type of transition closely related to atomic spectra, while the broad intense band, whose maximum in the mono-olefins is at shorter wavelengths, was ascribed to a purely molecular type of transition which is characterized by spectoscopists as an N→V transition. Unfortunately this differentiation between the two types of bands has not been generally noted by those who have used our results and considerable confusion in the literature has grown up in some of the theoretical conclusions which have been drawn.

Other results of our work are of interest to specialists in the field; I have tried in this brief review to sketch only the gradual evolution of what might be called a coördinated research program in a college department devoted primarily to teaching. Any success it has achieved is due to departmental coöperation, administrative encouragement and, most of all, to the individual contribution of each member of the group.

At the time of my retirement, I was interested in a sort of "stock taking" of my twenty years of association with this research project. There were some fifty or more honor's papers and master's theses on file in our library; there were thirty-five publications by different members of the staff, with their student collaborators in the journals of this country and in Europe. More reward-

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SCIENTIFIC RESEARCH IN A LIBERAL ARTS COLLEGE

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ing to the teacher is the interest in research that the students have shown; to the investigators there is the excitement and satisfaction that comes from exploring an almost uncharted area of scientific research and finding certain general relationships of fundamental value.

For myself, the research has added immeasurably to the joy of teaching. There is no standard by which to evaluate the reaction on our teaching other than the achievements of our graduates and that has been most satisfying. The way in which the present staff is carrying on research together with excellent undergraduate teaching is evidence enough of their belief in the value of research in a liberal arts college and gives promise of far greater achievement in the future than in our past.

Mount Holyoke inherited an interest in chemistry from the very begnning of the institution. Mary Mason Lyon, our Founder, was the first teacher of chemistry. Before the opening of the seminary in 1837 she had taken a course with Professor Amos Eaton of Rensselaer to learn, as she said, "a new and unusual way of teaching chemistry, where the students perform certain of the experiments themselves." Laboratory work was introduced that first year. At the celebration in 1887 of the Fiftieth Anniversary of the founding, Miss Lydia White Shattuck, a student of Mary Lyon and herself an outstanding teacher of science gave an address on *The Seminary and Science* in the course of which she said:

> Since the instruction of the Seminary has had a scientific trend from the beginning, without tendency to convert us into agnostics or infidels; since this is a scientific age and we are bound to keep abreast of the times, let us press forward along these lines till we find full recognition among the colleges of New England.

That was seventy years ago. Tonight, Miss Sherrill and I are reaping a rich reward from that investment of work and wisdom and faith of our pioneer teachers; we are sharing beyond our own deservings, in the realization of Miss Shattuck's dream of "full recognition among the colleges of New England."

MARY LURA SHERRILL

By JEAN V. CRAWFORD
WELLESLEY COLLEGE

An address on the occasion of the presentation of the James Flack Norris Award to Mary Lura Sherrill by the Northeastern Section of the American Chemical Society, Thursday, May 9, 1957.

Although Miss Sherrill is not being honored tonight for the degrees she has received or the fellowships she has held abroad or as a Garvan medalist, perhaps those who have not read the NUCLEUS may be interested in a brief biography. Miss Sherrill received both her Bachelor of Arts and Master of Arts degrees from Randolph-Macon Woman's College and her Ph.D. from the University of Chicago.

Practically the whole of Miss Sherrill's career has been devoted to teaching. She began her teaching at her Alma Mater immediately after receiving her Bachelor's degree. If the esteem in which her colleagues there still hold her is any measure of her success, the nine years of teaching at Randolph-Macon Woman's College were eminently successful. Whenever Miss Sherrill visits the College, the red carpet is brought out and the chemistry majors consider it a real privilege to be invited to meet her. If by any chance they are not invited to meet her, they are quite likely to ask that the organic class be given a cut so that they may have coffee with her. After leaving Randolph-Macon Woman's College, she was an Associate Professor for two years at the Woman's College of the University of North Carolina, from which she later received an Honorary

D.Sc. In 1921, after a year as a chemist at the Edgewood Arsenal, she came to Mount Holyoke College, where she continued until her retirement in 1954 and where she was Chairman of the Chemistry Department from 1946 to 1954.

If Beardsley Ruml is correct in a recent statement that the job of the administration in a college is to put out fires, not to start them, certainly the exact opposite is true for the successful teacher. When one recalls the really good teachers one has known and wonders what has made them that, a single characteristic seems to be common to all of them — an ability to convey again and again an enthusiasm for discovery; that is, good teachers start the fires. And for a successful teacher in a liberal arts college this enthusiasm for discovery has to be carried to all levels of intellectual development. This it seems to me Miss Sherrill was able to convey in a unique way: to the freshman intrigued with atomic structure; to the sophomore trying in vain to find tin in an unknown; to the junior encountering mechanisms of organic reactions; to the senior honor student undertaking a first piece of research; to the graduate student trying to prepare and characterize a new compound; and to the young instructor faced by a group of inquisitors for whom no holds are barred.

Miss Sherrill herself would be the first to say that the enthusiasm for discovery will not last long unless the teacher is actively engaged in research. The group project which Miss Carr and Miss Sherrill undertook on the ultraviolet absorption spectra of simple unsaturated hydrocarbons was, I think, unique at the time. The carefully purified alkenes needed for the investigation were prepared by Miss Sherrill and her senior honor students and graduate students. Even freshmen became curious when occasional whoops of joy came from the graduate assistants' office and they were soon informed that the spectrum showed that the last traces of impurity had been removed and that the 2-pentene was finally pure. Although the underclassmen did not have the remotest idea of the chemistry involved, they did see the joy of discovery and saw also that the result was not the work of one person but of a group working together.

A second group project in which Miss Sherrill and her students engaged was a part of a larger investigation, the synthesis of antimalarial drugs coordinated during the war by the O.S.R.D. So far as I know, Mount Holyoke College was the only woman's college to have such an O.S.R.D. contract, a tribute to Miss Sherrill as a research director. The synthesis of various quinazolines was a far cry from Miss Sherrill's earlier interests in the synthesis of simple hydrocarbons and the determination of various of their physical properties, such as dipole moments and ultra-violet and infrared absorption spectra. And yet she easily persuaded a sizeable number of recent graduates, candidates for the Master's degree and younger members of the teaching staff that the synthesis of a quinazoline was exciting enough to compensate for a hot, humid summer in the Connecticut Valley—without gasoline.

That this enthusiasm for discovery carried to the students is evidenced by the number of chemistry majors who went on to do advanced work. Out of 153 majors over a ten-year period from 1937-1946, 47, or 31%, received advanced degrees. In addition to instilling in their students that learning is an adventure, both Miss Carr and Miss Sherrill conveyed to them their own love of teaching. Concrete evidence of this comes from those who recall the excitement and stimulation of the classroom and laboratory but even more strikingly from the fact that out of this same group of 153 majors, 19, or 12%, have entered college teaching. This is a real tribute to the love of teaching that they had seen as undergraduates.

Those who studied under Miss Sherrill may be grateful primarily for her enthusiasm for discovery but they are also grateful for her faith in their ability to accomplish what seemed to them impossible, for her warmth, for her understanding and patience, for her lively sense of humor — and for her southern accent, which returned after each visit to North Carolina. And if there is any

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MARY LURA SHERRILL

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doubt about Miss Sherrill's devotion to teaching, there is one further example. Three years after her retirement she has refused to spend this coming weekend in Boston because she wants to be in South Hadley in time to teach an eleven-o'clock class tomorrow.

GROUP RESEARCH IN A SMALL DEPARTMENT

By MARY L. SHERRILL
MOUNT HOLYOKE COLLEGE

The James Flack Norris Award address, May 9, 1957

When the Secretary of the Award Committee wrote me of the Award and of the obligation to deliver an address on some phase of my work, he added "personally I would like to hear how you coupled a life-long interest in research with effective teaching." This was responsible for the very personal approach in this talk.

Dr. Ashdown was far too generous in his implications on both items. Perhaps a change in emphasis may give a more accurate slant. My primary interest has always been in teaching and the research interest developed in the group research with the realization of its value to the teaching. Teaching is much more than the training in methods, the presentation of facts, the interpretation of knowledge. It must stimulate in the student enthusiasm for discovery and an awareness of the "adventure of education." Example is a far more potent factor with the undergraduate than precept. Nothing is so effective in stimulating interest in a subject as the enthusiasm of a teacher who, himself, is contributing in some small way to the advance of knowledge. As far as the other implication "a life-long interest in research," this was secondary with me, yet many times I was sure that the research for my doctorate was going to be "life-long" even beyond the normal "three score years and ten." It stretched over seven years during five of which I was doing full-time teaching in the academic year.

A year's leave of absence from Randolph-Macon gave me five quarters for graduate study at the University of Chicago (1916-17) and initiated me into research. This was the period of World War I and not the ideal time for graduate study. The major Professors were deeply involved in war-time problems and for the novice in research, difficulties seemed insurmountable. A synthesis of the barbiturates, then covered by German patents, was my first problem. Just as a fairly promising synthesis developed, the German patents were seized by our Government and interest in this problem waned. Then a synthesis of the esters of methylenedisalicylic acid was undertaken, not a very exciting problem but an annoying one. Dr. Stieglitz, on one of his rare visits to the research laboratory looked at my sticky material with its odor of oil of wintergreen and said, "Miss Sherrill, I did not know that you were making chewing gum." This problem was finished in the "spare time" I found at Randolph-Macon after teaching General Chemistry to 150 students as well as giving a course in Qualitative Analysis. Neither problem was adequate for a thesis though both were included ultimately in my thesis. Then, due to family responsibilities, I taught two years at the Woman's College of the University of North Carolina. At the end of that time I resigned, determined to have full-time research at the University until my degree was achieved. The problem of financing it was the big question mark. It was then that luck came my way, giving me the opportunity of a research position with the Chemical Warfare Service. Financially it was a boon and Dr. Stieglitz urged its acceptance. It was understood that any work not "restricted" might be used for my thesis. This was my initiation into a group research project, the first, of three, in which I have had a share. This was not in the academic area but it taught me some valuable lessons both in human relationships and in developing self-confidence.

As an Associate Chemist at Edgewood Arsenal (1920-21), I was assigned a problem involving a practical synthesis of a non-toxic irritant gas. War-time secrecy was still dominant but fortunately, although my problem dealt only with the aromatic part of the desired compound, I was cognizant of the problem as a whole. Working with a young assistant, we were able in about two months to obtain a suitable procedure. On the other hand, a group of five men, all of whom had previous industrial experience, were working under the direction of a Chemical Warfare Service Captain. This group was handicapped by his view that restriction rules demanded that no overall knowledge of the problem be divulged. Therefore they were given specific things to do without any understanding of relationships. They felt frustrated and there was dissatisfaction in the group. When a little later the Captain was transferred, the Research Director asked me to take over the entire problem. I hesitated to undertake this as I felt it could not work satisfactorily. These men had more practical experience than I and it seemed my appointment might be only another frustration. I accepted the appointment with the understanding that the men be consulted as to my appointment and, then, if they were agreeable to it, that I should discuss the entire problem with them. The project then became a group responsibility. The entire atmosphere changed, interest developed, and the work speeded up enormously. Shortly several satisfactory compounds were prepared and tested for their effectiveness. When I left in September, morale was high and the research was moving ahead.

During the first years at Mount Holyoke it was possible to complete my doctoral thesis based on some of the Edgewood work and to direct the research problems of several M.A. candidates. Up to this time practically all my work had been in the field of aromatic chemistry. However, my interest was aroused by Dr. Carr's spectrographic work and the realization of the importance of the simpler aliphatic compounds, especially the alkenes. The years from the mid-twenties to the early forties were most interesting and satisfying. Then I had a part in real group research. The project was well planned by Miss Carr, one which enabled the special interests of the group, faculty and student, alike, to be shared. The synthesis and purification of the isomeric pentenes and other alkenes for absorption spectra measurements in the far ultraviolet, as my part of the program, opened up a variety of problems. It was possible to divide these so that honor students and master's candidates could have individual but related problems.

It is difficult today to realize the problems we met in the early work. Various methods of synthesis for each of the pentenes were tried. The danger of rearrangement was quickly evident. There was a lack of knowledge of accurate physical constants, widely different values of boiling points, densities and indices of refraction were reported by various investigators. The modern types of distillation equipment were not available. The first long fractionating columns in our laboratory came back with me from Belgium. Also the technique of azeotropic distillations with absolute methanol or ethanol for freeing the hydrocarbons of some impurities was acquired in Brussels. The absorption spectrum of the liquid hydrocarbons in the quartz region is very sensitive to the presence of minute traces of impurities such as peroxides, di-olefins, or aromatic hydrocarbons. Purity of a given compound was tested by the reproducibility of the absorption curve after redistillation of the sample. The distillates were collected in an atmosphere of nitrogen but even then speedy spectrographic examination, after purification, was necessary. In recent years, present members of the Department have made spectrographic measures of purified samples of the isomeric pentenes furnished by the American Petroleum Institute. It is very gratifying that these spectrographic data agree amazingly well with those obtained from the compounds synthesized in the early thirties.

The individual students had the challenge of their own problems but each was aware of what the others were doing. A spirit of cooperation developed

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GROUP RESEARCH IN A SMALL DEPARTMENT

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and also a certain amount of healthy competition for achievement. The group project made the best use of the limited research time for students and staff members. They spelled each other on distillations and shared late night vigils.

The research work was not limited to the academic year. Often a number of students and staff worked through spring vacation. The major members of the department worked usually for two of the summer months and some of the students joined the group. The students profited not only in the techniques of their problems but also in the use of the literature, the organization of their honor papers and masters theses and their presentation of the material at seminars. Their interest and later achievement added much to the satisfaction of the department.

The students were not the only ones who profited by the group research. Research became an increasing challenge to me. The study of the alkenes led me into a study of the addition reactions of the alkenes, the measurement of the Dipole-Moments of these derivatives and the Infra-red Spectra (1936) of the alkenes, increasing the breadth of my research and giving me experience in foreign laboratories.

In World War II it was our good fortune to have an Office of Scientific Research and Development grant and for me it was a new field of investigation, — the heterocyclic compounds. This was a group research project involving groups from many of the Universities and Colleges. The aim of each of the groups was to find a really effective anti-malarial drug, better than quinine and the other known synthetic drugs. There was close cooperation with the chemists and the pharmacologists. The leaders of the various projects met at least twice a year and these contacts with some of the most able chemists in the country was invaluable to me. Ideas were shared, problems discussed and the stimulus was rewarding. The monthly reports of each group's progress were most helpful.

In the department every one cooperated; the staff members gave generously of their time. The grant enabled us to have Dr. Margaret Endicott, on a full-time basis, to help coordinate the work. Without her ever-present help, we would not have been able to accomplish what we did. The student interest was enormous; they had not only scientific interest but also felt that they were contributing in some small way to war effort. The number of undergraduates enrolled in the department was higher than usual and their ability very good. In the years 1941-46, despite the demand of industry for chemists, a larger number of our graduates than usual went into the universities and received master's degrees and doctorates. A considerable number of these have continued in the field; others, though married, have maintained their interest by working part time. It is a real joy to see them at the Organic Symposia and the A.C.S. meetings and realize the depth of their scientific interest.

Group research, in a small department, is interesting, stimulating and more productive than any individual project could be in the same length of time. The problem must be one that challenges the initiative of each person but leaves her free to work out her own ideas. The success, in so small a group depends on teamwork toward a definite goal rather than on a leader. There will be difficulties and discouragements and much depends on the personalities of the group members and the adaptability of all concerned. The most brilliant intellectuals are often the most individualistic. Under the best of conditions, there were times when achievements seemed at low ebb and enthusiasm flagged. It was at such times that we could depend on Miss Carr, the real catalyst, who never lost her confidence in the worthwhileness of the investigation and whose enthusiasm and sense of humor could ease the situation and pull us out of the "slough of despond." This was true not only with the older members of the group, but also with the younger ones. I have a vivid memory of a young graduate student who,

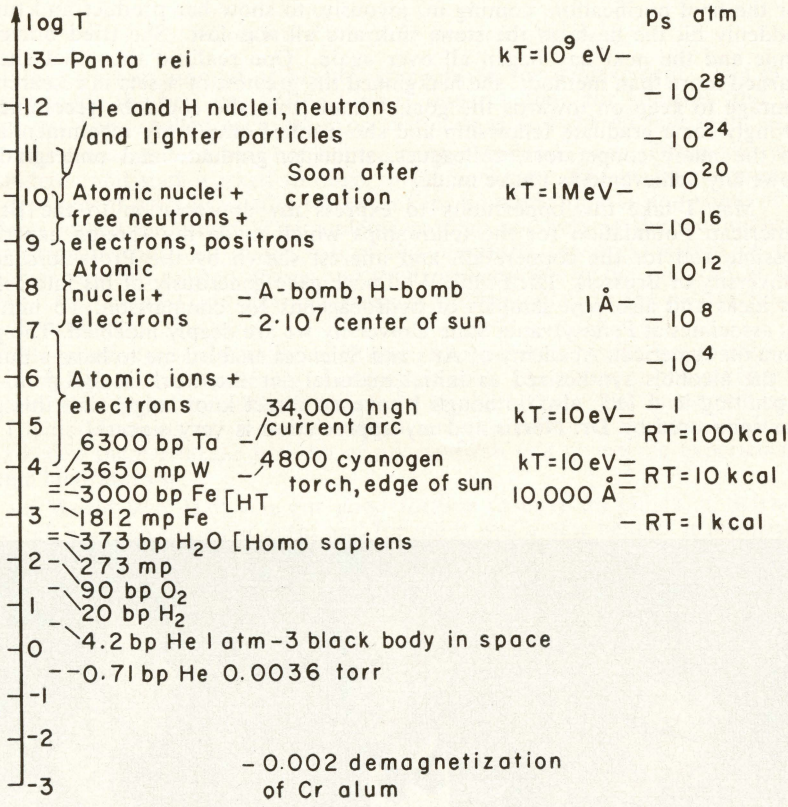
after months of work, had finally obtained nearly two liters of material ready for the final purification, coming in, joyously, to show her product and turning suddenly hit the flash on the stone sink and all was lost. She tried bravely to smile and the next day began all over again. One realized then that she had learned more than methods; she had gained the greatest of assets in research, the courage to keep on towards the goal. I knew that she could be recommended strongly for a graduate fellowship and she justified amply my recommendation. To the many cooperators, colleagues, students, graduate and undergraduate, I owe any achievements I have made.

May I take this opportunity to express my appreciation to the Belgian American Foundation for the fellowships which made my foreign experience possible and for the cooperation and interest shown by the Professors at the University of Brussels. Dr. Frank Whitmore gave generously of his interest and his ideas and also sent samples of hydrocarbons for comparison. To him and his associates at Pennsylvania State University we are deeply indebted. The grant from the American Academy of Arts and Sciences enabled me to have a number of the alcohols synthesized as initial material for the work in Belgium, thus expediting it. I feel, also, although I have no direct knowledge, that this grant was sponsored by Dr. Norris and my appreciation is very sincere.

Photograph by Fay Foto Service, Boston

Miss Sherrill and Miss Carr talking with G. Shannon Forbes, first recipient of the Norris Award.

LOGARITHMIC TEMPERATURE SCALE



TEMPERATURE AND CHEMISTRY

By Lars Gunnar Sillén
The Royal Institute of Technology, Stockholm, Sweden

Résumé of an address before the Northeastern Section April 11, 1957

The concept of temperature may be defined in many ways: from the maximum work obtainable on moving a certain quantity of heat from one temperature to another, from the average kenetic energy of molecules and from the energy of the thermal radiation.

To grasp the entire conceivable range of temperature, it is convenient to use a logarithmic temperature scale (see the figure).

Temperatures even lower than those given on the scale—down to 10^{-6} °K —may be obtained, perhaps, by demagnetization of matter following orientation of the atomic nuclei in a very strong magnetic field.

The range of chemistry in the traditional sense — involving the formation of molecules, seems to be restricted to the range, 10^2 °K to 10^4 °K. However, the same equilibrium law holding for chemical reactions — the law of mass action — can be applied also to the processes involving ionization of atoms and nuclear reactions, which are important at higher temperatures.

In the equation, in $K = \Delta S/R - \Delta H/RT^2$, the second term will become negligible if T is increased greatly. Consequently, a reaction with increasing

disorder (positive Δ S) will be favored if T is increased sufficiently, however large the energy requirement Δ H. For this reason, matter will tend to break up into smaller and smaller particles with increasing T.

AUTOMATION IN ANALYTICAL CHEMISTRY

By Cameron D. Lewis
E. I. du Pont de Nemours & Co., Inc.
Polychemicals Dept., Wilmington, Delaware

Summary of address before the Northeastern Section of the American Chemical Society, Cambridge, Mass., April 11, 1957

Practices in Process Development

A rapidly-increasing variety of analyses is performed in industry around the clock by automatic devices. Applications of such "analyzers" in process development work demand rugged, reliable and safe instruments much like those required in operating plants. Advantages of automatic analyzers, when compared to the usual batch methods of analysis, often lie in: speed of analysis, quality of data obtained, detection of changes occurring in small intervals, efficiency in gathering of design data, and protection of personnel in hazardous areas. Process development may also profitably include the testing of analytical instruments proposed for the eventual plant. This is particularly true for analyzers which are proposed for use in automatic control loops.

Problems in application of automatic analyzers require the cooperative skills of analytical chemists, chemical engineers and instrument specialists. In particular, the sampling point must be wisely chosen and the composition of the sample carefully preserved. Conditions such as pressure, temperature and flow must be adjusted to match the needs of the analyzer. Separations are performed and reactions carried out only if necessary, because they add undesired complexity of instrumentation. Separations are frequently essential for good trace analysis, however, and newer methods here include the stripping of a dissolved gas from a liquid substrate and the scrubbing of a gas by a liquid reagent which is selective for one component.

Of the many automatic analyzers now in the literature or commercially available, particular utility has been found for the following:

1. The Hersch galvanic cell, which determines oxygen at ppm. levels in many inert, hydrocarbon and other relatively non-reactive gases;
2. A similar galvanic cell for measuring hydrogen;
3. Keidel's electrolytic analyzer for determining moisture at ppm. levels in most gases, vapors, and in liquid hydrocarbons;
4. Non-dispersing infrared analyzers capable of high sensitivity in a wide variety of gas analyses, notably in hydrocarbon mixtures;
5. Spectrophotometers for determinations utilizing monochromatic infrared absorption;
6. A photoelectric analyzer operating in the ultraviolet and visible regions and applicable to high- and low-level measurements in certain gases and of color, turbidities or aromatic components in liquids;
7. A process refractometer utilizing a photoelectric null-balance system and a differential measurement with excellent temperature compensation, and allowing sensitivity to .000004 RI units, for particular utility in simple aqueous systems and in control applications;
8. A mass spectrometer, for process-monitoring in complex mixtures of gases and volatiles;
9. Gas chromatographic apparatus for similar applications; and
10. A continuous analyzer which measures acetic acid in acetic anhydride by adaptation of a thermo-analytical titration.

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AUTOMATION IN ANALYTICAL CHEMISTRY

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In the future, many of the newer instrumental techniques will be applied to initial or more widespread uses in automatic analyses. Certain sensitive but non-selective methods such as sonimetry and dielectric constant measurement may receive wider attention. X-ray and emission methods may lead to continuous analyses of solid samples. Methods which can be used for instantaneous multi-component analysis, e.g., nuclear magnetic resonance and modified spectroscopic methods, should find application to complex systems. In addition, automatic methods of data handling will facilitate process calculations or product compositions and yield data.

AUTOMATION IN ANALYTICAL CHEMISTRY

By Gordon D. Patterson, Jr.
Film Department
E. I. du Pont de Nemours & Co., Inc.
Wilmington, Delaware

Summary of an address before the Northeastern Section of the American Chemical Society, April 11, 1957

Practices in the Laboratory

The tremendous growth during the past decade of complex tools to assist researchers in solving their problems shows every sign of accelerating indefinitely. The aspects in which we are primarily interested now are those which aid the chemist or engineer, and more particularly the practicing analytical chemist, in answering the "what" and the "how much" of any sample. Of especial concern are the mechanical and electronic devises which have been developed to perform the various unit operations involved in any chemical analysis.

This field is broad enough that it can be, and indeed has been, surveyed from several different viewpoints.

Along with any attempt at classification must go a certain arbitrariness in definitions. I define the word *automation* in the broad sense of involving the replacement of any human effort by inanimate means. Some people have limited its meaning to manufacturing processes. Actually the modern juke-box is essentially just as good an example of automation as is the automatic petroleum refinery. Furthermore, I could discuss at length various concepts of analytical chemistry without accomplishing my main purpose. So, I will dismiss this subject by adopting once again the viewpoint that chemical analysis encompasses a very broad range of activities; that is any technique intended to assist in finding out how much of what there is in a given chunk of the universe, whether it be a few hundred atoms or a distant star.

Any outline must start with a consideration of what the field has in common in all its parts. Every analysis can be regarded as consisting of two major parts: namely, operations on (a) the sample and on (b) the desired constituent.

Both these problems are susceptible to automation. However it is in the separation and measurement steps that the most significant advances have been made. In this connection it should be pointed out that in the laboratory we rarely have a 100% automatic analysis. Instead the trend has been largely (1) to automize the more tedious portions of a procedure or (2) to enable measurements which are otherwise impossible (normally by electronic means). In assessing where in the laboratory we may profit most from the addition of automatic devices, then, we may be guided by considering the potential advantages:

1. Measurements are made feasible which are beyond the five senses.
2. Precision and accuracy may be improved.

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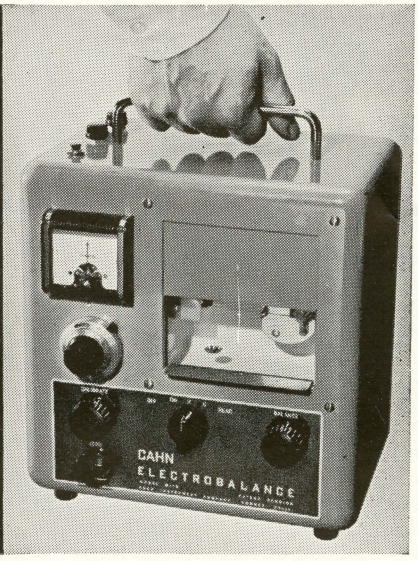

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3. Important time-savings may result.
4. Cost per analysis may be reduced.

Most important are the first two. We take pH measurements to 0.01 unit for granted now-a-days, forgetting that only 2 decades ago, such data consumed months of research level effort. The emission spectrograph is a superb example of a device which fills both qualitative and quantitative needs whenever appropriate elements are involved.

The latter two items of advantage in laboratory automation are often no less important, although we may often de-emphasize them as primary considerations, at least in the research laboratory. Of course, the time and money savings which go along with any reduction or replacement of human effort are never unimportant. However, it is in the quality control laboratory, where many repetitious operations are performed, that automation has a rather obvious place. Actually, the cost and time factors may often be the number one considerations.

Perhaps the most frequent analytical chore in a normal laboratory is the weighing operation, the measurement of mass. It is surprising that automatic or direct-reading balances were not developed much earlier than they have been. Prior to the past decade very little was done, other than in homemade prototypes, to bring this about. The use of chainomatic and keyboard-style means of semi-automatically placing known weights on one end of the beam were steps in the right direction. The use of the vernier scale in various balance designs with torsional beams, or reflected light beams off mirrors mounted on the beam, have enabled direct reading. Balances involving electrical indication of mass may depend on phototubes, but these are generally not amenable to rugged semi-routine applications requiring 0.1 mg. precision over wide weight ranges. Other electrical approaches involve the use of capacitance variation where the dielectric material attached to the beam or pointer moves through an electromagnetic field, or where a radioactive source and ionization counter serve a function similar to the light source and phototube. Perhaps most promising fundamentally is the use of feedback circuits to detect unbalance and restore equilibrium, usually through an electromagnetic force.

Worthy of more than passing comment is the work of Professor Duval and his associates in Paris with thermogravimetric analysis. His use and improvements of the Chenenard balance in ascertaining proper drying or ignition temperatures and stabilities of both well-established and new analytical precipitates has provided a very decided impetus to further studies elsewhere. It is encouraging to see evidence of considerable work of this sort being undertaken at various laboratories in the United States.

Perhaps second only to the measurement of mass in analytical operations is the titration. We have here really several problems, including detection of the endpoint, actual mechanical addition of the titrant, and measurement of the volume added, as well as more minor steps of placing a measured quantity of the sample into the titrating flask, of standardizing the titrant and of calculating the results etc.

Electrolytic or coulometric generation of titrants with suitably accurate sources of current not only reduces the need for preliminary standardization of reagents, but permits continuous or automatic intermittent titration of reactions while they are occurring, or of flowing streams.

While separations are avoided whenever possible, it is safe to predict that they will not only be with us but will increase considerably in the future. The most tedious steps in gravimetry often are those of precipitation, filtration and washing. Little has been offered us to automize these techniques. Conversely, automatic volatilization separations have been accomplished very elegantly. Automatic analytical stills are in widespread use, especially in hydrocarbon

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work. Controlled potential electrolysis is a valuable contribution to improved electrodeposition separations. The current fad, of course, is chromatography, and the recent popularization of gas chromatography has received much attention. We have already seen some indications of the power of this tool to achieve separations of small quantities of even high-boiling constituents. How else would you separate a series containing all members between C_{12} and C_{36}?

Since separations are to be avoided, we are forced to consider what measurable physical properties the desired constituent may have which differ from the matrix of the sample. Probably the most famous example of a pay-off of this line of thinking is Linus Pauling's oxygen analyzer based on the phenomenal paramagnetism of oxygen.

There are many other examples, especially those involving spectrophotometric measurements where specific properties have been sought and found which enable direct determination of the unknown material. For example, very small double-beam filter photometers capable of fitting on the lobe of a person's ear have proven valuable for measuring the oxyhemoglobin content of the blood.

Professor Seaborg was quoted recently as saying "The day has passed when we can expect our scientists to understand every detail of the experimental equipment upon which they depend. The housewife is freed from menial tasks by a battery of gadgets whose mechanical and electrical design she fails to comprehend. Our overburdened scientist should be granted some of the same luxury".

Concerning automatic calculations, the key calculator and strip-chart recorders only scratch the surface. We have available to us modest-sized computers versatile enough to handle all problems likely to be encountered in analytical and physical testing control and research, at costs which are moderate, compared not only to the man-hours saved, but also when evaluated against the extra information obtainable. The important subject of inter-laboratory standardization calls for this approach.

In summary, I believe that what some call the "laboratory revolution" will continue to be taken advantage of by analytical chemists in the interest of doing a better job in the face of increasing challenges. And the once-heard semi-facetious cry of running the thesis or a progress report directly off a recorder need not phase us!

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

Nineteenth Summer Conference

August 19-24, 1957

The conference will be held at Colby College, Waterville, Maine. On this college campus, not far from Great Pond and Belgrade Lakes, there will be an excellent opportunity to combine the pleasures of a vacation with the challenge of a good technical program. An outline of the events of the week follows.

Monday evening

"Greetings," Julius B. Bixler, President of Colby College

"Industrial Research and the Public Welfare," Miles J. Martin, General Electric Research Laboratory.

Tuesday morning

"Closed Circuit TV," Grant W. Smith, Pennsylvania State University.

"Inductive Chemistry at the Secondary Level." Sister Ernestine Marie, S.C.H., Msgr. Ryan Memorial High, Dorchester, Mass.

"The Training of Students for Graduate Work in Chemistry," Evans B. Reid, Colby College.

Tuesday afternoon

"The Role of Chemistry in Modern Metallurgical Engineering," Arthur A. Burr, Rensselaer Polytechnic Institute.

"Classification and Chemistry of the Elements in Terms of Electron Structure," Arthur N. Wrigley, Eastern Regional Research Laboratory.

Tuesday evening

"Colors of Life," Alsoph H. Corwin, The Johns Hopkins University.

Wednesday morning

"The Present Status of Geochronometry," Wallace Broeker, Columbia University.

"Scientific Manpower Problems," Harry F. Lewis, The Institute of Paper Chemistry.

Wednesday afternoon and evening

Trip: Keyes Fibre Co., Plastic Molding, Waterville, Maine or C. F. Hathaway Co., Shirt Manufacture, Waterville; Picnic; Theatre Party.

Thursday morning

Symposium, "Atomic Structure and Chemical Reactivity."

"Covalent and Ionic Binding," Donald C. Gregg, University of Vermont.

"Redox Reactions and Electrochemistry," John A. Timm, Simmons College.

"Periodic Table," Harry H. Sisler, University of Florida.

Thursday afternoon

Each of the symposium speakers will conduct discussion meetings on his topic, in two Sections.

Thursday evening

"Synthetic Sapphires — From Gems to Industry," A. K. Seemann, Linde Air Products Co.

Friday morning

"The Development of New Products for the Pharmaceutical Industry," Frederick J. Pilgrim, Charles Pfizer Co., Inc.

"The Role of Chemistry in the Development of Methods for Utilization of Nuclear Energy." Herbert M. Clark, Rensselaer Polytechnic Institute.

Friday afternoon

"Chemistry in the Manufacture of Modern Gasoline," Charles N. Kimberlin, Jr., Esso Research Laboratories, Baton Rouge, Louisiana.

Friday evening

"A Century of High School Science," Sidney Rosen, Brandeis University.