

# THE NUCLEUS

October 1994

Of the Northeastern Section of the American Chemical Society

Vol. LXXIII, No. 2

## Monthly Meeting

*Professional Relations Meeting;  
Hill Award to William O. Foye;  
Edward Berger on Ethical Issues*

## Safety

*A Swift Kick into Safety*

## Phosphate

*The Earthy Industry*

## Workforce Report

*Retirement of Chemists*



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Office: Marilou Cashman, 23 Cottage St., Natick, MA 01760. 1-800-872-2054 (Voice or FAX) or (508) 653-6329. Any Section business may be conducted via the business office above. Washington, D.C. ACS Hotline: 1-800-227-5558

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**Cover:** William O. Foye, 1994 Henry A. Hill Awardee. (Photo by A. Finland)

**Deadlines:** December issue: October 21, 1994

## THE NUCLEUS



Dedicated to the Memory of James Flack Norris  
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**Editor:** Arno Heyn, 21 Alexander Rd., Newton, MA 02161, Tel: 969-5712, FAX: 527-2032

**Associate Editor:** Myron S. Simon, 20 Somerset Rd., W. Newton, MA 02165, Tel: 332-5273

**Board of Publications:** Michael E. Strem (Chair), Joseph A. Lima, E. Joseph Billo

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**Advertising Manager:** Vincent J. Gale, P.O. Box 1150, Marshfield, MA 02050, Tel: (617) 837-0424 FAX: (617) 837-8792

**Contributing Editors:** Edward Atkinson, History of Chemistry, Book Reviews; Maryann Solstad, Health; Tari Varco-Shea, Calendar.

**Proofreaders:** Ernest I. Becker, Donald Rickett, M.S. Simon

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## Board of Directors

*NOTE: Board meetings are held on the section meeting day at 4:30 p.m. Members are invited to attend.*

### Condensed Minutes Meeting of May 12, 1994

**Chairman's Report:** J. Kaufman asked for volunteers to act as tellers for the May election. He forwarded a request by the NEACT for funds to support summer conference participants who need financial help to attend. The national ACS office is asking for a formal renewal of funding for the James Flack Norris Award for Physical Organic Chemistry. Dr. Kaufman quoted H. Merrell, Assistant to the ACS Executive Director for Governance Affairs, that addressing minority concerns is a survival question for the future.

**Treasurer's Report:** J. Piper presented the current budget status and it was VOTED to accept the Treasurer's report.

**Archivist:** M. Simon reported that Polaroid has agreed to house the archives of the Section.

**Councilors:** E. Hopkins stated that minutes of the March Council meeting have been sent to all Councilors and may be made available to anyone interested. M. Hoffman reported that 1000 undergraduate students had participated in the spring ACS meeting, a record number.

### Committee Reports:

**Education:** M. Hoffman announced that Dorothy Bagley has resigned from the High School Education Committee after long and loyal service and will be replaced by Steve Lantos. P. Samuel reported that Dr. Lansbury, the speaker at the Undergraduate Research Symposium, had spoken with all of the undergraduate research student participants about their research.

**Esselen Award Committee:** After clarifying the budget question of the Esselen Committee, the board VOTED:

"With regard to NESACS Board Meeting Minutes of March, 1994,

## ACS TV Satellite Programs

U. of Massachusetts-Dartmouth will participate in the presentation of the following ACS TV Satellite programs:

### Teaching Chemistry, 1994 —

#### A Materials Science Anthology

November 7, 1994, 6:00 - 8:00 pm

Cost: \$25/person until October 16.

After October 16, \$30/person

#### Elements of Your Chemistry Career

November 10, 1994, 6:30-7:30 pm

No charge.

Both programs will be given at the UMASS Dartmouth — Library Browsing Area. To register for either or both programs contact:

Dr. James A. Golen

Chemistry Department

UMASS Dartmouth

North Dartmouth, MA 02747

Tel.: (508) 999-8245 ◇

paragraph 8 [of the unabridged official minutes], the discussion and sense of the Board had been based on incomplete information, and the Board is now satisfied that due procedure was followed by the Esselen Committee."

**Hospitality:** D. Howell stated that more than 130 dinner reservations had been made for this night's dinner.

**Professional Relations:** L. Rubin stated that the October meeting will be on scientific ethics, the meeting to be at Henderson House.

### Other Committees:

**Continuing Education:** A. Viola communicated through Dr. Kaufman that 29 participants had attended the highly successful Short Course on Organic Synthesis.

**Medicinal Chemistry Group:** M. Singer announced that the September 28 meeting at Tufts University will be a symposium on Combinatorial Chemistry, consisting of an afternoon symposium at 2:30 p.m. and evening meeting.

**Speaker's Bureau:** M. Solstad encouraged volunteer speakers to give their names to Dr. Michael Dube, the new head of the Speakers Bureau.

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## Nominations

### Gustavus John Esselen Award

The Northeastern Section is seeking nominations for its Esselen Award for Chemistry in the Public Interest.

The Award, consisting of a bronze medal and a sum of \$ 5,000, recognizes a chemist whose scientific work has contributed to the public well-being and has thereby communicated positive values of the chemical profession. The significance of this work should have become apparent within five years preceding nomination and the Awardee shall be a living resident of the United States or Canada at the time of nomination. There is no limitation to the field within chemistry: Thus, past awardees have worked in environmental chemistry, radiochemistry, steroid chemistry, ecological chemistry and biochemistry.

Nomination deadline is November 1, 1994. Nominations and inquiries should be directed to Dr. Arthur S. Obermayer, 239 Chestnut Street, West Newton, MA 02165. Joint nominations are acceptable. The award recipient will be notified by February 1, 1995. ◇

## Monthly Meeting

*The 764th Meeting of the Northeastern Section of the American Chemical Society*

### Professional Relations Meeting

#### The Henry A. Hill Award

#### Honoring 50-year Members

Thursday, October 13, 1994

Henderson House, Weston, MA

**5:30** Social Hour

**6:15** Dinner

**7:30** Evening Meeting, Dr. James Kaufman, presiding

Presentation of the Henry A. Hill Award to William O. Foye

Henry A. Hill — Esther A.H. Hopkins

Introduction of the Award Recipient — Phyllis A. Brauner

Presentation of the Award — James A. Kaufman

Presentation of certificates to 50-year members

**8:00** Ethical Issues in Laboratory Research

Edward Berge, Dean of Science, Dartmouth College

Refreshments will be served after the program.

Dinner reservations should be made no later than October 6. Please call Marilou Cashman at (800) 872-2054. Reservations not cancelled at least 24 hours in advance must be paid. Members, \$21.00; Non-members, \$23.00; Retirees, \$12.50; Students, \$8.00. THE PUBLIC IS INVITED. Anyone who needs special services or transportation, please call Marilou Cashman a few days in advance so that suitable arrangements can be made.

*Next meeting: James Flack Norris Award to be presented to Samuel P. Massie (Prof. emer., Naval Academy, Annapolis, MD), who will give the address: "An Arkansas Traveler". Thursday, November 10 at the Pearson Chemistry Building, Tufts University, Medford, MA. Reception and dinner 5:30, evening meeting 8:00.*

### Directions to Henderson House

Henderson House is located in Weston, MA, just north of the Weston-Wellesley line.

**Going West on Route 30.** A little over a mile west of the intersection of Rte. 128 and 30 and the Mass. Turnpike, take the hairpin left onto Oak Street. ("Oak Street to Cliff Road" sign). Follow the road on mile to a stop sign. Continue 200 yards further, take the

first right onto Westcliff Rd. and continue up the hill to Henderson House.

**Going West on Route 9.** Right after Rte. 9 passes under Rte. 16 in Wellesley Hills take the sharp right turn onto Cliff Rd. just after the GULF station. Proceed on Cliff Rd. for about 1/2 miles, just past the Wellesley/Weston line. Turn left onto Scotch Pine Rd. Bear right on the curves and follow the signs to Henderson House, which is on Westcliff Rd. on the left on top of the hill. ◇

## Biography

Edward Berger received a Ph.D. in Biology in 1969 from Syracuse University in the area of Genetics and Developmental Biology. Following postdoctoral work at Harvard University and the University of Chicago he accepted a faculty position in the biology department at SUNY, Albany. In 1975 he joined the biology faculty at Dartmouth, where he is currently the Albert Bradley Third Century Professor in the Sciences, and Dean of the Graduate School. In addition to his research on the molecular biology of insect hormone action, Dr. Berger carries out funded research in the area of Ethics, focussing on ethical issues emerging from the Human Genome Project, and on scientific ethics. ◇

## Abstract

### Ethical Issues in Laboratory Research

Over the past ten years America's scientific community has experienced growing public and federal criticism regarding the integrity of the research process.

The goal of my presentation is to describe some of the central issues constituting this concern, focussing on the professional responsibilities of scientists regarding mentoring, publication, and the reporting of alleged scientific misconduct. ◇

## Employment Assistance

The Committee for Employment Services will staff an information table during the 5:30 to 6:30 Social Hour at Henderson House. Information will be available concerning positions in the Northeastern and National areas. Services offered by the ACS Employment Clearing House, resumé and interview preparation and career assistance may be discussed with Committee counselors. ◇

# National Chemistry Week

November 6-12, 1994

The Northeastern Section, in cooperation with the ACS Division of Education and the UMASS Dartmouth, is sponsoring two satellite courses: *Teaching Chemistry, 1994* and *Elements of Your Chemistry Career* on November 7 and November 10, respectively. (See the separate announcement on p. 4). Additional sites may be added, to be announced in the November issue. These programs target high school students considering careers in chemistry.

In addition, Dr. Phyllis Brauner is planning some exciting events: A debate at the State House on Recycling Plastics and the annual symposium at the Museum of Science, which will focus on DNA, including forensic applications. We will feature an event to attract inner city youth, to be announced later. The Third Annual Northeast Regional Undergraduate Chemistry Day will be held at Boston University on November 5, and the James Flack Norris Award Meeting, honoring the outstanding educator Prof. emer. Samuel P. Massie, formerly of the U.S. Naval Academy at Annapolis, will be held November 10. See announcement of these events elsewhere in this issue. ◇

## Board of Directors

continued from page 4

**Old Business:** It was VOTED to renew support by the Section of the National ACS Norris Award in Physical Organic Chemistry.

**New Business:** The board continued the discussion of guest dinners at Section meetings without making a decision. ◇

# Third Annual ACS Northeast Regional Undergraduate Day

Boston University, Metcalf Center for Science and Engineering  
590 Commonwealth Ave., Boston, MA 02215

November 5, 1994, 9:00 a.m.

Sponsored by the Northeastern Section of the American Chemical Society in Celebration of National Chemistry Week

Welcoming and Keynote Addresses

Workshops: Making a Career in Chemistry  
Choosing a Graduate School  
Developing Interview Skills  
Preparing a Resumé

Graduate School and Industry Fair

**There will be a \$5 registration fee to cover morning coffee, lunch, and workshop materials.**

For more information, or if your school is interested in sending a representative to the Graduate School and Industry Fair, please contact Stephen Doherty at (617) 353-2503 (FAX: (617) 353-6466; internet: doherty@chem.bu.edu).

Hosted by: Department of Chemistry, Boston University  
Chemia (ACS Student Affiliates Chapter at Boston University) ◇

## New NESACS Program for Undergraduates

NESACS introduces a new program for undergraduate students this year to encourage them to attend national ACS meetings. Funds are available for grants-in-aid of \$250 each to four students at colleges within the Section to enable them to present papers on their research at the Undergraduate Research Poster Session within the Division of Chemical Education at the 209th National ACS Meeting in Anaheim, CA, April 2-7, 1995. The departments must, at a minimum, match the grant. Application forms are available from the departmental chairs and the Section office. The deadline for receipt of applications, which include a 150-word abstract, a two-page description of the research completed and planned, and a letter of support from the research supervisor, is Friday, November 11; the deadline for submission of the Abstract to the ACS is December 1. ◇

## Historical Note

Last year James G. Hershberg concluded a dozen years of research with the publication of his masterful biography, *James B. Conant: Harvard to Hiroshima and the Making of the Nuclear Age* (Knopf, New York, 1993, 948 pp., \$35.00). At the time I had the naive idea of writing a book review for the *NUCLEUS*, but wisely gave up the idea when I began to read the scholarly critical reviews that appeared in a wide variety of publications. The four reviews I am most familiar with are readily available in all libraries: McGeorge Bundy, *Nature* **368**, 365 (March 24, 1994); Kai Bird, *The Nation*, **258**, 495 (April 11, 1994); Carol S. Gruber, *Science*, **264**, 989 (May 13, 1994); and Wil Lepkowski, *C&EN*, **72**, 33-35 (July 11, 1994). Bundy knew Conant very well. By coincidence, Bird is currently writing a biography of Bundy!

Of the 948 pages of Hershberg's book only 64 deal with Conant's early life and years as a chemist up to his becoming president of Harvard. During

those years he was a member of the Northeastern Section and served as our Chairman in 1921. Appendices, footnotes, and the index occupy 174 pages. The footnotes are very important. While constantly referring to them at the back of the book I was reminded of what someone has called "the tyranny of footnotes". The subtitle is an accurate description of its major contents and all reviewers agree that Hershberg has made a major contribution to the early history of the atomic age.

This book prompts me to record a couple of Conant stories. There remain a few of us New England chemists who had the privilege of attending a luncheon at the Harvard Faculty Club in October 1945 at which Conant and Karl Compton swapped stories of their war years for over two hours. Tape recorders were not common in those days, a pity.

When Conant became president of Harvard in 1933 the sales of his organic chemistry text shot up and he became a drawing card at those few chemical functions he continued to attend. One such affair was an organic chemistry symposium at which he delivered a talk on the heats of hydrogenation of ethylenic linkages. The interesting feature of this presentation was that he admitted that the work described was not his, but that of George Kistiakowsky whom Conant had lured to Harvard from Princeton a few years earlier. I can't exactly remember the lame excuse that Conant gave for his serving as George's mouthpiece. (George spoke excellent English at the time.) He obviously knew what to do to attract a crowd.

Edward R. Atkinson,  
Amherst, MA ◇

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# ACS Short Course

## Pharmacology For Chemists

A Two-Day Short Course Sponsored by the Northeastern Section, ACS, Committee on Continuing Education

National ACS is making top-rated ACS Short Courses available to local sections at tuition fees greatly reduced from the normal \$785. The NESACS Committee on Continuing Education is pleased to present this course, which has been offered successfully at each National ACS Meeting since 1979.

**Dates and Time:** Thursday, Nov. 17, 1994, 8:30 a.m. – 6:00 p.m.  
and Friday, Nov. 18, 1994, 8:30 a.m. – 6:00 p.m.

**Place:** Snell Library, Room 90, Northeastern University, 360 Huntington Ave., Boston, MA

### Program Agenda:

*General Concepts and Principles of Pharmacology:* definitions, survey of the literature; membrane models; structure of liquid water and implications to pharmacology; absorption and distribution of drugs; active and passive transport; drug metabolism; storage, excretion and enzyme induction; receptor site theory; theories of drug activity; pharmacokinetics; primary drug screening; dose ranges; acute toxicity; LD<sub>50</sub> and ED<sub>50</sub>; dose response — potency vs efficacy.

*Nervous System:* anatomy and physiology; the reflex arc; autonomic nervous system, autonomic physiology and pharmacology; cholinergic agonists and antagonists; adrenergic agonists and antagonists; analgesics and related agents - non-narcotic, narcotic-endorphins, narcotic-antagonists.

*Chemistry of the Mind:* physiology and neurotransmitters in the central nervous system.

*Cardiovascular Agents* — if time permits.

**Instructor:** Joseph G. Cannon, Professor and Head of Medicinal Chemistry and Natural Products, College of Pharmacy, University of Iowa. Prof. Cannon is one of the highest-rated instructors in the ACS continuing education program.

### Pre-registration Required — Registration Fees:

ACS Members if mailed before Oct. 31 ..... \$225.00; after Oct. 31..... \$275.00  
Non-ACS Members if mailed before Oct. 31 ... \$325.00; after Oct. 31..... \$375.00

There will be a limited number of scholarships for unemployed ACS Members on a space-available basis.

Parking Fee \$3.00/day University cafeterias will be available for lunches.

For further information contact: Prof. Alfred Viola — (617) 373 2809

### Registration form for Short Course: Pharmacology for Chemists

Name: \_\_\_\_\_ Affiliation: \_\_\_\_\_

Mailing Address \_\_\_\_\_ Telephone: \_\_\_\_\_

Mail with remittance to :  
(Please make checks payable  
to NESACS)

Prof. Alfred Viola, Chair  
NESACS Committee on Cont. Ed.  
Department of Chemistry  
Northeastern University  
Boston, MA 02115

## ACS News

### Workforce Report on the Nature of Retirement for Chemists

Condensed from the December 1993 Workforce Report by Joan S. Burrelli, Office of Professional Services, ACS

Early retirement incentives have been used widely in the U.S. chemical industry in the past decade as a means of reducing the labor force during the massive restructuring which has occurred. Consequently, there has been great concern about the economic and professional status of older chemists. Mergers and acquisitions of companies, often accompanied by cuts in the workforce in an attempt to trim costs, have become widespread. Job loss increased during the recent recession. Even though the recession is 'officially over' restructuring and downsizing continues.

Older chemists are especially hard hit because they are less likely to find

other employment than younger chemists who have also been terminated. Current recruiting concentrates on seeking some new graduates, with very few openings for more experienced workers.

In 1993 the ACS conducted a survey of retired or retirement age members to provide information about retirement and terminations.

Specific answers were sought on:

- the extent to which retirement is voluntary or involuntary
- adequacy of pensions—are member financially hurt by early retirement or multiple terminations?
- post-retirement employment options—are early retirees who wish to continue working able to get another job in chemistry?

Surveys were sent in March 1993 to 5,083 members who were either in retired dues status or between ages of 55 and 70. By May 68% had responded.

The survey found that the restructuring and downsizing have adversely affected some older members, but most members in the 55–70 age range are

either employed or voluntarily retired.

Restructuring has bypassed most members employed in government or in colleges and universities. Currently, some government agencies are offering early retirement options and some universities have done so, but most of the older chemists among this group retire voluntarily and are happy with their retirement. Of those formerly or now in industry, only about half are currently or formerly retired, and less than half of these were offered an early retirement package.

As a summary, between 71 to 93% stated that the timing of retirement was at the right time; between 48–62% expressed themselves as being very satisfied with retirement, about a third were moderately satisfied, with between 2–9 % being dissatisfied; between 58 to 78% considered their pension adequate, with the lower figure being in industry, and between 13–35% stating that the pension was less than adequate. A small percentage considered their pension more than adequate (4–10%). In terms of percentage of salary, the figures followed a broad gaussian curve with the peak being between 50%–74% of salary. For those under age 65, the predominant model appeared to be jointly paid health insurance between the retiree and former employer, with this being virtually the only option for former government employees.

The average age at the time of retirement for industrial employees was 60, for government employees was 59, for academic employees 62.

The report gives details of the pension plans, pensions as percent of final salary, availability of pre-retirement counseling and post-retirement or post-termination employment. To quote the Conclusion:

"Some older members, especially those formerly employed in industry who were offered early retirement packages or were terminated have been negatively affected by the poor economy of the last few years. Most members in the 55–70 age range, however, are either currently employed or voluntarily and happily retired, especially those who were employed in government or in colleges or universities. About 40% of the retirees who

were formerly employed in industry were offered an early retirement package. They are much less happy with retirement than those who retired voluntarily, although their benefits are, for the most part, the same. Older members who were terminated by their employers (about 8% of the respondents) had much less notice of their impending job loss than did early retirees and are faced with high unemployment and, for many, a lack of health insurance. Many, though, have now found new employment. Most of the respondents who were terminated, about one-fourth of members who formerly retired from industry or government and about 13% of those who retired from academe, are now working. Most are employed in smaller firms or colleges, most got their current job through personal contacts, and most found their job within six months."

Copies of the Workforce Report or of the full parent report "The Economic and Professional Status of Retired Chemists" are available free of charge from the ACS Office of Professional Services, Corinne A. Marasco, Editor, 1155 Sixteenth St., NW, Washington, DC 20036. ♦

## Book Review

### American Chemists and Chemical Engineers, Vol. 2

Wyndham D. Miles and Robert F. Gould editors  
Gould Books, Guilford, CT, 1994, 365 pp, ISBN 0-9640255-0-7, \$23.00 postpaid

by Edward R. Atkinson

Volume 1 of this series, edited by Wyndham Miles, was published by the ACS in 1976 as one of the ACS Centennial activities. It was reviewed in these pages as a *Historical Note* (*The NUCLEUS*, 55, No. 1, 10, October 1976); copies of the review are available on request to Edward R. Atkinson. Copies of Volume 1 are still available from the ACS Books Department.

Now Wyndham Miles has been joined as co-editor by Robert Gould, formerly managing editor of C&EN and head of the ACS Books Department. They and 40 contributors have produced 269 biographical sketches similar in style and length to the 571 sketches in Volume 1. Of the sketches in the present volume Miles has writ-

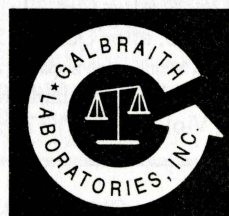
ten 98 and Gould 24. The sketches in Volume 2 include not only persons who have died during the 18 year interval since Volume 1, but also many persons whose sketches were not available when Volume 1 went to press. There remain to be written sketches for dozens of prominent American chemists and chemical engineers and we hope that they can all be included in a projected Volume 3. Gould Books elected to publish the current volume when a fee for the ACS imprimatur seemed excessive.

All sketches include references to works where more detailed information may be found. Cross references to sketches in both volumes are common. Volume 2 includes a 66-page index which increases the archival value of

continued on page 10

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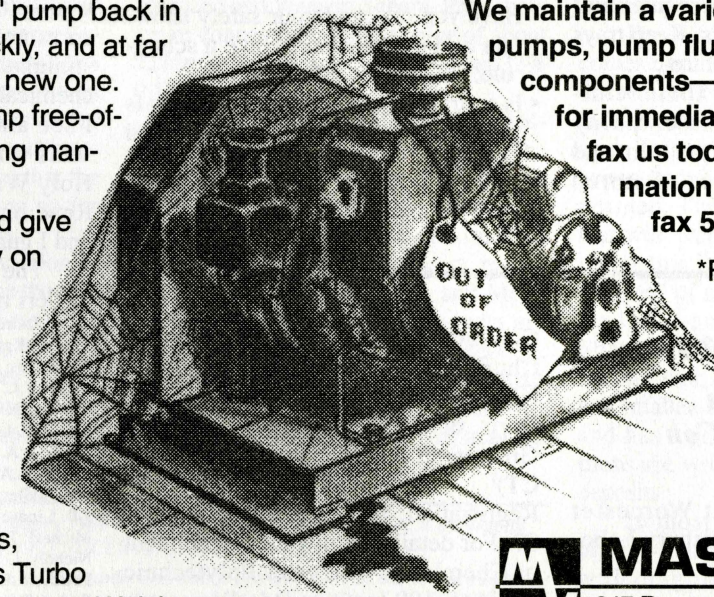
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## Health and Safety on My Mind

by M.A. Solstad

### A Swift Kick Into Safety

I've just been visiting a small college chemistry department. Their facilities are not what they knew they should be; they wanted me to tell them in writing what they really knew, but couldn't quite get a handle on. In other words, to kick them in the rear, along with the people holding the purse strings. People concerned with safety are often viewed as a pain by those who are doing "more important things." If that is the case with your laboratory, these reminders will help:

- Check your 4 A's of Safety:  
ATTITUDE Without this all else is useless.  
AWARENESS Get your information straight. Look around.  
AUTOMATIC Safer way to work should be automatic.  
AUTHORITY To lead and to discipline.
- Update your chemical inventory
- Organize you MSDS's
- Does your chemical storage make chemical sense. Avoid proximity of reactives or incompatibles. Forget the alphabet for chemical storage organization. Keep corrosives and liquids on lower shelves. Keep trays under bottles as spill control.
- Have your hoods had their semi-annual checkup? Have face velocity checked: Between 60 fpm min. and 150 fpm. Are they free of stored items?

## Demonstrations

### as a Teaching Tool in Chemistry: Pro and Con

One day Conference at Worcester Polytechnic Institute, Salisbury Laboratories (Free parking).

Saturday, October 15, 1994, 9--5.

- Do students know how to work with a fume hood? more than 5" back from the face of hood; sash lowered to marked optimum height; extra junk kept out of hood and away from slots; avoid extra activity and traffic in front of hoods; keep head out of hood, except during setup.
- Are you firm about safety goggles in the lab? (Where there is no splash hazard, safety glasses might be permitted). Are sandals, long loose hair, bangles forbidden in laboratory work?
- Do you have an emergency plan in place? Including:  
Evacuation route; assembly point  
Gas, electricity shut-off.  
Whom to notify in building, Fire department, government, DEP, EPA, etc.  
Is a list of emergency numbers near each phone?  
Where are spill kits; fire extinguishers?
- Do you have a chemical hygiene plan? If not, get busy. Is it up-to-date?  
Can you comply with your CHP? If you comply, would your chemists be safe?
- Have you checked your safety showers and eye washes? Have a schedule. Flush eye washes daily.
- Is a strict labeling policy in effect. Is every solution named, initialed and dated? ◇

Conducted by: Paul Kelter (Dept. of Chemistry, U. of Nebraska, Lincoln NB) and Ron Perkins (Chairman-Elect, Divis. of Chem. Education, ACS and Greenwich High School, Greenwich, CT)

Registration: \$10; Lunch available for \$7. For details contact the Department of Chemistry, Worcester Polytechnic Institute, 100 Institute Rd., Worcester, MA 01609-2280. ◇

## Book Review

continued from page 9

the work. Of the persons included in Volume 2, 37 were born before 1800 and 10 became college presidents. The authors of the individual sketches generally include frank personal comments of a type not found in formal biography. Consider, for example, the Miles sketch of James Henry Salisbury (1823-1905) whose name was passed on to later generations in "Salisbury Steak", the restaurant name for a hamburger patty (before McDonald's) but who did the reputation of chemists a favor.

There are few errors in the work. Your reviewer was responsible for the incorrect statement that George Shannon Forbes taught at Northeastern University for 18 years after his retirement from Harvard. The Northeastern Faculty assures me that Forbes taught there for only about 5 years.

Of the 269 sketches in the current volume 61 are about men and women who clearly spent significant portions of their professional lives in New England. There are many others who were born or educated here before striking out for the hinterland west of the Hudson River. In my opinion, chemistry libraries in both academic and industrial settings should own these books so as not to deprive their clientele of stimulating moments in chemistry and chemical engineering. For personal use I see an analogy with those devout souls who are said to read a chapter of Holy Writ before retiring each night. Read one of these sketches each day and I guarantee pleasant dreams.

The 61 biographies of New Englanders mentioned above include:

C.W. Andrews; W.O. Atwater; H.W. Atwater; W.H. Bassett; Katherine Blunt; W.C. Bowen; W.S. Brown; G.J. Brush; Henry Carmichael; J.S. Chamberlain; L.F. Clark; J.L. Comstock; J.B. Conant; J.R. Cotting; Bradley Dewey; W.P. Dexter; Asa Ellis, Jr.; Ebenezer Emmons; L.F. Fieser; G.S. Forbes; Martin Gay; S.F. Green; D.A. Hahn; Benjamin Hale; Frederick Hall; E.P. Harris; A.A. Hayes; H.A. Hill; T.B. Hill; W.N. Hill; H.A. Iddles; John Johnston; F.G. Keyes; E.P. Kohler; J.B. Lindsey; N.S. Manross; J.M. Merrick, Jr.; H.A. Michael; J.A. Nash; L.C. Newell; J.R. Nichols; W.R. Nichols; G.S. Olds; S.F. Peckham; C.H. Peirce; John Peirce; E.D. Peters; M.A. Phelps; A.L. Porter; J.A. Porter; T.R. Pynchon; F.C. Robinson; S.P. Sharples; C.U. Shepard, Sr.; M.S. Sherrill; E.P. Stevenson; J.E. Teschermacher; W.H. Walker; C.M. Warren; R.P. Williams; R.B. Woodward. ◇

## Phosphate – The Earthy Industry

by James V. Thompson<sup>1</sup>

Phosphate is very important in our personal life, inasmuch as it is contained in our bones. The fertilizer industry assay *BPL*, meaning *Bone Phosphate of Lime* or  $\text{Ca}_3(\text{PO}_4)_2$  has its history in the phosphate content of bones. At one time bones were the major source of phosphate for fertilizer. While the use of phosphate containing natural materials, such as bones, fish, dung and guano, goes back into great antiquity, having been mentioned by writers in 200 B.C., the nature of the phosphorus content was not understood. It was Palissy in 1550 A.D. who first suggested that the fertilizer value of dung came from the soluble salts that it contained.

Brand, a German chemist, is credited with discovery of phosphorus in 1669. In his search for the philosopher's stone he evaporated large quantities of urine. (One would hope that he had an adequate fume hood!)<sup>2</sup> He is said to have obtained a substance that was luminous in the dark and he named it *phosphorus* (ed. in Greek, *light bearer*). Gahn, a Swedish chemist, in 1769 seems to have been the first to discover that human and animal bones contain phosphorus. In 1775 Scheele published a description of a method to prepare elemental phosphorus from bones, employing charcoal as a reductant in the absence of air. Bones became the principal raw material for phosphates by the mid-nineteenth century. They were in such demand that the battlefields of Europe were dug up for their human and animal remains.

The basic process for conversion of bones to fertilizer was to calcine them to get rid of organic matter, and treat the calcine with sulfuric acid (a British patent in 1842). The product was what is today called normal superphosphate, a mixture of anhydrite ( $\text{CaSO}_4$ ) and mono calcium phosphate,  $\text{CaH}_4(\text{PO}_4)_2$ .

<sup>1</sup>Reprinted by permission from the February 1989 VORTEX of the California Section. A biography of J.V. Thompson is in the September 1993 NUCLEUS, p. 15

<sup>2</sup>(ed.) According to H. Remy's *Treatise on Inorganic Chemistry*, this was done in the absence of air. I can second the aside about a fume hood: As a graduate student I was once given the task of analyzing a 24 hour sample of urine for lead, which required evaporation to dryness. While doing that without the benefit of forced-draft fumehoods, then unavailable to me, I managed to drive everyone out of the Chemistry Building during that weekend!



Alchemist Brand discovering phosphorus after the big 1669 boil-down

By the mid-nineteenth century it was becoming obvious that there were limits to the supply of bones and that some other source of phosphate must be developed. In 1867 phosphate rock in the U.S. was first mined in South Carolina. The Florida "Land Pebble" deposits in the Bartow area were first mined in 1888, Tennessee mining started in 1894, and in the Western States in 1906. In 1965 one mine in North Carolina was brought into production by what was then Texas Gulf Sulfur Company.

### Mineral Raw Materials

Phosphate ores are found in many parts of the world. The United States has the highest production, followed by Morocco and Western Sahara. Phosphate ore or concentrates have a value of about \$23/mt at an average grade of about 32%  $\text{P}_2\text{O}_5$ .

In the Florida and Tennessee phosphate fields, while ore is still in the ground and progressing through the washer or concentrator, the analysis is kept in "Bone Phosphate of Lime" or "BPL" [ $\text{Ca}_3(\text{PO}_4)_2$ ]. In the west, meaning Utah, Wyoming, Idaho, and Montana, ore grades and mill products are reported in  $\text{P}_2\text{O}_5(\text{P}_2\text{O}_5 \times 2.18 = \text{BPL})$ . Phosphate rock or concentrates, also called "rock" in the trade, when converted to fertilizer products, are assayed in terms of  $\text{P}_2\text{O}_5$  content.

### Types of Phosphate Deposits

There are two general types of deposits in the United States and the world. These are igneous deposits containing the mineral apatite, and sedimentary deposits of marine origin containing phosphate pellets or oolites. The formula for apatite is  $3\text{Ca}_3(\text{PO}_4)_2 \cdot \text{CaF}_2$ . The phosphate in sedimentary deposits has about the same formula. There is no phosphate produced from apatite in the U.S. at this time. The sedimentary deposits range from the semi hard rock types in the West and Tennessee to the poorly consolidated and geologically younger deposits of Florida and North Carolina.

The age of the deposits ranges from Ordovician in Tennessee (350 million years ago) to Permian in the West (200 million years ago) to Miocene in Florida and North Carolina (25 million years ago).

Most Western ore requires very little concentration and after calcining to remove organics goes directly into fertilizer manufacture. The unconsolidated ores of Florida and North Carolina all require concentration before conversion to fertilizer products.

### Summary of Florida Phosphate Industry

By far the greatest production comes from Florida and in 1986 the state accounted for about 84% of the total U.S. production. The Florida mines are open cast or "strip" mines. The mining areas are flat and in places poorly drained. There is a sandy overburden that will average 15 to 25 feet thick and under this is the "matrix" made up of "slimes" of about 5 microns in size, silica sand—mostly <1.0 mm—and phosphate pebbles ranging from a few coarser than 6 mm down to 50 microns and smaller. Matrix is 10 to 30 feet thick, and has a grade of 6 to 15% BPL, but there are wide variations in grades of deposits.

In most Florida operations both mining and stripping is accomplished with dragline excavators. This ore is slurried with water and pumped to the

continued on page 12

## Phosphate

continued from page 11

washer or concentrator which may be one to two miles away. In the early days of phosphate production in Florida the treatment plant was called "the washer" and, indeed, that's all it did. The matrix was scrubbed in a log washer and passed over a vibrating or rotating trommel screen with an opening of 1.0 mm to 3.0 mm. The oversize was the "pebble" phosphate with a grade of 72 to 80 BPL and it was the only product. The screen undersize contained much usable phosphate.

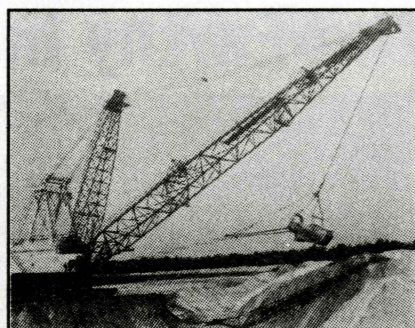
In 1925 a froth flotation process was developed to concentrate the finer fractions. In this process the solids are treated with reagents that selectively coat the phosphate and not the silica sand. The reagents, mostly fatty acids and diesel oil, cause the phosphate particles to adhere to an air bubble which lifts or "floats" the phosphate to the surface of a flotation machine, leaving the silica behind ("tailings"). Before reagentizing, the slimes must be removed because they would consume too much reagent due to their vast surface area ("slimes" are hard to define; in general they are hydrated clay minerals finer than 400 mesh). Phosphate operations in Florida produce two waste products. These are the slime tailings, which still contain much phosphate and will assay as high as 30 BPL, and the silica floatation tailings. The silica tailings are not much of a problem, but slimes are forever. They can seldom be thickened to over 10 to 12% solids and after standing for years in a pond they may not exceed 20 to 25% solids. Admixing with stripping overburden and storing them in worked out areas is one solution (of sorts). A young engineer can go to retirement working on this problem.

### Tennessee Phosphate Rock

The deposits are contained in limestone. Weathering has removed the limestone over long periods of time by action of surface and ground waters. The remaining material is phosphate oolites, clay and iron oxides. Tennessee rock at 50 to 60 BPL goes into electric furnace production of elemental phosphorus.

### Western Phosphate Rock

Most western phosphate ores are



A Bucyrus-Erie walking dragline used in the Florida phosphate mines

hard rock compared to the more placer like deposits of Florida, Tennessee and North Carolina. The deposits are located in Wyoming, Idaho, Utah and Montana. The reserves amount to billions of tons. The deposits are sedimentary of marine origin but the geology is too complex for a general discussion.

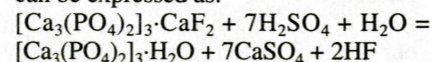
### Utilization of Phosphate Rock

Where phosphate rock is to be acidulated with sulfuric acid the iron and alumina content is important. The "I and A" content (the term used in the trade) should not exceed 2.5 to 4% combined. Iron and alumina remove phosphate from the "available"  $P_2O_5$  assay of fertilizers. Also, the weight ratio of CaO to  $P_2O_5$  should not exceed about 1.6 to 1.0 or else the cost of sulfuric acid may become prohibitive. Inasmuch as most phosphate is deposited in sea water it may contain chlorides. Chloride cannot exceed about 0.13% or severe corrosion may take place in the fertilizer plant. MgO can be a problem in wet phosphoric acid plants because, as the acid is concentrated, the  $MgSO_4$  concentrates. No more than 0.25% MgO is desirable. All phosphate contains fluorine. The content differs from place to place, but a  $P_2O_5/F$  ratio of less than 8:1 might cause problems with processing. Some phosphate, particularly in the west, has a high organic content and this can cause discolored phosphoric acid in wet acid plants and uncontrolled foaming in the agitators.

### Normal Superphosphate

This is the oldest of the phosphate fertilizers and it goes back to 1842 when sulfuric acid was mixed with calcined bones. In this process sulfuric acid is added to phosphate of 72 BPL or better to produce a mass that is allowed to

"cure" in a machine called a "den". Over the years there have been many patented dens but the purpose of all of them is the efficient and controlled production of normal superphosphate. The chemistry can be expressed as:

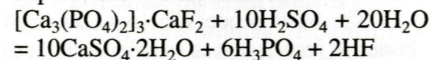


The product is monocalcium phosphate but the one molecule of water is removed at 120°C. The calcium sulfate is present as anhydrite. The HF will react with silica which is always present and forms  $H_2SiF_6$ . Almost everything that goes into the process remains in the product except some  $CO_2$  from carbonates, water vapor and some evolved fluorine compounds. The product in terms of  $P_2O_5$  is only as good as the raw material. A 21%  $P_2O_5$  product is considered good. Normal superphosphate plants have low capital cost compared to other phosphate fertilizer plants.

### Wet Phosphoric Acid

It is called wet because it is made from phosphate rock and sulfuric acid rather than burning elemental phosphorus to  $P_2O_5$  and adding water. Lower grades of phosphate rock can be used for wet phosphoric acid provided the "I&A", MgO, excess carbonate and organics are satisfactory. Grades as low as 68% BPL (30%  $P_2O_5$ ) can be used if the contaminant is mostly silica. Western phosphate is calcined to remove organics before use in phosphoric acid plants. The organics provide part of the calcining fuel. Of course, wet phosphoric acid is contaminated with all of the soluble material in the ore.

The chemistry may be complex but the following equation would seem to express the overall reaction:

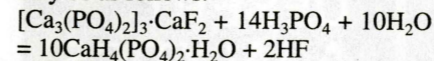


The process is operated in a manner designed to produce gypsum for reasons of filtration efficiency and recovery. Phosphate rock is fine ground and added to strong sulfuric acid. The phosphoric acid produced is about 62%  $H_3PO_4$  which is evaporated to about 75%. In recent years "super" phosphoric acid has been made containing over 100% because of  $P_2O_5$  being dissolved in the strong acid. It is a thick viscous liquid. Byproduct uranium, vanadium and fluorine compounds are recovered from

some plants. The waste gypsum produced is a big environmental problem. Attempts have been made to use the gypsum but there is a market for only a small quantity and the piles grow higher every year.

### Triple Superphosphate

Normal superphosphate is low grade (ca. 21%  $P_2O_5$ ) because it contains the anhydrite ( $CaSO_4$ ) that was present in its manufacture. In the manufacture of triple superphosphate, wet phosphoric acid (or furnace grade acid) is added to high grade phosphate rock. The compound monocalcium phosphate is the same in triple superphosphate as in normal superphosphate but there is no contaminating anhydrite. The chemistry may be as follows:



The HF reacts with silica in the rock to produce  $H_2SiF_6$  and this is at times recovered as a byproduct. Electric furnace acid can be used and more will be said about this later.

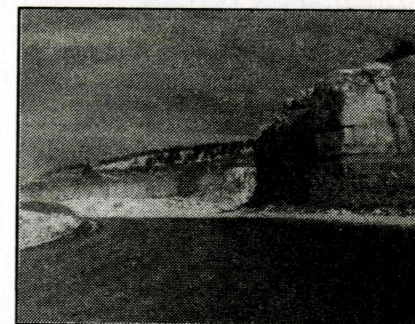
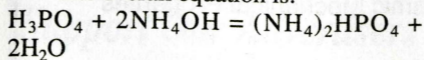
The best of triple superphosphate will assay about 48% total  $P_2O_5$  and 46% available  $P_2O_5$ , but much enters the market at 43 to 44% available, particularly in the West where lower grade rock may have to be used for mixing with phosphoric acid.

Triple superphosphate has all but replaced normal superphosphate. In the past, particularly in the Southeast, there were many small local compounders of normal superphosphate who bought rock and sulfuric acid and made the low grade product in a small den plant. These are being replaced by larger triple super plants that are part of a complete fertilizer complex.

### Diammonium Phosphate

Diammonium Phosphate, or "DAP", as it is often called in the trade, is simple to make and, of course, combines two fertilizer compounds in a single salt. Anhydrous ammonia and phosphoric acid are reacted to make the product. Either electric furnace phosphoric acid or wet acid made from phosphate rock can be used and byproduct ammonia from coke ovens or synthetic ammonia can be used.

The overall equation is:

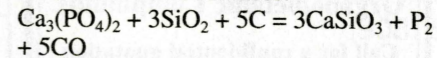


Ore face adjacent to haulage road near Vernal, UT. The top 60% is waste.

A sludge of DAP crystals is fed to a drying, sizing and granulating system.

### Elemental Phosphorus

Elemental phosphorus can be made in a blast furnace or an electric furnace. No phosphorus is made by blast furnace in the U.S. at this time. In simple terms, the following is the equation for both blast and electric furnaces:



Note that silica is required to slag the CaO content. It is from the fluid slag that the  $P_2$  is evolved as a vapor mixed with CO.

The feed must be either lump rock or agglomerated fines. Inasmuch as silica is required there would be no point in taking it out of the phosphate rock only to add it back to the furnace charge. For this reason electric furnace rock is only about 24%  $P_2O_5$  where the rock contains natural silica, as is the case with most phosphate rock of this grade. Furnace feed rock must have the proper "slagging ratio" of CaO and  $SiO_2$ . Iron in the ore takes up phosphorus to form ferrophosphorus which has metallurgical uses and can also be treated for its vanadium content. Furnaces are stationary, nontilting units as large as 60,000 KVA. Recovery of phosphorus in the feed is about 92% and the power required is about 13,000 kwh per ton of phosphorus. The electric furnace industry is energy intensive and has migrated to sources of cheap power, such as Niagara Falls, the TVA area and the area served by the Bonneville Power Administration.

Most elemental phosphorus goes into phosphoric acid of high purity compared to wet acid. Sodium and other phosphates are made from this acid as well as detergents which now have a bad

name with the environmental people. The electric furnace people in the West, with their newer and very large furnaces often have a surplus capacity and at times are accused of "dumping" cheap acid on the fertilizer market. This has been in the past a big political hassle between the electric furnace people and the wet acid producers. The wet acid manufacturers claim that the furnace acid is made with cheap public power and dumped on the market to their disadvantage. The energy crunch stopped this argument.

### End Uses and the Mixed Goods House

The products discussed herein, normal and triple superphosphate, diammonium phosphate, wet acid and electric furnace acid seldom get to the small consumer in these forms. A few large corporate farms might buy these products in carload quantities but most small farmers and home gardeners buy by the sack — and for the most part from the "mixed goods house".

The sack at the local nursery has three numbers printed on it in bold letters, such as 8-10-8. These tell the NPK content of the sack. N is for nitrogen (the only honest analysis), P is for "phosphoric acid" of which there is none, expressed as  $P_2O_5$ , of which there is none as such, and K is for potash, expressed as  $K_2O$ , of which there is none as such. These analytical terms are ground into state laws and can never be changed.

In addition to the products of the phosphate, potash and nitrogen industry the mixed goods house may use a few other weird compounds. Things like peanut shells, cottonseed hulls, dried blood, steamed bone meal, sewage sludge, coco meal, guano, manure of all kinds, whale guano (this one must be difficult to harvest) and fish meal. A sack of 8-4-4 retails in the San Francisco area for \$9.98 per 25 pounds. It is marked "organic based" which means that some, if not all, of the nitrogen comes from some of the crud listed above. Technical people in the fertilizer industry have for years sworn that there is no difference between "organic" nitrogen and ammonia or urea. The sack price works out to about \$800 per short ton and surely half of it is inert. ◇

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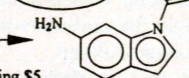
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# Calendar

## For additional information, call:

Boston College – (617) 552-8077  
Boston University – (617) 353-2537  
Brandeis University – (617) 736-2500  
Clark University – (508) 793-7116  
Dartmouth College – (603) 646-2501  
Harvard University – (617) 495-5333  
MIT – (617) 253-4080  
St. Anselm College – (603) 641-7148  
Northeastern University – (617) 373-2822  
Tufts University (Chemistry, Medford Campus) – (617) 627-3441  
Tufts University (Chemical Eng., Medford Campus) – (617) 627-3900  
Tufts University Health Science Campus – (617) 956-6867  
UMass Dartmouth – (508) 999-8232  
UMass Lowell – (508) 934-3650  
University of New Hampshire – (603) 862-1550

## October 3

Professor Peter Dervan (California Institute of Technology)  
“Sequence Specific Recognition of Double Helical DNA by Triple Helix Formation”  
Northeastern University  
Room 129 Hurtig Hall at 4:00 pm

## October 4

Professor Peter Dervan (California Institute of Technology)  
“Design of Peptides for Sequence Specific Recognition in the Minor Groove of DNA”  
Northeastern University  
Room 129 Hurtig Hall at 4:00 pm

## October 5

Dr. William F. Bailey (University of Connecticut)  
“New Developments in Organo-Lithium Chemistry”  
University of Massachusetts Dartmouth  
Room 305 Science & Engineering Building (Group II) at 4:00 pm

## October 6

Dr. Edward I Stiefel (Exxon Research and Engineering Co.)  
“Molybdenum and Sulfur in Cofactors, Catalysts, Complexes, and Clusters”  
Boston College  
Room 127 Merkert Chemistry Center at 4:00 pm

## October 12

Dr. John Farrington (Woods Hole Oceanographic Inst. and UMass Dartmouth)  
“Biogeochemistry of Organic Contaminants in Massachusetts Coastal Waters”  
University of Massachusetts Dartmouth  
Room 305 Science & Engineering Building (Group II) at 4:00 pm

## October 13

Professor Gilbert M. Nathanson (University of Wisconsin)  
“Molecular Beam Studies of Collisions and Reactions Between Gases and Liquids”  
Boston College  
Room 127, Merkert Chemistry Center at 4:00 pm

## October 18

Dr. K. Soosaar (Photon Research Associates, Inc.)  
“New Methods for Large Scale Molecular Dynamics”  
Northeastern University  
Room 129 Hurtig Building at 4:00 pm

## October 19

Dr. Philip W. Le Quesne (Northeastern University)  
“Isolation and Synthesis of a Psychoactive Alkaloid and a Bioactive Peptide”  
University of Massachusetts Dartmouth  
Room 305 Science & Engineering Building (Group II) at 4:00 pm

## October 20

Professor Clayton H. Heathcock (University of California Berkeley)  
“Total Synthesis of the Marine Alkaloid Petrosin: Why is a Natural Product with Eight Stereocenters Racemic?”  
Boston College  
Room 127, Merkert Chemistry Center at 4:00 pm

## October 26

Dr. James H. Weber (University of New Hampshire)  
“Methylmercury Compounds in Estuaries: Pollution or Nature?”  
University of Massachusetts Dartmouth  
Room 305 Science & Engineering Building (Group II) at 4:00 pm

## October 27

Professor Paul R. Schimmel (Massachusetts Institute of Technology)  
“Structure-Function Relationships of an Operational RNA Code for Amino Acids”  
Boston College  
Room 127, Merkert Chemistry Center at 4:00 pm

## Notices for the Nucleus Calendar should be sent to:

Tari Varco-Shea  
Department of Chemistry  
Wellesley College  
Wellesley, MA 02181  
Tel: (617) 283-3056  
Fax: (617) 283-3642  
e-mail: tvarcoshea@lucy.Wellesley.edu ◇

# THE NUCLEUS

19 Mill Road  
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