

THE NUCLEUS

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Of the Northeastern Section of the American Chemical Society

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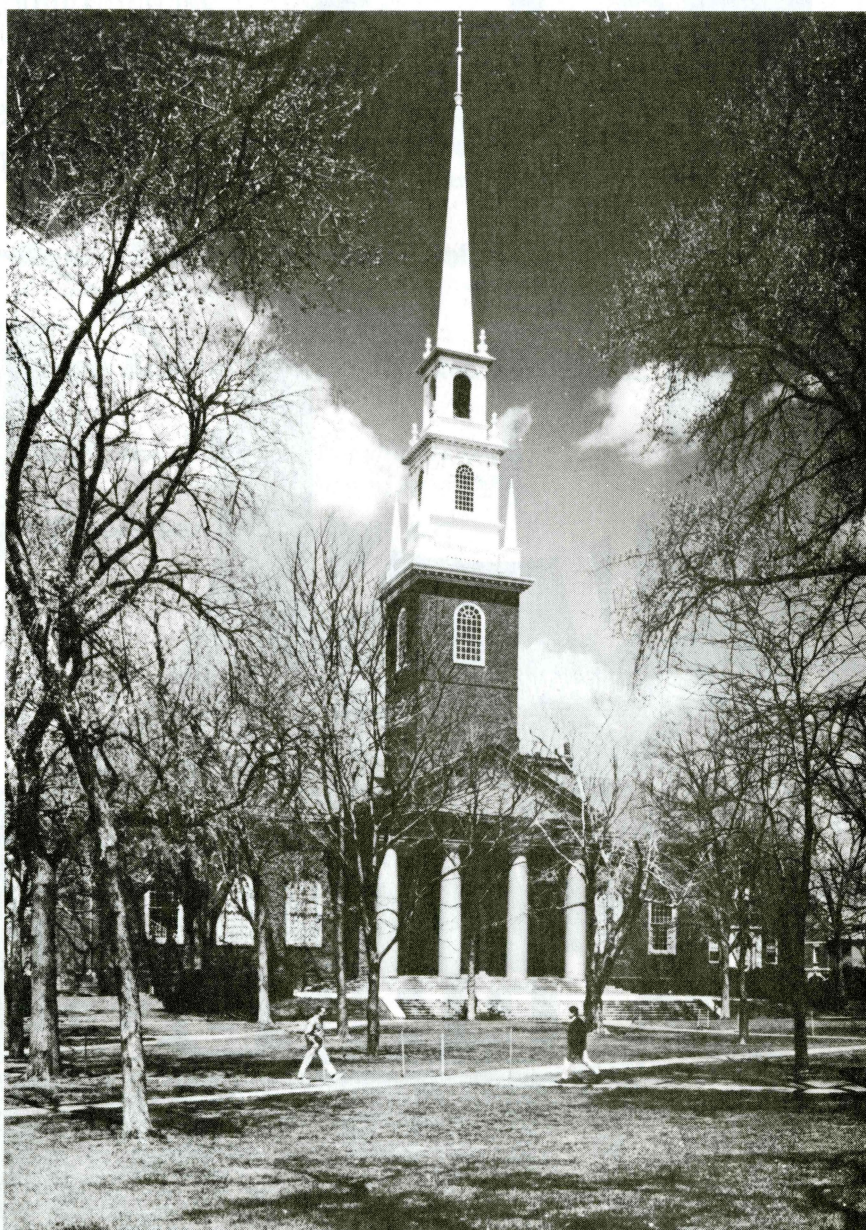
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Rowland and Molina*

1986 Summer Scholar Reports III

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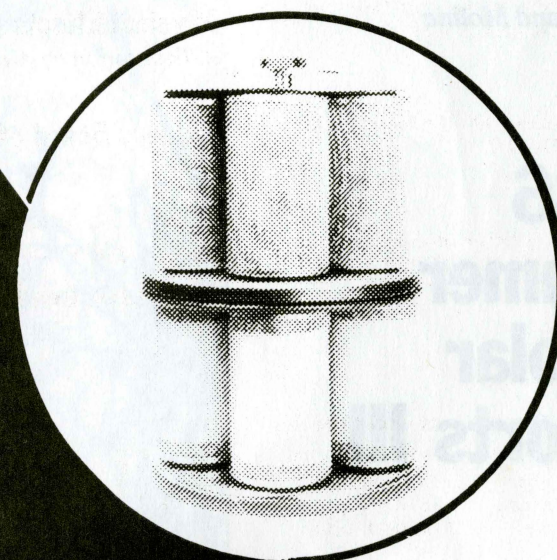


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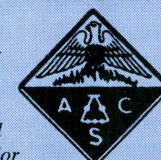
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Contents

Gustavus John Esselen _____ 4
Gentleman and Chemist, by Thomas R.P. Gibb

Monthly Meeting _____ 5
First G.J. Esselen Award for Chemistry in the Public Interest to be presented to F.S. Rowland and M.J. Molina for Stratosphere Studies

Medicinal Chemistry Meeting _____ 6
Prof. R.T. Borchardt on Design of Antiviral Agents

1986 Norris Summer Scholar Report III _____ 7
"Regulation of Aspartate Transcarbamylase," by Margaret A. Pitts

Physical Effects of Exponential Solutions _____ 10
A Translation by Arno H.A. Heyn

January Board of Directors Minutes _____ 12

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photo courtesy of Harvard News Office.

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THE NUCLEUS

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Gustavus John Esselen

Gentleman and Chemist

by Thomas R.P. Gibb

The technical contributions of chemists and chemical engineers are customarily freeze-dried and incorporated into the terse and stylized pages of journals, or patents . . . or they are bottled in pill-bottles or cosmetic dispensers, or contained in huge factory process-kettles on the way to becoming the materials that our advanced civilization demands. The great American Public seldom associates the fulfillment of these demands with the profession of chemistry.

Some of the contributions of Dr. Esselen are in this category. He and his associates solved problems that made production possible, or modified processes to make them more economical. His chemistry was sound and significant in the success of many businesses served by his consulting organization. His analyses of samples and of technical problems were ingenious and reliable.

Others will tell of these accomplishments of Dr. Esselen's; I want to tell about his interactions with a very large circle of people, including the American Chemical Society of which he was a Director and a Councilor, and with the Northeastern Section, whose Chairman he was in 1922 and 1923, following James Bryant Conant. (Only two other individuals have succeeded themselves as Chairmen.) The Section honored its favorite son with a unique tribute: the 1948 honor scroll named for James Flack Norris and given "to the person who has done most to advance the interests of this Section."

Gus is one of the shapers of the Section. His was the voice of reason on a great many argumentative committees. He was the source of ideas at Board meetings: what was best to do, and how to do it. He was on the Norris Bequest Committee when the wise and far-reaching decision to honor teachers of chemistry was made. He was the fatherly advisor to whom I turned for

advice when I was stunned by my election to the leadership of the Section.

I wish to tell more about Gus as a gentleman: scientists and engineers sometimes forget that there is more to their professional lives than the rearranging of pipes and valves, or molecules or wave-functions. I once gave a Phi Beta Kappa lecture whose theme was that one of the great contributions scientists make to human progress is the example provided by their enforced honesty, their skepticism of



'what everyone knows,' and their reliance on observation and reason. The role-model provided by Gus Esselen must have helped shape the character and career of many hundreds of people, not just young chemists but all those who came under his benign influence in his town, his church, his many clubs and associations. He had all the characteristics of a gentleman, not the least of which are kindness and humor.

When I moved to Marblehead in 1947, Gus persuaded me and my wife to join one of his clubs, the Swampscott Reading Club, one of the oldest dramatic groups in the country. Members met once a month or thereabouts, in some

member's home, to read aloud and act out a play, selected by a member other than the host. The Gibbs had about as much acting ability as Mortimer Snerd (Edgar Bergen's bashful dummy) but we were warmly welcomed by this group of kindly people. We learned to love some of the great plays 'performed.' Gus was the effective leader of this group, and his love and wide knowledge of literature helped all of us.

Gus died a few years later, October 1952. After recovering from the shock of his loss, the Section passed a resolution signed by James B. Conant, Kenneth Bell, Frederick S. Bacon and the Chairman, paying tribute to Dr. Esselen's contributions to chemistry and chemical engineering, "To his untiring and competent service to the American Chemical Society; and the wise and beneficent influence he exerted in this and the many professional societies to which he gave so generously of his time and ability; to his interest and active participation in church and civic activities."

How many prominent chemists will qualify in their eulogies for the "wise and beneficent influence" or the "interest and active participation in church and civic activities" phrases? It was here that Gus excelled. His son's gift to the Section is a testimony to his father's greatest service to chemistry: his example to those who admire, and also perhaps to those who do not admire the role of the chemist in society. As the proportion of the latter increases, as has been true, lamentably, the importance of the example we chemists provide for the general public is commensurately greater. We need more gentlemen-chemists like Gus Esselen!

I should like to tell a brief story which illustrates the esteem in which chemists are held by intellectuals who are not scientists: some years ago I was a delegate representing the ACS at the

Continued on page 15.

April Meeting

The 700th Meeting of the Northeastern Section of the American Chemical Society

The Esselen Award Meeting

Thursday, April 16, 1987

Harvard University Faculty Club

5:30 p.m. Preprandial Hour

6:15 p.m. Dinner

Harvard University Science Center

8:00 p.m. The Esselen Award
— M.S. Simon

8:05 p.m. Gustavus John Esselen
— E.R. Atkinson

8:20 p.m. F. Sherwood Rowland and
Mario J. Molina
— A.S. Obermayer

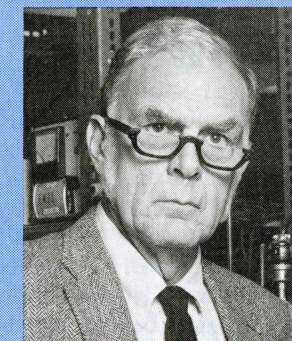
8:35 p.m. Presentation of Gustavus J.
Esselen Award to Drs. Rowland
and Molina—M.S. Simon

8:40 p.m. Laboratory Chemistry and Stratospheric Ozone—M.J. Molina

9:10 p.m. Chlorofluorocarbons and the Antarctic Ozone Hole—F.S. Rowland

9:40 p.m. Reception for the Awardees

Dinner Reservations (Black Tie Optional) should be made not later than April 7, 1987 by calling Professor David Howell at Northeastern University, tel. 437-3952. Persons who make reservations which are not cancelled at least 24 hours in advance will be billed for the dinner price. Members, \$18.00; Non-Members, \$20.00; Students and Retirees, \$5.00. THE PUBLIC IS INVITED.



Dr. Rowland



Dr. Molina

Abstracts

Laboratory Chemistry and Stratospheric Ozone

In order to predict the potential effects of man-made chemicals on stratospheric ozone, numerical model calculations are carried out using parameters on rates of well over one hundred elementary chemical and photochemical reactions. These parameters are supplied as a result of laboratory

studies which have evolved significantly over the past decade.

Our understanding of heterogeneous chemical processes involving aerosol particles is only now beginning to emerge, and is not nearly as mature as our understanding of homogeneous gas-phase reactions. Heterogeneous chemical processes are most likely involved in explaining the large depletions of stratospheric ozone which have been observed in recent years over Antarctica.

Continued on page 6.

Biographies

Frank Rowland

Dr. Rowland is the Aldrich Professor of Chemistry at the University of California at Irvine. He has published approximately 270 scientific publications in the areas of chemical kinetics, radiochemistry and atmospheric chemistry. He was educated at Ohio Wesleyan (A.B., 1948), and University of Chicago (M.S., 1951; Ph.D., 1952), and taught at Princeton, and Kansas before joining the Irvine faculty in 1984.

He has won numerous awards and prizes including the Tyler Prize in Ecology and Energy, (1983) and the Environmental Science and Technology Award of the American Chemical Society (1983).

He has served the American Chemical Society as Chairman of the Division of Nuclear Science and Technology (1973-4) and Chairman of the Division of Physical Chemistry (1974-5).

M.J. Molina

Dr. Molina is Senior Research Scientist at the Jet Propulsion Laboratory at Caltech. His major research interests are in the physical chemistry of the atmosphere using the tools of gas phase chemical kinetics and photochemistry. He was educated at the Universidad Nacional Autónoma de Mexico (Ingeniero Químico, 1965) and University of California at Berkeley (Ph.D., 1972).

He has been honored by a number of awards including the Tyler Prize in Ecology and Energy (1983) and the Society of Hispanic Professional Engineers' Award for Achievements in Science and Technology (1983).

He has given numerous invited lectures and served on many committees, and has testified before committees of both houses of Congress in his efforts to warn the world of the dangers of tampering with an environment we know so little about. ◇

MCG Meeting

Medicinal Chemistry Group Meeting

Tuesday, April 21, 1987

Boston College
Cushing Hall, Auditorium 001
Chestnut Hill, Massachusetts

Ronald T. Borchardt, Ph.D.

University of Kansas
Lawrence, Kansas

Will Speak On:

S-Adenosylhomocysteine Hydrolase as a Potential Target for the Design of Antiviral Agents

- 4:00 p.m. Coffee and Refreshments
- 4:30 p.m. Seminar
- 6:00 p.m. Dinner* with Dr. Borchardt
Ming Garden Restaurant

For dinner reservations, please contact Dr. R. Milius at 437-5192 by April 20, 1987.

*Members: \$10.00
Students and Retirees: \$6.00

MCG Biography

Ronald T. Borchardt is Solon E. Summerfield Professor of Pharmaceutical Chemistry and Biochemistry, and Courtesy Professor of Medicinal Chemistry. He also serves as Chairman of the Department of Pharmaceutical Chemistry and Director of The Center for Biomedical Research. Professor Borchardt received his B.S. degree in 1967 from the School of Pharmacy, University of Wisconsin and his Ph.D. in 1970 from the Department of Medicinal

MGC Abstract

S-Adenosylhomocysteine (AdoHcy) hydrolase (EC 3.3.1.1) has become an attractive target for the design of antiviral agents. This cellular enzyme catalyzes the reversible hydrolysis of AdoHcy to adenosine and homocysteine, which are normally removed rapidly by separate cellular metabolic pathways. However, inhibition of cellular AdoHcy hydrolase results in intracellular accumulation of AdoHcy, a significant increase in the intracellular AdoHcy/S-adenosylmethionine (AdoMet) ratio and subsequent inhibition of AdoMet-dependent methylations of the 5'-terminal cap structure of viral mRNA.

This "methylated capped" structure is necessary for efficient ribosome binding and subsequent translation of the viral mRNA into viral proteins. The viral-specific methyltransferases which catalyze both sugar and base methylations of the 5'-terminus of viral mRNAs, like other AdoMet-dependent methyltransferases are inhibited by AdoHcy. This talk will focus on the design and synthesis of inhibitors of AdoHcy hydrolase, their effects on the purified bovine liver enzyme and on AdoHcy and AdoMet metabolism in murine L-929 cells and their effects on vaccinia virus replication. ◇

Chemistry, School of Pharmacy, The University of Kansas. After serving as a Senior Assistant Scientist at the National Institute of Health from 1969 to 1971, Professor Borchardt returned to the University of Kansas as an Assistant Professor of Biochemistry. From 1974 through 1979 he was an Established Investigator of the American Heart Association and in 1981 he was named Solon E. Summerfield Professor of Biochemistry. ◇

OZONE HOLE

Continued from page 5.

Chlorofluorocarbons and the Antarctic Ozone Hole

The chlorofluorocarbon (CFC) family of compounds finds a variety of convenient technological uses in modern society, and most of these eventually result in release of the CFCs into the open environment. Compounds such as CCl_2F_2 (Fluorocarbon-12), CCl_3F (FC-11 and $\text{CCl}_2\text{FCClF}_2$ (FC-113) are all very long-lived—75 years or longer—and have accumulated steadily and rapidly in the atmosphere. As a consequence, the organochlorine concentration of the atmosphere has increased from about 0.6 parts per billion by volume (ppbv) in 1900 to 0.8 ppbv in 1960 and about 3.5 ppbv in 1986, growing at a current rate exceeding 1.0 ppbv per decade.

The only important atmospheric sink for these compounds is ultraviolet photolysis in the upper stratosphere. This photodecomposition releases atomic chlorine which then initiates the ClO_x chain reaction which removes ozone from the stratosphere. Such an ozone loss permits more solar UV-B radiation to reach the earth's surface. The major UV-B effect on mankind is skin cancer, and increased UV-B will cause an increase in the incidence of skin cancer; deleterious effects can be expected for many other biological species as well. The preferential loss of ozone in the upper stratosphere causes a shift in its vertical distribution, and this can cause a marked decrease in upper air temperatures.

During the past decade, very substantial losses of ozone have been recorded over the latitudes south of 45°S latitude and especially over Antarctica. Ozone depletion has been especially severe during the southern hemispheric spring (September/October), reaching losses of 50% or more over much of Antarctica. The recent loss of ozone correlates well with the rapid increase in atmospheric chlorine, and the depletion is almost certainly connected with chlorine chemistry and the ClO free radical. ◇

1986 Norris Summer Scholar Report

III—Site Directed Mutagenesis of Aspartate Transcarbamylase at Position 108

by Margaret Pitts
Evan R. Kantrowitz, Faculty Advisor
Department of Chemistry
Boston College

Introduction. Escherichia coli aspartate transcarbamylase catalyzes the first reaction in the pyrimidine biosynthesis pathway, the reaction between carbamyl phosphate and L-aspartate to form carbamyl aspartate and inorganic phosphate. In addition to its catalytic function, aspartate transcarbamylase also controls the rate of this pathway. CTP, the end product of the pyrimidine pathway, inhibits the enzyme while ATP, the product of the parallel purine pathway stimulates the reaction. Aspartate transcarbamylase is the epitome of a regulatory enzyme exhibiting cooperative homotropic interactions along with heterotropic activation and inhibition.

The aspartate transcarbamylase holoenzyme is composed of two types of subunits, catalytic and regulatory. The two catalytic subunits, each composed of three polypeptide chains, are responsible for catalysis. Each catalytic subunit contains three active sites, is insensitive to allosteric effectors, and is characterized by a hyperbolic substrate saturation curve. The three regulatory subunits, each composed of two polypeptide chains, contain the effector sites which are responsible for the regulatory properties of the enzyme.

Over the past 20 years aspartate transcarbamylase has been studied extensively using a variety of biochemical and biophysical methods (1,2). The two genes for the enzyme (*pyrBI*) which constitute an operon have been sequenced and the primary and three-dimensional structures of the enzyme have been determined.³

A powerful tool for studying the relationship between structure and function is the use of specific amino acid substitutions. Previous work in this laboratory indicated that the substitution of tyrosine for glutamine at position

108 of the catalytic chain altered the allosteric properties of the enzyme. However, the mutant enzyme was never isolated in pure form. The objective of this research was to recreate this mutant enzyme by site-directed mutagenesis, then

purify and kinetically characterize it.

Results

(a) Site Directed Mutagenesis of *pyrB* at Gln-108. The replacement of tyrosine for glutamine at position 108 of

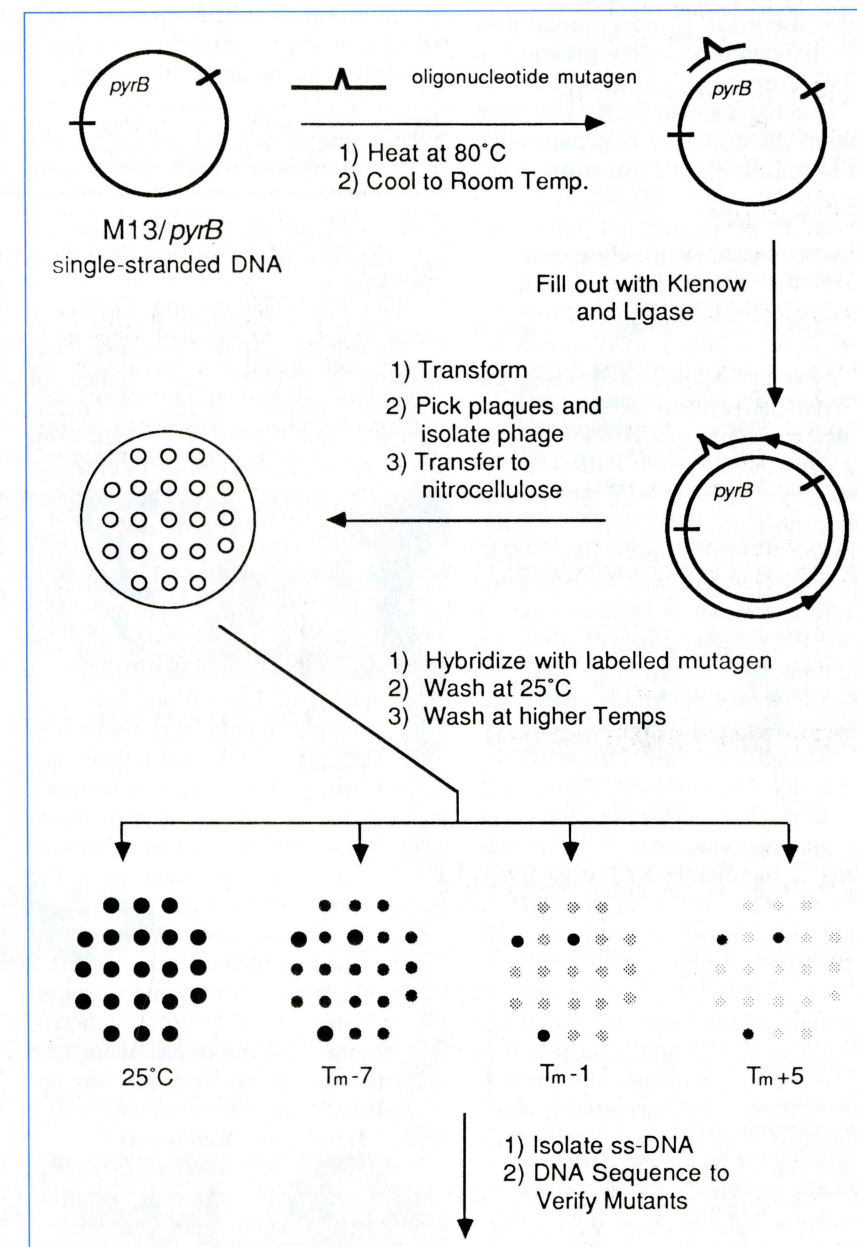
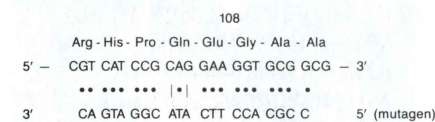


Figure 1. Site-directed mutagenesis as performed at site 108 of aspartate transcarbamylase using the one primer method.

the catalytic chain of aspartate transcarbamylase was accomplished by site directed mutagenesis⁴ (see Figure 1). This procedure is based on the use of an oligonucleotide with one or more mismatches hybridized to a single-stranded template derived from the phage M13 which contains the gene to be mutated (*pyrB*). The construction of the M13 phage carrying the entire *pyrBI* operon has been described.⁵ After hybridization of the mutagenic oligonucleotide to the M13-*pyrBI* single strand, it is extended using the Klenow fragment of DNA polymerase I in the presence of T4 DNA ligase.

To convert glutamine to tyrosine at position 108 a 21 base oligonucleotide was synthesized with two mismatches (see below).



After extension and ligation, the M13 replicative form (RF) was transformed into competent HB2154 [*F'* *ara*, *thi*, Δ *pro-lac*, *mutL* :: Tn10(Tet^r)/*F'* *proAB*, *lacI*^q, *lac* Δ *XMI5*] and plated onto a lawn of HB2151 [*F'* *ara*, *thi*, Δ *pro-lac*/F' *proAB*, *lacI*^q, *lac* Δ *XMI5*]. HB2154 is defective in DNA repair and therefore mismatch repair does not occur.⁶ Plating onto a lawn of HB2151, a repair-positive version of HB2154, reduced the time the M13 RF was in the repair-defective background.

(b) Confirmation of the mutation at site 108. Dot blot hybridization was used to distinguish between wild-type and mutant candidates. ³²P labelled mutagen oligonucleotide was hybridized to single stranded DNA isolated from forty-eight possible mutant candidates which were spotted on nitrocellulose. Since the labelled mutagen oligonucleotide will adhere more strongly to the mutant sequence than the wild-type sequence, the mutants have an identifying characteristic of adhering the labelled probe at higher temperatures than the wild-type which contains two mismatches. Twenty-one of the forty-eight candidates were identified as possible mutants by this procedure (see Figure 2). Dideoxy sequenced was used to confirm the muta-

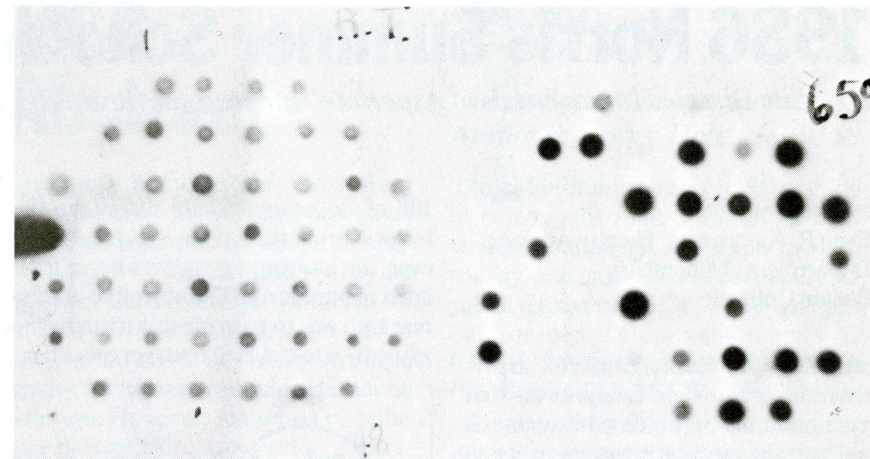


Figure 2. Results of the dot blot hybridization. (Left) Initial autoradiograph after hybridization and 25°C wash. (Right) Final autoradiograph after 65°C wash. Eight of the 21 remaining spots were sequenced to verify that a mutation had occurred.

tion using an oligonucleotide primer located approximately 80 bases from the site of the mutation.

(c) Expression and purification of the mutant aspartate transcarbamylase. A 756-base pair fragment of the *pyrBI* operon containing the mutation at position 108 was removed from the recombinant M13 phage by cleavage with Pst I and BstE II. The fragment containing the mutation was isolated and ligated with a fragment isolated from plasmid pEK38 which has the remaining portion of the wild-type *pyrBI* operon along with the gene for ampicillin resistance and both the pBR322 and M13 origins of replication. Selection was accomplished after transformation into U39A [*F'* *ara*, *thi*, Δ *pro-lac*, Δ *pyrB*, *rpsL*]. A plasmid was isolated, pEK52, that carried the desired mutation. To ensure that no other mutations had occurred during mutagenesis, the entire portion of the *pyrB* gene on the Pst I to BstE II fragment was sequenced by the dideoxy method using a set of three oligonucleotide primers spaced along the *pyrB* gene. Overproduction of the mutant aspartate transcarbamylase with tyrosine at position 108 was accomplished using the derepression system of Nowlan and Kantrowitz.⁷

A single species with exactly the same mobility as wild-type aspartate transcarbamylase holoenzyme was observed by polyacrylamide gel electrophoresis of the purified Tyr108C enzyme, under nondenaturing conditions.

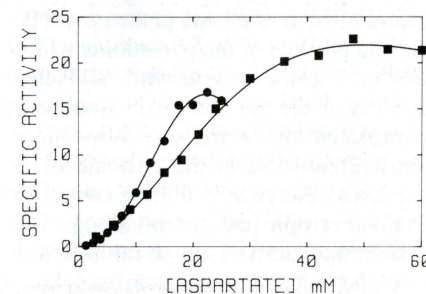


Figure 3. Aspartate saturation curves of wild-type (●) and mutant aspartate transcarbamylase (■) with tyrosine at position 108 of the catalytic chain. Specific activity is reported in mmol of carbamyl aspartate formed per hr per mg of protein. Colorimetric assays were performed at 25°C in 0.05M Tris acetate buffer (pH 8.3) at saturating carbamyl phosphate (4.8 mM).

(d) Preliminary characterization of the Tyr108C enzyme. The mutant enzyme was characterized kinetically by determining the velocity of the reaction versus aspartate concentration with carbamyl phosphate saturating. The kinetic analysis was performed using a colorimetric assay.⁸ As seen in Figure 3, the mutant enzyme exhibits both an increase in maximum observed specific activity and $[S]_{0.5}$, the substrate concentration at one-half of the maximum observed specific activity. Computer analysis of the aspartate saturation curve also indicated a decrease in the Hill coefficient from 2.4 for the wild-type enzyme to 1.6 for the Tyr-108C enzyme.

(e) Conclusions. In the wild-type aspartate transcarbamylase, glutamine

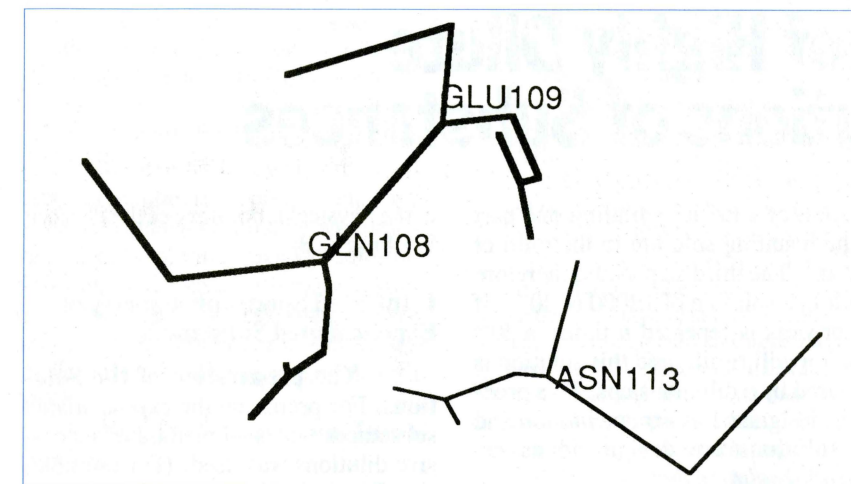


Figure 4. The interaction between Asn-113 of the regulatory chain (light) with Gln-108 and Glu-109 of the catalytic chain (dark) of aspartate transcarbamylase. In this work Gln-108 was replaced with tyrosine.

108 is involved in the interactions which hold the catalytic and regulatory subunits together. Specifically, Gln-108 and Glu-109 of the catalytic chain interact with Asn-113 of the regulatory chain (see Figure 4). Our preliminary data suggests that this region of the regulatory-catalytic subunit interface is

important for both modulating the activity of the enzyme and in the allosteric transition. During my Senior year, I will continue the analysis of this mutant enzyme in order to deduce information concerning the role of the interface in the allosteric interactions of aspartate transcarbamylase. ◇

References

1. Kantrowitz, E.R., Pastra-Landis, S.C. and Lipscomb, W.N. (1980a). *Trends Biochem. Sci.*, **5**, 124-128.
2. Kantrowitz, E.R., Pastra-Landis, S.C. and Lipscomb, W.N. (1980b). *Trends Biochem. Sci.*, **5**, 150-153.
3. Krause, K.L., Volz, K.W. and Lipscomb, W.N. (1985). *Proc. Natl. Acad. Sci. USA*, **82**, 1643-1647.
4. Zoller, M.J. and Smith, M. (1982). *Nucleic Acid Res.*, **10**, 6487-6500.
5. Smith, K.A., Nowlan, S.F., Middleton, S.A., O'Donovan, C. and Kantrowitz, E.R. (1986). *J. Mol. Biol.*, **189**, 227-238.
6. Carter, P.J., Bedouelle, H. and Winter, G. (1985). *Nucleic Acid Res.*, **13**, 4431-4443.
7. Nowlan, S.F. and Kantrowitz, E.R. (1985). *J. Biol. Chem.*, **260**, 14712-14716.
8. Pastra-Landis, S.C., Foote, J. and Kantrowitz, E.R. (1981). *Anal. Biochem.*, **118**, 358-363.

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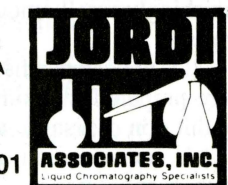
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Physical Effects of Highly Dilute Exponential Solutions of Substances

by Erwin Heintz, Strasbourg, Alsace

Translation by Arno Heyn, January 1987
Reference: *Die Naturwissenschaften*, 1941, 29(48) 713-725.

Chem. Abstracts, 37,4954⁵ (1943).

Comment of the Editor: Despite repeated attempts by the author and editor, unfortunately it has not been possible to have independent confirmation of the amazing results. The paper is therefore published with reservations and in the hope that publication will stimulate such independent confirmation.

Note of the Translator: Because of the length of the paper many sections are summarized briefly, indicated by indentation. In case the reader wonders whether this article is an April Fool story (a popular pastime in European journals), the cover date of the issue is November 28, 1941.

It is well known that highly dilute solutions can produce strong biological and physiological effects. Until 1923 it was assumed that such effects were only noticeable down to dilutions of 10^{-10} to 10^{-15} , where 10^{-10} means one gram of substance in 10^{10} cc of solution.

Since then, a number of papers have appeared in which the authors have independently gone to much lower concentrations. Effects are reported for dilutions as great as 10^{-30} and beyond, without having reached a lower limit to such effects. The surprising thing is that solutions which are so dilute that they should contain less than one molecule of the substance are reported to show effects. . . . How can a solution show any physical effect if there is no, or only a vanishingly small amount of substance present?

It is to be noted that these solutions were prepared in a very specific way: By dilution of a stock solution (usually of 10^{-1} concentration, i.e. containing 1 gram of substance in 10 cc solution) in

the ratio of 1:10, then diluting one part of the resulting solution in the ratio of 1:10, etc. The third step would therefore result in a solution of 1:1000 or 10^{-3} . If the process is repeated n times, a 10^{-n} solution will result, and this solution is prepared by n dilution steps. This process is designated as *exponentiation* and the solutions are designated as *exponential solutions*.

He suggests that such special effects may be due to the action of preparing solutions by successive dilution steps. He described the experimental approach taken for testing the physical effect of the successive dilution process:

in the physical laboratory of the clinic at Freiburg i. Br.

I. Infrared Spectrophotometry of Exponentiated Substances

1. The preparation of the Solutions. For preparing the exponentiated substances the usual method of successive dilutions was used. (For example, 1 g Cupric sulfate was dissolved in water, diluted to 10 cc and shaken a specified amount of time at a frequency of about 180 per minute¹. This first solution, which has the concentration 1:10, or 10^{-1} represents the first exponential solution and is designated as D_1 .

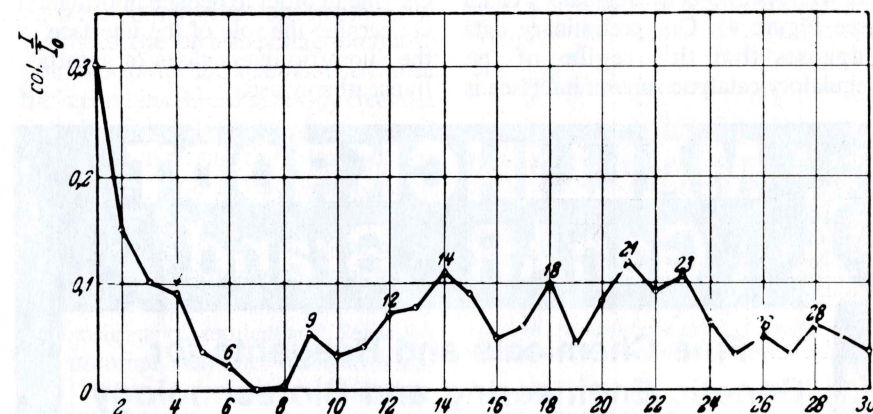


Figure 1. Sodium nitrate. Intensity ($h\text{-col}/I_0$) of the IR absorption band at 7.1μ of D_1 - D_{30} solutions.

The first two parts of the investigation, IR spectrophotometry and conductivity measurements, were carried out in the physical-biological laboratory of the medical faculty of the University of Strasbourg between 1935 and the outbreak of the war under the direction of Prof. F. Vles and were reported at a meeting of the Societe de Physique biologique in Strasbourg in 1935.

Thanks to the courtesy of Prof. Dr. Bohnenkamp, the second section on UV spectrophotometry was carried out

Successive dilutions were prepared, each time by diluting 1 ml of the previous solution ten-fold. Generally he went through 30 dilution steps, resulting in concentrations of 10^{-1} to 10^{-30} . For cases where more than the 9 ml of each solution which were left were required, another series was prepared, starting with 5 g, dissolving and diluting to 50 ml, and using 5 ml for making the next solution by dilution to 50 ml. In this manner 45 ml were available for each solution.

Continued on page 11.

At first, small soft glass bottles were used, later, bottles made of the less soluble Pyrex glass were used. No differences in the spectra were observed.

Of course, all equipment used, such as containers, pipets, etc. was cleaned extensively. First by washing in hot dilute sodium hydroxide solution, followed by chromic-sulfuric acid solution, followed by several water rinses, and finally the container or device was shaken with distilled water and dried at 120°C .

2. Infrared Spectrum Investigation.

After taking IR absorption spectra of the starting substances, characteristic absorption bands were chosen for each substance and measured for the 30 exponentiated solutions of each set. Curves were prepared to show the absorption as a function of the dilution. Instruments used were

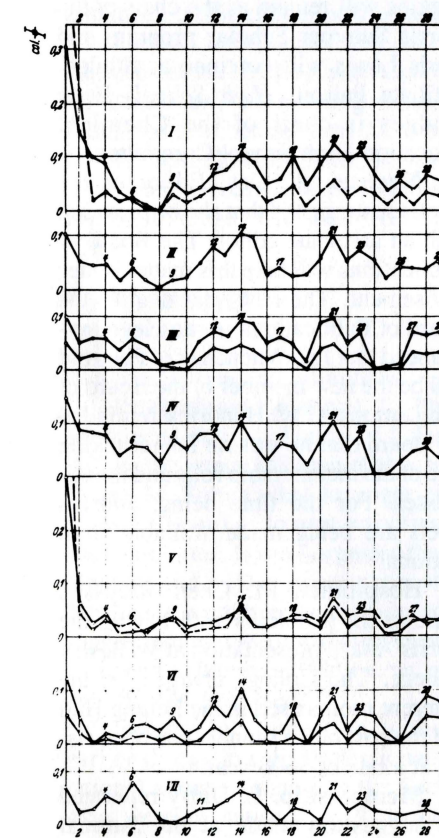


Figure 2. IR absorption intensities of specific bands of D_1 - D_{30} solutions of: I— NaNO_3 ; II— Na salicylate ; III— Pb nitrate ; IV— Acetic acid ; V— Cu nitrate ; VI— Hydrazine ; VII— CaCO_3 .

described in previous work of the author on proteins², using an IR spectrometer with rock salt prism and a thermopile detector and direct read-out of the galvanometer deflection.

Experiments were conducted by placing a cuvette consisting of thin mica plates provided with a 0.1 mm mica spacer containing the solution. The galvanometer deflection was called I. An identical, but empty cuvette gave the deflection I_0 . The ratio I/I_0 cancelled out any absorption due to the mica. Measurements were made in the wavelength range of 2-8 microns. Water was used as the solvent, but because of the strong absorption of water above 2 microns, the 0.1 mm film thickness was used and wavelengths were chosen where the water absorption interfered least.

To compensate for changes in dimension due to the flexibility of mica, absorptions were determined using water alone and the absorption results of solutions corrected accordingly. The data were recorded in terms of the $-\log I/I_0$ (designated "col I/I_0 " in the figures).

Absorptions were determined for dilution series for the following substances: $\text{Pb}(\text{NO}_3)_2$, $\text{Cu}(\text{NO}_3)_2$, NaNO_3 , picric acid, acetic acid, hydrazine, l-cystine, sod. salicylate and CaCO_3 . For acetic acid, dilution series were prepared in benzene, as well as in water.

Results will be considered in more detail, using sod. nitrate solutions as an example. See Fig. 1. (On the curve, the numbers and the abscissa refer to the corresponding exponential solution, thus "12" means solution D_{12} , of 10^{-12} concentration). It is seen that down to D_6 the absorption decreases more or less as expected according to Beer's law. At D_7 the absorption band has disappeared, and one would expect no further change. It should be mentioned that even in the range D_1 to D_6 the decrease is not uniform, however. After D_6 the absorption increased and decreased rhythmically, with a maximum value at D_{21} . . .

Fig. 2 shows comparative absorption curves for several substances:

I= NaNO_3 at 7.1 microns (solid curve with 0.1 as D_1 , broken lines with 0.3 as D_1 . II=sod. salicylate at 7.2 microns; III= $\text{Pb}(\text{NO}_3)_2$ (upper curve at 4.0 microns, lower curve at 4.3); IV=acetic acid at 7.1 microns; V= $\text{Cu}(\text{NO}_3)_2$ at 7.1 microns (solid curve: $D_1=10^{-2}$, broken curve: $D_1=4\times 10^{-1}$); VI=Hydrazine (Upper curve at 6.65 microns, lower curve at 7.1, both with $D_1=10^{-1}$). VII= $\text{Ca}(\text{NO}_3)_2$ at 3.9 microns, $D_1=1.3\times 10^{-5}$.

After a detailed discussion of the data he concludes:

Solutions show an IR absorption spectrum down to a concentration of 10^{-30} , yet there may be physical effects even beyond this dilution. Absorption maxima are obtained at the same exponential dilutions, regardless of the substance used. The rhythm of the curves obtained is independent of the starting substance.

The second part of this paper will follow in a future issue.

Notes.

¹ The author tried various times and speeds of shaking and, finding no differences, used a 1.5 minute shaking time for the subsequent tests.

² E. Heintz, Arch. Physique biol., (1937) 14 (3), 131-232.

MAY 1

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Board of Directors Meeting

January 15, 1987

submitted by David M. Howell

The January meeting of the Board of Directors of the Northeastern Section, ACS was called to order by the new chairman, Lloyd Taylor, at 5:30 pm in the Seminar Room 9MB, Harvard University. The following members of the Board were present: E. Joseph Billo, Mary Burgess, Michaeline Chen, Catherine Costello, Donald Ciappenelli, Lawrence Duffy, William Foye, Walter Gensler, Thomas Gilbert, Wallace Gleekman, G. Richard Handrick, Michael Hearn, Arno Heyn, David Howell, James Kaufman, Truman Light, Avram Medalia, John Neumeier, James Piper, Arthur Reis, Donald Rickter, Myron Simon, Robert Stolow, Lloyd Taylor and Valerie Wilcox.

Chairman Taylor's first order of business was the presentation of the past Chairman's pin to Donald Ciappenelli. Since this was the start of a new year, all members of the Board were asked to introduce themselves. Among those present was A. Medalia from the Elastomers & Plastics Division.

A vote was taken concerning the location of the meetings of the Board. A majority preferred to have the meetings continue at Harvard.

L. Taylor had received a letter from K. Biemann, outgoing chair of the Richards' Medal Committee. The letter described the difficulties in timing which originate from the January 1 beginning of terms of office for members of the Committee. The idea of changing the date the Committee takes office will be considered by the Constitution & Bylaws Committee.

Secretary. D. Howell mentioned several corrections to the Secretary's minutes of December, 1986. T. Light wished that the statement about "Affiliates" at the last meeting be changed to read "Local Groups." Several members noted that the sum on page two of the minutes should read \$2.8 million.

Treasurer. J. Piper presented his regular December monthly report. Monies owed the Section by the

Trustees will be collected in 1987.

Trustees. J. Perkins, W. Gensler, and A. Obermayer are the trustees for 1987.

Budget. J. Piper announced that the Budget Committee is to meet next week. The report will be circulated prior to the February Board meeting.

Constitution & Bylaws. T. Light announced that his committee was waiting for a report from the Long Range Planning Committee with regard to the final decision as to which ad hoc committees should become standing committees.

Chemical Education. *College & University*—M. Hearn announced that Emily Dudek of Wellesley will be the new chair of the Undergraduate College Research Symposium. Sr. Dorothy Higgins will remain as the chair of the Norris Summer Scholar program and Doris Lewis will continue as Student Affiliate liaison. *High School*—Bette Bridges is chair of the Chemical Education-High School Committee.

Nucleus. A. Dey, Editor of the *Nucleus*, suggested that she be provided with an associate editor. The Board of Publications will take this matter under advisement. The new chairman of the Board of Publications, Arno Heyn, announced that Jean Vnenchak of Polaroid will be the new member of the Board of Publications. G.R. Handrick reminded the Board that he was no longer taking care of the membership rolls and the addresses. For the time being, address labels are being made available from National.

Hospitality. M. Chen discussed some of the problems with having the Norris Award presentation at Wellesley College. The College charges for the different rooms used in the Dining Hall and the cost of the dinners has been rising at a rate of \$600/year.

Membership. L. Duffy reiterated his suggestion made at the Annual Meeting that the Membership Committee could help revitalize the membership and activities of the various committees of the Section. They could act

Continued on page 13.

Norris Award Nominations

Nominations are being received for the 1987 James Flack Norris Award for Outstanding Achievement in the Teaching of Chemistry. The annual award, consisting of an appropriate scroll and honorarium, is presented by the ACS Northeastern Section of the American Chemical Society. Nominees must have served with distinction as teachers of chemistry in a university, college, or secondary school.

Nominating materials should include a curriculum vitae and a listing of honors, awards and publications, especially those germane to the Norris Award, a nominating letter, and as many seconding letters as are necessary to convey the depth and breadth of the nominee's qualification for this award.

Further information may be obtained from the Norris Award Committee Chairman. Nominating materials should be sent before *April 15, 1987* to Dr. E. Joseph Billo, Norris Award Chairman, Department of Chemistry, Boston College, Chestnut Hill, MA 02167. ◇

BOARD MINUTES

Continued from page 12.

as a liaison to other committees.

Professional Relations. L. Taylor announced that M. Simon of Polaroid will be the new Chairman of this committee. M. Simon asked for suggestions from the Board as to new activities for the Committee. It was suggested that E. Hopkins and A. Dey, as members of the National Committee, would have some suggestions. A meeting to discuss problems and solutions of the recent mass lay-offs was discussed.

Safety. In connection with the earlier discussion (in Professional Relations) about members of the Section who were in national ACS organizations concerned with the same general subject, J. Kaufman mentioned his membership in the Division of Chemical Safety and the Council Committee on Health and Safety. ◇

Board of Publications

1986 Report to the Board of Directors

by John L. Neumeier, Chairman

The Board of Publications had a productive year. The Board, consisting of the following members, met monthly at Editor Dey's house:

Adrienne S. Dey, Editor
William E. Adams, Business
Manager and Advertising Manager
Arno H.A. Heyn
Harry Orf
John L. Neumeier

The following issues highlighted our activities during the year.

1. Contracts for the Editor and Advertising Manager of *The Nucleus* were negotiated and signed by Drs. Dey and Adams.
2. The Board of Publications requested and was allocated the sum of \$2700.00 for a professional redesign and layout of *The Nucleus*. The services of Richland Design Associates, Cambridge, Massachusetts were contracted for and carried out to the Board's general satisfaction. The first issue of the newly designed *Nucleus* was published in November 1986.
3. G. Richard Handrick, who has most faithfully and effectively carried out the task of Editor of the Directory and Circulation Manager for *The Nucleus* for over fifteen years, has resigned these positions effective January 1987. A new circulation manager has been chosen. It was also decided that mailing labels provided by national headquarters of the ACS be used for future distribution of *The Nucleus*.
4. A budget for eight issues of *The Nucleus* in 1987 was discussed and approved by the Board of Publications and submitted to the Budget Committee of the Section. ◇

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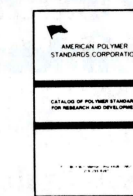
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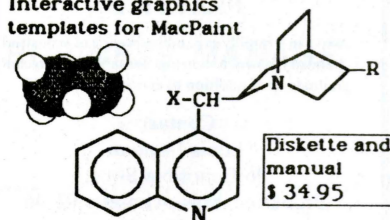
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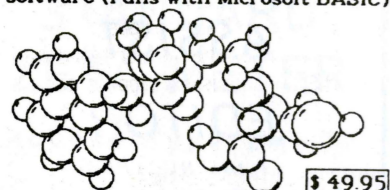
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Letter to the Editor

To the Editor:

It was disturbing to read a blatantly prejudicial passage in the *Historical Notes* of the March issue of the *Nucleus*:

"It so happened that the first custodian was an Italian *boy* with a wife and child. The halls of the building reeked of oregano for years. Kriehle was disturbed more than the rest of us, for he had *inherited from his Pennsylvania Dutch ancestors* an unusually keen sense of smell."

It would be more understandable, yet no less offensive if such a description had appeared in the 1936 issue of the *Nucleus* since that editorial staff may not have been sensitive to the pejorative implications of the term "boy" and of the ascription of a physical acuity to ethnicity. I would expect your staff to be sensitive to these issues.

Margaret R. Souza
Assoc. Professor of Chemistry
Bridgewater State College

Editor's Comment:

The editor, who is herself an immigrant who exchanged Italian citizenship for that of the United States and who has forebears and immediate family from Central Europe and Asia, found the comments quoted above to be fairly harmless and open to interpretation. In any case, any letter to the editor, even if so critical, is appreciated since it shows that there is life out there! Regrettably, since we undertook the face lift of the *Nucleus* in 1986 at considerable effort, especially on the part of the editor, and at substantial expense to the section, there has not been a single comment from our readers or any increase in advertising as we had hoped.

The letter does illustrate a misconception, namely that the *Nucleus* has a staff. STAFF? What staff?? Each issue is put together and seen through final production by the editor who works in

Continued on p. 15.

ESSELEN

Continued from page 4.

inauguration of Brown University chemist James S. (Spike) Coles as President of Bowdoin College. I was recognized by Tommy *****; a venerable professor of classics at Bowdoin, in the delegate's dressing room. He remembered me, but embarrassingly, not that I was a chemist. I shall always remember the disgust with which he complained that of all the viable candidates 'They' had to pick a chemist for president! 'Chemist' to him was obviously somewhere between garbage man and plumber. I think I kept a straight face and gently asked Professor ***** what James B. Conant did for a living before he became president of Harvard!

I tell this story not only to illustrate a point, but also to make clear how important it is that Gus Esselen's life and work gives so many people a new and better concept of 'Chemist.'

One of the requirements for the Gustavus John Esselen Award is that the work and presumably the character of the recipient must be such that he or she "... has thereby communicated positive values of the chemical profession." Surely this is a most fitting memorial to Gus—good friend, good citizen and good chemist!!

LETTER

continued from page 14.

complete isolation in Needham. Two major jobs, those of business manager and advertising manager, have been filled for several years by one person. A glance at page three of the *Nucleus* will reveal the names of all the persons even remotely involved with the *Nucleus*. We could spin off any number of smaller jobs if we had interested volunteers. How about it? Call the editor at 444-5933 if you are interested in being involved in any aspect of the production of the *Nucleus*.

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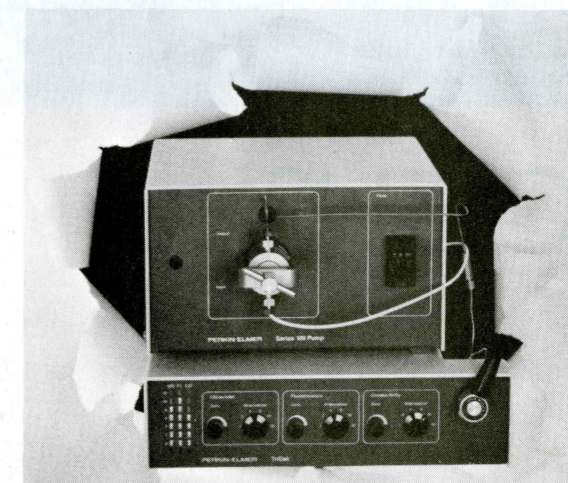
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Calendar

Wednesday, April 1

Dr. Guilford Jones (Boston University)
"Photoinduced Electron Transfer
Involving Organic Charge Transfer
Complexes: Novel Dependence on
Excitation Wavelength"
Wellesley College
Science Center Rom 278 at 4:15 pm

Thursday, April 2

Dr. James G. Quinn (University of
Rhode Island)
"The Geochemistry of Organic Pollutants
in Narragansett Bay"
Southeastern Massachusetts University
Science & Engineering Building Room
305 at 11:00 am

Dr. R. Zwanzig (University of
Maryland)
Title to be announced
Boston College
Gasson 305 at 4:00 pm

Professor Robert Zwanzig (University of
Maryland)
Title to be announced
Boston University
Science Center Room 107 at 4:00 pm

Professor Paul L. Houston (Cornell
University)
"Laser Studies of Molecular Dynamics"
University of New Hampshire
Parsons Hall Room L-103 at 11:00 am

Dr. D. Sogah (E.I. DuPont de Nemours)
"Macromolecular Engineering in Silicon-
Mediated Polymerizations"
MIT Polymer Seminar Series
MIT Room 4-145 at 3:00 pm

Tuesday, April 7

Professor G. Davies (Northeastern
University)
"Transmetalation Reactions"
University of New Hampshire
Parsons Hall Room L-103 at 11:00 am

Wednesday, April 8

Dr. Sydney Ross (Sprague Electric
Company)
"The Role of Complexes in the Reaction
Mechanisms of N-Halosuccinimides"
Worcester Polytechnic Institute
Goddard Hall Room 227 at 4:00 pm

Thursday, April 9

Dr. Joseph E. Earley (Georgetown
University)
Title to be announced
Boston College
Gasson 305 at 4:00 pm
Dr. Yacov Kantor (Harvard University)
"Statics and Dynamics of Sheet
Polymers"
MIT Polymer Seminar Series
MIT Room 4-163 at 4:00 pm

Wednesday, April 15

Dr. J. Hodge Markgraf (Williams
College)
"Strained Heterocyclic Systems"
Worcester Polytechnic Institute
Goddard Hall Room 227 at 4:00 pm

Thursday, April 16

Dr. Thomas Whitney (Duracell
Corporation)
Title to be announced
University of New Hampshire
Parsons Hall Room L-103 at 11:00 am
Dr. Do Y. Yoon (IBM)
"Ordering in Semi-Flexible Liquid
Crystalline Polymers"
MIT Polymer Seminar Series
MIT Room 4-163 at 4:00 pm

Monday, April 20

Professor Pat Confalone (DuPont
Experimental Station)
"The Total Synthesis of Natural Products
and the Design and Synthesis of
Unnatural Products"
Brandeis University
Gerstenzang 122 at 4:00 pm

Tuesday, April 21

Professor Charles Overberger
(University of Michigan)
Title to be announced
University of New Hampshire
Parsons Hall Room L-103 at 11:00 am

Wednesday, April 22

Dr. Peter C. Lillya (University of
Massachusetts)
"Disclotic Liquid Crystals: Molecules
Which Stack Like Poker Chips"
Worcester Polytechnic Institute
Goddard Hall Room 227 at 4:00 pm

Thursday, April 23

Dr. Bill Jorgensen (Purdue University)
"Computer Simulations of Organic and
Biomolecular Systems"
Boston College
Gasson 305 at 4:00 pm

Thursday, April 30

Professor A. Kjaer (Technical University
of Denmark)
Title to be announced
University of New Hampshire
Parsons Hall Room L-103 at 11:00 am

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